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ANNALES AGRICULTURAE FENNIAE, VOL. 17: 109—114 (1978)
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FEEDING VALUE OF GRASS MOLASSES PELLETS AND THEIR INFLUENCE ON THE FAECAL MICROBIOTA OF HORSES

TERTTU PELTONEN, VAPPU KOSSILA, LIISA SYRJÄLÄ and IRMA IMMONEN

PELTONEN, T., KOSSILA, V., SYRJÄLÄ, L. & IMMONEN, I. 1978. **Feeding value of grass molasses pellets and their influence on the faecal microbiota of horses.** Ann. Agric. Fenn. 17: 109—114. (The State Horse Breeding Establishment, SF-32100 Ypäjä, Finland.)

The feeding value of 10 % grass molasses pellets was studied in 16 Finn-horses. These were divided into two groups of 8: one experimental and one control group. The animals were fed on Timothy hay and oats; either with (experimental group) or without (control group) grass molasses pellets. The feeding trial was conducted for 4 months.

Qualitative and quantitative investigations were carried out on the faecal ciliate fauna and quantitative investigations on the faecal bacterial flora of the horses. The average number of bacterial cells was 52,69 $\times$ 10^9 per ml. in the experimental group and 50,03 $\times$ 10^9 per ml. in the control group. The average number of ciliate cells was 425 900 and 272 300 per ml. respectively. The differences in the numbers of microbes between the two groups were not statistically significant. The high differences in microbial numbers between individual animals were caused by other factors, and not feeding.

Grass molasses pellets were found to be a suitable feed for horses. The nutritive value of the pellets was higher than that of Timothy hay. Hay can be partly replaced by pellets in horse rations.

Index words: equine, faecal microbiota, grass molasses pellets.

INTRODUCTION

Hay is an essential ingredient in a horse's diet. As roughage, it functions as a structure and filling material in horse feeding and it is an important source of Calcium and such provitamins as carotene. Hay contains variable amounts of protein, depending on the plant species and the harvesting time. Hay furnishes energy for bacteria and ciliates in the caecum and colon of horses.

Soil, plant species and harvest conditions have a considerable effect on the quality of hay. Poor quality hay causes disturbances in health and reduction in performance of the horse. In this feeding trial, the suitability of grass molasses pellets in horse-feeding and the possibility of their substitution for hay was studied.

MATERIAL AND METHODS

Grass was cut from the field and machine-pressed, with addition of 10 % molasses, into 20 mm diameter pellets. These pellets were tested on 16 adult Finn-horses, of which 8 belonged to the experimental group and 8 to the control group. Each group was composed of 3 stallions and 5 mares.

The horses were fed three times daily with hay and oats, in amounts determined by the degree of training. In the experimental group, part of the hay replaced by pellets, with each horse receiving 4 kg pellets/day. About 50—80 g Calcium-rich mineral and 200 g wheat bran was given to each horse daily. The experiment was carried out over a period of 4 months and was divided into 4 four-week feeding periods.

The horses were exercised for 1 ½ hours/day, four or five times a week. The live weight of the horses was checked to show wheather or not the energy intake was sufficient.

During each feeding period, faecal samples were collected from the rectum. 5 g of the rectal contents were measured and transferred to a glass bottle containing 45 ml of 4 % formaldehyde. The bacterial cells were counted with the aid of a microscope. The counting methods are described by WESTERLING (1970) and SYRJÄLÄ at al. (1973).

Feeds were analysed using Official Standardised Analytical Methods.

RESULTS

The composition of the pellets and other feeding materials used are given in Table 1. Pellets contained more protein, fat and NFE but less crude fibre than hay. At times the quality of the hay was not the best because of dust and mould.

In the experimental group, 33 % of the total energy was derived from the pellets, 21 % from hay and 46 % from oats. In the control group, 50 % of the total energy intake was furnished by hay and 50 % by oats. About 39 % of the total, daily, dry matter intake of the experimental horses was obtained from the pellets. Live weight, daily feed and nutrient intake of the horses are given in Table 2. The greater energy and protein consumption in the experimental horses was due to their receiving more exercise than the control horses.

The average numbers of microbe cells are given in Table 3. There were large differences in the numbers of microbes between individual horses, but differences between groups were not statistically significant.

Some genera of ciliates were identified (HSIUNG 1930). The most common ciliates were *Blepharocorys*, *Bundleia* and *Triadinium*. Some identified genera are shown in Figs. 1—11.

Table 1. Average composition and feeding values of the feeds used in the trial

	Timothy hay	Grass molasses pellets [1]	Oats
Dry matter, %	87,04	90,26	86,43
In dry matter, %:			
Ash	6,10	7,57	3,18
Organic matter	93,89	92,42	96,81
Crude protein	7,45	10,08	13,17
» fat	1,68	2,47	5,82
» fibre	32,62	26,34	9,84
» carbohydrate	84,76	79,87	77,82
NFE	52,14	53,52	67,97
Mcal/kg	1,79	1,81	2,58
fu/kg	0,47	0,58	0,91
kg dry matter/fu	1,85	1,56	0,94
DCP g/kg	35,67	53,67	88,77
» , %	3,56	5,36	8,87

[1]) Pellets manufactured by Naantalin Juurikassokeri Oy
NFE = nitrogen free extract
fu = feed unit (1 fu = 0,7 starch unit)
DCP = digestible crude protein

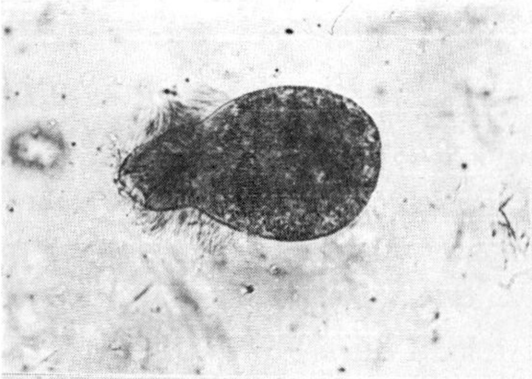
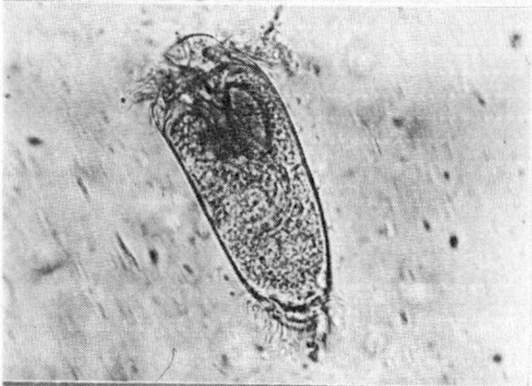


Fig. 1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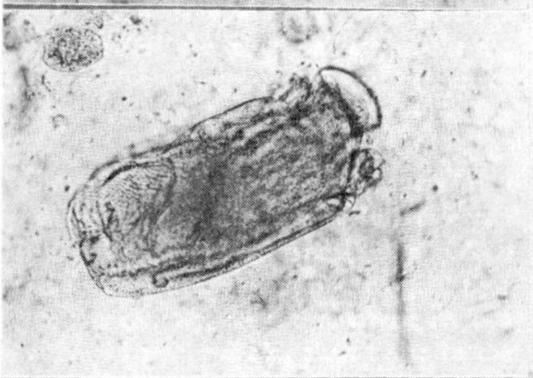
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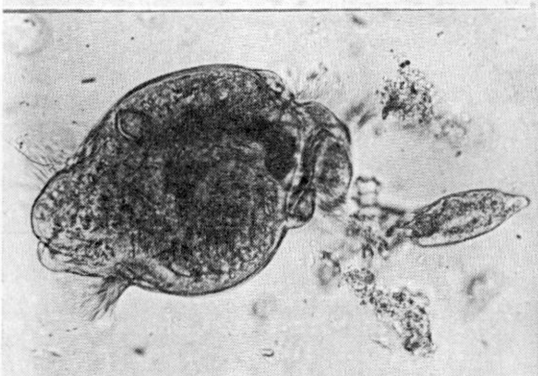
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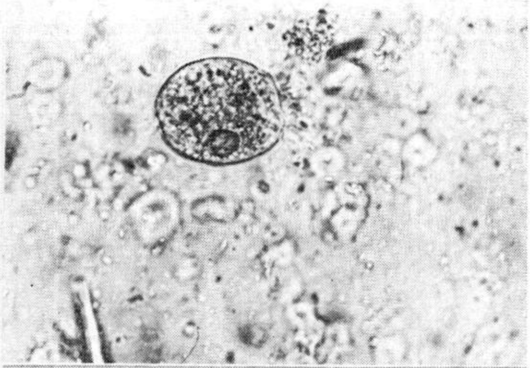
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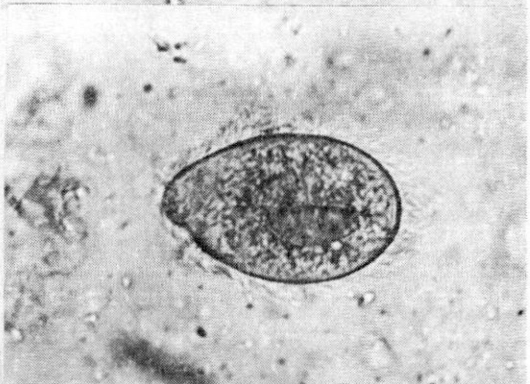
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Fig. 8

Fig. 9 Fig. 10 Fig. 11

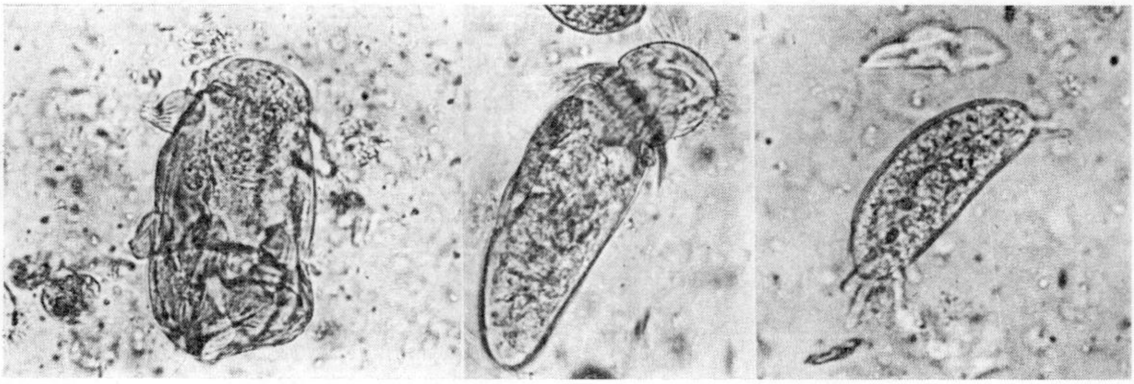

Fig. 1—11. Some genera of ciliate identified from the rectal contents of the horse. 1. *Blepharoprosthium* 400x. 2. *Blepharocorys* 400x. 3. *Cycloposthium* 200x. 4. *Tetratoxum* 310x. 5. *Bundleia* 400x. 6. *Triadinium* 670x. 7. *Paraisotricha* 630x. 8. *Polymorpha* 670x. 9. *Tripalmaria* 400x. 10. *Spirodinium* 470x. 11. *Allantosoma* 650x.

Table 2. Live weight; daily feed and nutrient intakes of horses during 4 feeding periods [1])

	Period 1		Period 2		Period 3		Period 4	
	A	B	A	B	A	B	A	B
Live weight, kg	529	512	521	505	524	502	524	503
Timothy hay, »	2,9	6,4	2,9	6,4	2,9	6,3	2,9	6,3
Pellets, »	3,4	—	4,0	—	3,9	—	3,8	—
Oats, »	3,0	3,6	3,3	3,0	3,5	2,7	3,4	3,0
Dry matter, »	8,3	8,8	9,0	8,2	9,1	8,0	8,9	8,3
Fibre, »	1,9	2,1	2,0	2,0	2,1	2,1	2,0	2,1
Mcal	19,4	21,0	21,1	19,5	21,1	18,8	20,8	19,6
fu	6,2	6,4	6,7	5,9	6,8	5,6	6,6	5,9
DCP, g	537	546	638	521	621	497	602	506

[1]) Each period was 28 days except period 1, which was 37 days.
A = experimental group, B = control group.

Table 3. Average changes in faecal dry matter and number of bacteria and ciliates in experimental and control groups during 4 feeding periods

	Dry matter, %		Bacterial cells, n × 10^9/ml				Ciliate cells, n × 10^3/ml			
	Experim.	Control	Experimental		Control		Experimental		Control	
			$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s
At the beginning of the trial	23,46	22,53	51,17	15,75	51,93	12,99	544,05	837,96	422,80	379,87
Period 1	24,00	22,91	64,71	20,29	56,36	5,78	376,38	756,12	147,65	249,14
Period 2	21,33	20,52	52,17	9,16	56,27	17,67	658,48	682,38	429,91	513,08
Period 3	23,41	22,77	43,78	4,92	39,22	10,07	299,52	500,01	115,55	118,54
Period 4	23,08	21,82	52,93	10,30	47,26	7,78	279,57	375,05	183,84	332,62

n = number of bacterial or ciliate cells.
$\bar{x}$ = mean
s = standard deviation

DISCUSSION

Grass molasses pellets were palatable, and most horses preferred them to hay. Pellets caused no health disturbances or reduction in the performance of the horses.

Pelleted rations have the following advantages according to OTT (1973)

- more consistent balance of nutrients
- less feed wastage
- greater nutritive value when fed *ad libitum*
- less dust
- reduction in storage-space requirements
- reduction in gut fill (hay belly)
- less labour in handling feed

Some disadvantages are also apparent

- increased incidence of wood chewing
- reluctance of some horses to eat pellets

It has been noted that the chopping or grinding of hay for horses does not improve its nutritive value, if the hay is of good quality. Pelleting of hay appears to improve its nutritive value, and to increase the rate of energy consumption. Grass can also be pelleted and used effectively (OTT, 1973). Pelleting roughage has reduced the digestibility of fibre in horses (MEYER et al. 1974). HINTZ's et al. (1966) and ERIKSSON's (1973) investigations failed to reveal any significant effects of pelleting hay on the digestibility of crude fibre. The rate of passage of oat pellets through the digestive tract was similar to that of long hay in the study by KOSSILA and LJUNG (1976).

Microbial population and activity in digestive tract of the horse can be influenced by many factors. The microbial population is affected by gross composition, by trace element content and by other minor constituents of the feed, as well as by the feed's physical state. For instance, it has been suggested that finely-ground feed-particles may cause the intestinal feed-turnover rate to become faster than the division rate of the larger ciliates, resulting in the disappearance of the ciliates (HOBSON 1969). KERN et al. (1973) found that diet affected the proportion of protozoal types: with oats, *Blepharocorys uncinata* increased in number ($P < 0,01$), and when Timothy hay (with or without oats) was fed, the *Cycloposthium bipalmatum* population increased ($P < 0,05$). No differences ($P > 0,05$) in the total protozoa/ml ingesta were found, but an increase ($P < 0,05$) in the total and viable bacteria/ml ingesta occurred when oats were fed to ponies.

Grass molasses pellets were found to be suitable feed for horses, and they had neither harmful effects on the digestive functions, nor caused reductions in physical performance of the horses. The nutritive value of the pellets was higher than that of Timothy hay and, thus, it can be concluded that part of the hay in the diet of horses can be replaced by grass pellets.

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SELOSTUS

Melassoitu ruohokopsi hevosten ruokinnassa ja sen vaikutus hevosen fekaaliseen mikrobistoon

T. PELTONEN, V. KOSSILA, L. SYRJÄLÄ ja I. IMMONEN

Valtion hevosjalostuslaitos, Maatalouden tutkimuskeskus ja Helsingin yliopisto

Melassoidun ruohokopsin soveltuvuutta hevosten ruokintaan tutkittiin 16 suomenhevosella. Niistä 8 kuului koeryhmään ja 8 vertailuryhmään. Rehuina käytettiin timoteiheinää ja kauraa molemmille ryhmille sekä koeryhmälle lisäksi kopseja (4 kg/pv). Kokeen kestoaika oli 4 kuukautta.

Hevosten sonnan mikrobimäärät laskettiin. Bakteerien keskimääräinen lukumäärä oli 52,69 $\times$ 10^9/ml koeryhmällä ja 50,03 $\times$ 10^9/ml vertailuryhmällä, kun taas keskimääräiset alkueläinmäärät olivat vastaavasti 425 900/ml ja 272 300/ml.

Ryhmien väliset erot eivät olleet tilastollisesti merkitseviä. Suuret yksilölliset erot mikrobimäärissä johtuivat muista syistä kuin ruokinnasta.

Melassoidun ruohokopsin todettiin soveltuvan hevosten ruokintaan. Kopsien ravintoarvo oli suurempi kuin timoteiheinän ravintoarvo ja heinää voidaan hyvin korvata kopsilla.

ANNALES AGRICULTURAE FENNIAE, VOL. 17: 115—142 (1978)

Seria AGRICULTURA N. 58 — Sarja PELTOVILJELY n:o 58

WEED SPECIES, FREQUENCIES AND DENSITIES IN WINTER CEREALS IN FINLAND

Mikko Raatikainen, Terttu Raatikainen and Jaakko Mukula

Raatikainen, M., Raatikainen, T. & Mukula, J. 1979. **Weed species, frequencies and densities in winter cereals in Finland.** Ann. Agric. Fenn. 17: 115—142. (Univ. Jyväskylä, Dept. Biol. SF-40100 Jyväskylä 10, Finland.)

The survey looks at the weed flora occurring in winter cereal cultivations in the whole of Finland. A sample area covering method, where the plant stand was protected for the duration of treatment with herbicide, was developed for the survey in order to study the weed situation when no herbicide had been sprayed.

The number of taxa found in the fields was 190. The most common species and their frequencies were, for the spring annuals, *Chenopodium album* 89, *Galeopsis* spp. 88, *Erysimum cheiranthoides* 76, *Polygonum aviculare* 76 and *P. convolvulus* 63; for the winter annuals, *Viola arvensis* 89, *Matricaria* spp. 83, *Stellaria media* 73, *Myosotis arvensis* 69 and *Lapsana communis* 53; and for the perennials, *Equisetum arvense* 51, *Ranunculus repens* 51 and *Taraxacum* spp. 50.

Winter cereals were found to harbour, on average, 256 weed plants or shoots /sq. metre. The most densely growing taxa and their densities (plants/m^2) were found, among the spring annuals *Galeopsis* spp. 36, *Chenopodium album* 27, *Erysimum cheiranthoides* 12 and *Polygonum aviculare* 9; among the winter annuals *Viola arvensis* 28, *Matricaria* spp. 14, *Stellaria media* 12, *Myosotis arvensis* 7 and *Lapsana communis* 6; and among the perennials (shoots/m^2) *Agrostis* spp. 10, *Agropyron repens* 10, *Poa pratensis* 7, *Phleum pratense* 7 and *Ranunculus repens* 7.

On the basis of the occurrence and density of weed species the winter cereal cultivation area was divided into two phyto-geographical sections. The discussion examines the temperature and oceanic-continental factors, as well as soil and cultural factors which influenced delineation of the sections.

Index words: weed flora, weed distribution, winter cereals.

1. INTRODUCTION

Winter rye was the most common type of cereal grown in Finland during the 19th century, but at the turn of the century, spring-sown oats took over as the most common Finnish cereal. In the late 19th century the area under wheat was about a tenth of that under rye. Over half of this was accounted for by winter wheat. In the 20th century the area under winter rye declined further while that under winter wheat increased. This trend was still highly apparent in 1950—1975 (Mukula and Rantanen 1976, Mukula et al. 1976).

During the period when this study was conducted, in 1972—1974, the area under winter rye was, on average, 61 500 hectares and that under winter wheat 52 000 hectares. The overall area under winter cereals came to 4,3 % of the area under cultivation in Finland and 9,0 % of that under cereals.

Weeds in winter cereals attracted attention from a very early point, and numerous reports, especially on thistles, were recorded in the 19th century. Occasional information of this kind on the occurrence of various species among winter cereals is to be found in e.g. flora, local flora, weed control manuals and popular articles.

More extensive information on the weed seeds spread with winter cereals is available from, for example, reports by the State Seed Control Institute and the HILLI (1961) study. On the other hand, there are very few large-scale reports on weeds in winter cereal as such. LINKOLA (1921) describes the weed vegetation of eight burnt-over clearings sown with rye in Ladoga Karelia and North Karelia; PESOLA (1952) the vegetation of one rye field in Kuusamo and one in Salla; BORG (1964) the weed flora of two rye fields in the rural districts of Helsinki; PORANEN (1973) the vegetation of 13 rye fields in the rural districts of Kuopio and Siilinjärvi; and KAUHANEN (1975) the weed vegetation of 19 rye fields in the Iisalmi region.

At the outset of the present survey in 1969, data on the weeds of only three rye fields had been published in Finland. The preliminary study of the present survey provided the principal data on 136 winter cereal weeds and these were utilized by T. RAATIKAINEN (1970) when she prepared the first regional survey of Finnish winter cereal weeds.

The present survey on weeds in winter cereal fields is the third of the projects on weed ranges conducted by the Institute of Plant Husbandry of the Agricultural Research Centre. The other projects in the series and their field work stages are: 1) Weeds in spring cereals and their abundance. This was carried out in 1961—1965 (MUKULA et al. 1969, PAATELA and ERVIÖ 1971, MUKULA 1974). 2) The yield of grassland for hay, flora composition and changes in it. The field work was done in 1966—68 (M. RAATIKAINEN and T. RAATIKAINEN 1975). The third project, now being published, deals with weeds in winter cereals and their abundance. The field work was done in 1969 and 1972—74 and the results are being published in several articles, this being the first.

The main aim of the project on weeds in winter cereals was to analyze:

1) weed flora and frequency of species,
2) plant density of annuals and biennials and shoot density of perennials, no./m^2,
3) biomass of weed species, g/m^2, and
4) changes in biomass caused by weed control practices.

This first article provides general accounts of 1) and 2). Later publications will deal with these subjects by winter cereal species. Some advance data have already been published on the projects being dealt with (T. RAATIKAINEN 1970, M. RAATIKAINEN, T. RAATIKAINEN and TINNILÄ 1971 a, 1971 b, M. RAATIKAINEN 1974, 1976, 1978 a).

2. SURVEY AREAS AND METHODS

2.1 Preliminary study

Because weeds in winter cereals had not been studied before and many of the fields were treated with herbicides, we found ourselves initially in a situation in which new survey methods and approaches had to be developed and adopted. To test these, a varied and flexible preliminary study was arranged, in which details of the questionnaire, interview and the empirical surveys were worked out and adjusted. In addition to the present authors, two other people who had taken part in the field survey took part in this preliminary study (see section 2.2.1). The preliminary study was made in the parishes of Paimio and Laihia in 1969 (Fig. 3). 43 winter cereal fields were studied in both parishes. In Paimio, (P) there were 41 fields under winter wheat and in Laihia (L) 10. The rest were under winter rye. Winter barley is not grown in Finland. In addition, a total of 50 winter cereal fields were studied in several parishes in the Finnish lakeland.

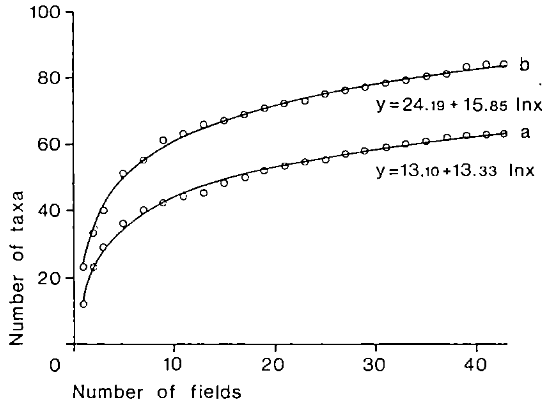

Fig. 1. Dependence of the number of taxa found in field (a) and sample area (b) on the number of fields studied in the Paimio preliminary study area.

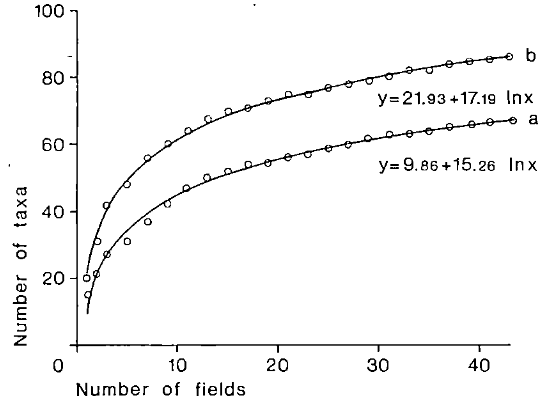

Fig. 2. Dependence of the number of taxa found in field (a) and sample area (b) on the number of fields studied in the Laihia preliminary study area.

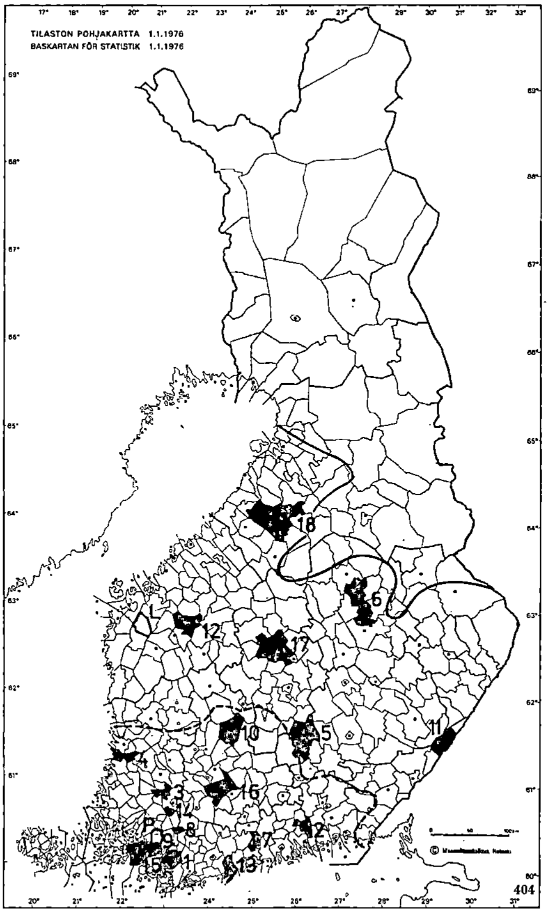

Fig. 3. Winter cereal survey regions. Numbers of regions in Table 2. Northern limit of winter wheat cultivation indicated by broken line and that of winter rye by unbroken line.

In the preliminary study in Paimio and Laihia, four 0,25 sq.m. sample areas were picked by random selection from each winter cereal field. For the herbicide spraying period, these were covered with 1,5 × 1,5 m plastic sheeting in fields subject to spraying. On 3—6 and 10—17 June 1969 the weed plants and shoots found in the sample areas were counted by species.

The preliminary study showed that a survey of the sample areas in 30 fields in Paimio and Laihia provided an adequate, overall picture of the composition of the weed flora. If the number of fields studied had been raised to 40, 4 more taxa would have been found in the sample areas (Figs. 1 and 2). This would only have raised the total number of taxa by 7 %, though the amount of work would have risen by around 30 %. For an analysis of the flora in the region, it proved better to study the entire flora in the fields while working there. Using this procedure, the number of taxa found in 30 Paimio fields rose 34 % and the number found in Laihia 30 %, but the amount of work involved did not even increase 1 % (Figs. 1 and 2). A survey of 30 fields was in fact adequate even for analysis of the entire flora of the regions covered by the preliminary study, for if the number of fields had been raised to 40, for instance, the number of taxa would only have risen by 5 species, i.e. 6 %, though the amount of work involved would have grown by around 20 %.

Table 1. Minimum number of fields (n) required in order for the number of units per m² of the taxa mentioned below to give a 95 % significant result in the preliminary study areas. The average number of plants or shoots /m² is given in column x̄.

Taxon	Paimio x̄	Paimio n	Laihia x̄	Laihia n
Achillea millefolium	0,2	67	1	30
Agropyron repens	8	49	8	20
Agrostis spp.	3	20	35	35
Capsella bursa-pastoris	6	19	0,5	103
Cerastium caespitosum	0,9	19	3	9
Chamaenerion angustifolium	—	—	2	23
Chenopodium album s. lat.	43	18	53	13
Equisetum arvense	3	22	0,2	56
Erysimum cheiranthoides	12	6	15	17
Fumaria officinalis	1	22	0,1	85
Galeopsis spp.	38	4	172	3
Galium vaillantii	2	24	0,2	48
Gnaphalium uliginosum	7	103	35	31
Lapsana communis	5	17	7	98
Leontodon autumnalis	0,5	89	0,6	25
Luzula spp.	0,1	61	3	22
Matricaria spp.	43	11	2	15
Myosotis arvensis	13	8	4	43
Myosurus minimus	21	24	1	31
Polygonum aviculare s. lat.	6	6	22	11
P. convolvulus	8	8	7	12
P. lapathifolium	2	69	20	18
Ranunculus repens	0,5	39	15	17
Rumex spp.	0,1	62	7	8
Scleranthus annuus	0,3	38	—	—
Sonchus asper	0,2	21	0,2	36
Spergula arvensis	5	44	57	13
Stellaria graminea	0,1	61	2	31
Stellaria media	62	28	5	15
Taraxacum spp.	2	36	3	50
Thlaspi arvense	0,9	28	0,8	21
Trifolium repens	3	11	5	12
Trifolium pratense	0,3	74	0,3	31
Urtica dioica	—	—	0,3	40
Veronica serpyllifolia	2	25	3	23
Viola arvensis	52	3	26	13
Vicia cracca	2	36	0,5	34

The minimum number of samples needed to attain a 95 % significance for the number of plants or shoots of the various taxa per sq.m. (Table 1) was also evaluated from the Paimio and Laihia data. According to the preliminary study, an average of 5 taxa would have been analyzed with 95 % significance if there had been 10 fields; 14 if there had been 20; 21 if there had been 30; and 27 if there had been 40. A level of about 20 taxa was considered adequate and thus the survey proper aimed at studying 30 fields in each region. In Paimio and Laihia, 12 of the 21 taxa were common to both.

On the basis of the preliminary study, a printed list was also drawn up of the 71 most common species and the 4 most common genera in which the plants are often difficult to identify by species.

2.2 The survey proper

2.2.1 The survey regions, research workers and research period

The scope of the actual survey was worked out on the basis of the time spent on the preliminary study and the resources available. The actual survey period was 1972—1974, and 18 regions were selected for study. The land area under winter cereals in the 1969 statistics was divided by the number of regions, which gave a range for the selection. The survey regions were then located in an agricultural centre area. The result was, the larger the land area under winter cereal belonging to an agricultural centre[1]), the more survey regions were located on it. The parishes to be studied were then picked by random selection from the 1969 municipal list of agricultural centres. Six of these survey regions were picked for study each year (Fig. 3, Table 2).

At least two experienced field workers were chosen for each survey region as follows: Kauko Aunola (2, 7, 13), Ritva Eskola (4, 9, 18), Mauri Haapanen (5, 10, 16), Terttu Haapanen (5, 10, 16), Tarmo Halinen (17), Heikki Hokkanen (7), Veikko Kauhanen (3, 8), Pirkko Matikainen (Laihia, 6, 11, 14), Päivi Mattila (17), Inkeri Mustonen (13), Heikki Niinimäki (12), Ossi Ojanen (15), Jorma Pietala (1), Lahja Pietiläinen (Paimio, Laihia, 6, 11, 14), Raimo Pohjanniemi (1), Mauri Pöntinen (12), Mikko Raatikainen (Paimio, Finnish lakeland), Terttu Raatikainen (Finnish lakeland, 2, 17), Tuija Terämaa (4, 9, 18), Timo Törmälä (12) and Matti Yli-Rekola (3, 8, 15).

[1]) In Finland, the term „agricultural centre" refers to the regional agricultural advisory areas, which are nearly the same as the administrative provinces of the country.

Table 2. Survey regions (see Fig. 3), early summer survey period 1, and the number of fields and farms.

No.	Region	Survey period	Number of fields	Number of farms
1	Perniö	3.— 7. VI 1972	30	12
2	Lapinjärvi	1.— 5. VI 1972	30	16
3	Alastaro	1.— 6. VI 1972	30	17
4	Luvia—Nakkila	3.— 8. VI 1972	27	22
5	Hartola—Joutsa	4.—11. VI 1972	32	27
6	Siilinjärvi—Lapinlahti	5.—13. VI 1972	28	22
7	Tuusula	4.— 8. VI 1973	30	17
8	Kuusjoki	4.— 8. VI 1973	30	17
9	Sauvo	4.— 8. VI 1973	29	14
10	Juupajoki—Orivesi	4.— 8. VI 1973	30	24
11	Parikkala—Saari	4.—15. VI 1973	30	26
12	Lapua	4.—10. VI 1973	27	22
13	Kirkkonummi	4.—10. VI 1974	31	11
14	Mellilä	4.—10. VI 1974	32	16
15	Parainen	3.— 8. VI 1974	31	12
16	Kalvola—Hattula	5.— 9. VI 1974	33	24
17	Saarijärvi—Äänekoski	6.—14. VI 1974	30	24
18	Oulainen—Haapavesi—Pulkkila	10.—18. VI 1974	30	23
			540	346

On survey farms where herbicide spraying was to be carried out, the team visited the farm for the first time as soon as the ground frost had melted, in April—May, to mark the sample areas and to distribute the plastic sheets which the owner or his representative then used to cover the sample area and its surroundings during spraying.

The empirical survey proper was made in early summer when the weeds had emerged and herbicide spraying was over (Table 2). The aim was to work at the same phenological time all over the country, so the southern regions were surveyed rather earlier than those in the north.

2.2.2 *The field research*

T h e q u e s t i o n n a i r e which was sent in late winter covered the arable area under winter cereal, and requested permission to make the survey. The questionnaire was sent to over 1 000 farms. On all farms with winter cereal the owners permitted the survey. Winter cereals were not, however, grown on all farms, especially in the northernmost regions.

T h e i n t e r v i e w s — some done during the spring rounds in April—May, but most not until the early summer rounds in June — asked the farm owner or his representative for the following general data:

- farm arable area (to the nearest 0,1 ha)
- number of winter cereal cultivation fields (a maximum of 5 fields were chosen for this survey, regardless of the number under cultivation).

The term 'field' was defined as part of a uniform winter cereal cultivation sown after the same crop and on the same kind of soil. If the cultivation had to be divided into several fields, the largest was chosen for the survey, though this had to be a minimum of 0,1 ha in area. The following details were requested for each field:

- field area to an exactitude of 0,1 ha (measurements taken if necessary)
- type of soil (coarse mineral-silt soil, clay soil, organogenic soil)
- drainage (open ditches, subsurface drainage, no drainage)
- soil humidity (dry, average, wet)
- number of times combine-harvested in the last 10 years
- number of herbicide sprayings in the last 10 years

— age of the field in arable use
— distance of the field from the farm buildings by road or track
— plants cultivated in the four previous years
— winter cereal sowing date
— variety of winter cereal
— quantity of winter cereal seed in kg/ha
— clover and/or grasses undersown (no, yes)
— chemical treatment of winter cereal seed (no, yes; chemical)
— fungicide spraying against overwintering parasitic fungi (no, yes; fungicide)
— insecticide spraying (no, yes; insecticide)
— herbicide spraying (no, yes)
— date of herbicide spraying
— commercial preparation used for herbicide spraying
— amount of preparation used for herbicide spraying (l/ha or kg/ha)
— herbicide spraying method used (on tractor, on cart, carried)
— volume of water used for herbicide spraying in l/ha
— store fertilizing of the field in autumn
  — animal manure (no, yes; tons/ha)
  — other fertilizer (no, yes; fertilizer and amounts used in kg/ha, from which the amount of the various nutrients were calculated)
— winter fertilizing (no, yes; fertilizer and amount kg/ha)
— spring fertilizing (no, yes; fertilizer and amount kg/ha)
— use of growth regulator to prevent lodging (no, yes; commercial preparation and amount in l/ha).

The empirical survey was begun during the spring rounds, but was not seriously embarked upon until the rounds of the early summer. In this survey many of the data obtained from the interviews were checked on the spot; a map was drawn of the field and four circular 0,25 m² sample areas at least 2 m from the edge of the field or the bank of an open ditch were marked out in the field, using randomly selected figures. A stick was set up in the middle of the sample area, which the farmer or his representative removed for the herbicide spraying period, covering the sample area and its surroundings with the thick 1,5 × 1,5 m plastic sheet provided by the field workers (Fig. 4). The sheet was held down with stones or lumps of earth. The plastic was removed after spraying and the stick replaced in the hole.

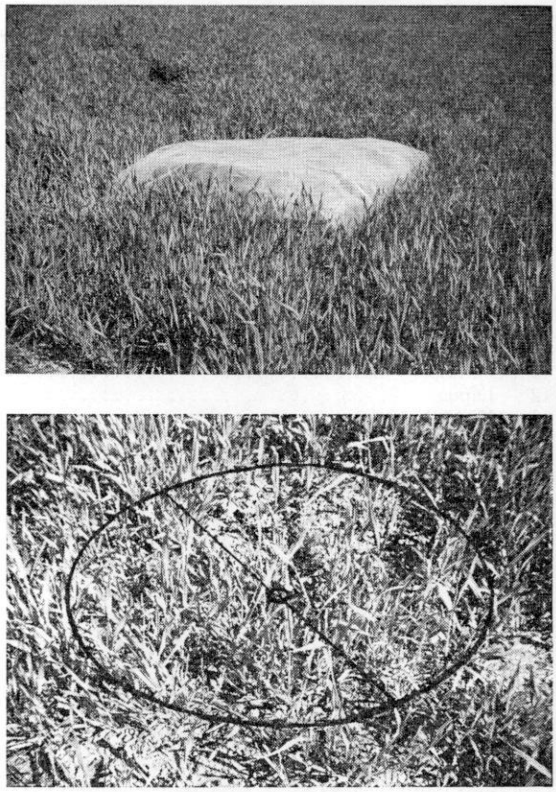

Fig. 4. The 0,25 m² metal circle used to delineate the sample area and the plastic sheeting used to cover it during herbicide spraying.

During the spring rounds, 35 winter cereal fields were taken for survey in each region, so that following any failures there would still be 32 fields for survey in the early summer, and again, following any failures, 30 would remain in the late summer, to be reported on in later publications. If there were even more failures, the superfluous ones were eliminated, giving a final number of fields of 27—33 per region (Table 2). The total number of fields surveyed was 540, with a surface area of 864 ha, which represents 0,8 % of the country's total winter cereal area. There were 346 farms in the final study, and on these farms an average of 1,6 winter cereal fields were studied.

The empirical survey was made on 1—18 June, in 1972—74 (Table 2). The following were then recorded:

- — the height of cereal stand, measuring it up to the top of the main shoot
- — the cereal percentage cover on four 0,25 m^2 sample areas
- — the total percentage cover of weeds on four 0,25 m^2 sample areas
- — the number of seedlings or shoots of phanerogam species (e.g. *Agrostis*, *Equisetum*) or, in some cases, genera (*Agrostis*, *Galeopsis*, *Luzula*, *Matricaria*) in four 0,25 m^2 sample areas. The nomenclature used was that of Lid (1963) to make for easier comparison with earlier studies in the series (Mukula et al. 1969 and M. Raatikainen and T. Raatikainen 1975)
- — the phanerogam species growing on the field but not round its edges. This list was usually made while the two field workers were studying the sample areas and taking samples from the field.

The questionnaire, interview and empirical survey were usually successful. The greatest failure was in region 1, for which no individual plant density findings are available.

2.3 Mathematical analysis

To work out the weed flora with sufficient accuracy, a species area curve (e.g. Mueller-Dombois and Ellenberg 1974) was used to determine the minimum number of fields to be surveyed. To work out the number of plants or shoots of the various species per sq.m with sufficient accuracy in the different regions, the Snedecor (1965) size-of-sample formula was used.

In making the regional breakdown on a phytogeographical basis, the Sørensen (1948) quotient of similarity method was used, applied as follows:

$$QS = 100 \frac{\Sigma 2c}{\Sigma(a + b)}, \text{ where}$$

a = number of individuals of the species in the sample areas in region 1
b = number of individuals of the same species in sample areas in region 2
c = the lower of these two figures

To make the regional breakdown, the 102 most common taxa out of a possible 190 were used, as not all the taxa could be data-processed for reasons of economy.

3. RESULTS

3.1 Flora and frequency of species

In the 540 winter cereal fields studied, at least 190 phanerogam taxa were found (Table 3). If the 86 winter cereal fields in the preliminary study areas of Paimio and Laihia are also included, at least 191 phanerogam taxa were found in the winter cereal fields. The species occurring in the sample areas were registered most carefully in all the survey regions. Outside these areas, the differences in population size of the species were registered with different accuracies in different regions. In the best surveyed regions, 21—41 taxa which occurred outside the sample areas were registered; in average-good regions 10—19 and in poor regions 2—10. 16,8 such taxa were recorded on average. The species outside the sample areas raised the number of taxa in the regions to 23 (5—91 %).

The number of taxa registered in both the fields and the sample areas was highest in eastern Finland and decreased towards the south and west (Fig. 5), where the figures were 61 % and 81 % of the totals from eastern Finland. Several factors probably caused this higher number of species in winter cereal cultivations in eastern Finland: 1) several species have spread into Finland from the southeast and east, 2) the pH of

Table 3. The frequency percentage of weed taxa in Paimio (P) and Laihia (L), and in the regions (1—18), sections (I—II) and the whole country (C). For the number of regions cf. Fig. 3 and Table 2.

Taxon	1969		1972						1973						1974						1972—1974		
	P	L	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	I	II	C
Achillea millefolium	42	53	—	37	20	30	91	86	20	23	17	70	73	11	6	34	39	9	77	40	25	63	38
A. ptarmica	16	21	3	—	30	19	47	64	3	20	—	20	40	44	—	16	3	—	33	27	10	43	20
Aegopodium podagraria	2	—	—	—	—	—	28	—	3	—	—	7	7	—	—	—	3	3	—	3	1	6	3
Agropyron repens	51	47	33	40	13	74	53	54	17	13	28	40	93	59	6	19	55	39	13	40	31	52	38
Agrostis spp.	30	60	3	10	13	78	63	82	27	20	17	67	53	100	—	44	3	—	13	47	23	60	35
Alchemilla vulgaris coll.	2	—	—	3	—	—	19	21	3	—	—	3	20	—	—	—	—	3	7	—	1	11	4
Alopecurus aequalis	7	2	—	—	3	44	—	—	7	—	7	—	—	—	—	3	—	—	—	3	5	+	4
A. geniculatus	19	9	—	—	—	—	6	43	—	27	—	20	—	19	—	38	19	3	—	3	9	12	10
A. pratensis	5	5	—	—	3	4	9	—	—	27	3	—	—	4	—	—	3	—	—	—	3	2	3
Alopecurus spp.	—	—	—	—	27	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	1
Anemone nemorosa	2	—	—	3	6	—	—	—	—	3	—	—	—	—	—	6	—	—	—	—	2	—	1
Angelica silvestris	2	—	—	—	3	—	9	—	—	3	—	7	3	—	—	—	—	—	—	—	1	2	1
Anthemis spp.	—	—	—	—	10	4	—	—	—	10	—	13	—	—	—	25	3	—	—	—	5	—	4
Anthricus silvestris	2	21	—	—	13	—	25	7	—	10	3	13	17	4	—	3	23	3	7	3	6	10	7
Arabidopsis thaliana	9	—	—	—	3	4	3	39	—	13	—	23	3	—	—	—	3	—	—	—	4	8	5
Artemisia vulgaris	—	—	—	—	—	—	6	4	—	—	—	3	—	—	—	—	6	12	3	—	2	2	2
Atriplex patula	—	—	—	—	—	4	—	—	7	3	—	—	—	—	—	22	16	3	—	—	5	—	3
Atriplex spp.	7	—	—	—	—	7	9	—	—	—	—	—	—	—	—	3	23	—	—	—	3	2	2
Barbarea vulgaris	—	—	3	3	3	4	3	18	—	—	—	23	3	7	—	6	3	—	3	—	4	6	4
Betula spp.	—	—	—	—	—	52	3	18	—	—	—	7	—	—	—	3	—	6	—	—	6	4	4
Bidens tripartita	—	—	—	—	—	—	—	—	—	3	—	—	—	4	—	3	3	3	—	7	1	2	1
Brassica campestris	14	—	—	—	3	15	6	—	10	10	10	20	—	—	3	3	6	—	—	—	7	1	5
Brassica spp.	—	—	—	—	—	—	—	—	—	—	—	—	7	—	—	16	—	—	—	—	1	1	1
Bromus sp.	—	—	—	—	—	—	—	29	—	—	—	—	—	—	—	3	—	—	—	3	+	5	2
Calamagrostis spp.	—	—	—	—	—	—	—	—	10	—	—	—	—	—	—	—	3	3	—	—	1	—	1
Campanula patula	—	—	—	—	—	—	—	4	—	—	—	—	—	4	—	—	—	—	—	—	—	1	+
Campanula spp.	—	—	—	—	—	—	—	—	—	—	—	—	3	—	—	—	—	—	—	—	—	1	+
Capsella bursa-pastoris	63	26	20	63	47	30	50	57	40	63	69	70	50	—	68	44	58	45	17	27	51	33	46
Cardaminopsis suecica	—	—	—	—	3	—	3	—	—	—	—	—	—	7	—	9	3	—	—	—	1	2	1
Carex spp.	—	—	—	—	—	—	—	32	—	—	—	—	23	—	—	—	—	9	—	—	1	9	4
Carum carvi	—	—	—	—	—	—	—	4	—	13	—	—	—	—	—	3	—	—	—	—	1	1	1
Centaurea cyanus	37	—	20	17	27	15	44	36	3	17	21	23	53	4	13	31	6	15	17	7	17	27	21
Cerastium arvense	—	—	—	—	—	—	—	7	—	—	—	—	3	—	—	—	—	—	—	—	—	2	1
C. caespitosum	37	67	—	50	30	41	63	82	13	57	24	73	77	59	—	53	23	12	43	23	31	58	40
Chamaenerion angustifolium	5	67	—	—	13	26	25	46	—	3	3	10	13	19	—	9	3	9	17	60	6	30	14
Chenopodium album s. lat.	98	88	87	93	97	100	91	79	80	93	79	83	87	81	81	97	100	97	80	97	91	86	89
C. polyspermum	—	—	—	—	—	—	—	—	—	—	—	—	—	—	6	—	29	6	—	—	3	—	2
Chrysanthemum leucanthemum s. lat.	2	2	—	—	3	—	—	14	—	—	7	—	13	—	—	3	3	—	10	10	1	8	4
C. vulgare	—	—	—	—	—	—	—	4	—	—	—	—	7	—	—	—	—	—	—	—	—	2	1
Cirsium arvense	51	19	30	40	73	26	41	50	17	80	31	27	37	19	6	81	77	39	7	3	44	26	38
C. heterophyllum	—	—	—	—	—	—	—	18	—	—	—	—	13	—	—	—	—	—	—	—	—	5	2
Crepis tectorum	—	—	—	—	—	—	3	—	—	—	—	—	3	4	—	—	—	—	—	—	—	2	1
Dactylis glomerata	—	2	—	—	3	—	—	7	—	3	—	3	—	4	—	3	3	—	3	—	1	2	2
Deschampsia caespitosa	—	—	7	—	—	4	16	46	10	—	—	7	10	26	—	3	—	—	20	10	3	21	9
Epilobium montanum	12	28	—	—	—	—	13	4	—	—	—	—	—	—	—	—	—	—	3	—	—	3	1
E. palustre	—	2	—	—	—	—	—	32	—	—	—	—	7	—	—	—	—	—	—	7	—	8	2
Equisetum arvense	77	35	33	57	83	56	56	54	53	73	66	43	53	41	23	66	84	21	23	27	55	42	51
E. palustre	7	2	7	7	10	—	3	18	7	27	—	3	10	—	—	13	3	—	—	—	6	5	6
E. silvaticum	23	16	—	13	27	—	28	57	30	33	7	40	13	4	—	31	16	3	27	3	17	22	19
Erophila verna	16	—	—	—	7	—	3	—	—	10	3	—	—	—	—	—	3	6	10	—	2	2	2
Erysimum cheiranthoides	93	74	10	97	90	81	84	86	93	93	90	97	90	85	—	88	77	76	73	57	74	79	76
Festuca rubra	—	—	—	—	3	7	—	14	3	10	—	7	7	11	—	13	3	—	—	—	4	5	4
F. pratensis	—	—	—	7	—	—	—	7	—	—	—	7	23	7	—	6	3	—	—	—	2	6	3
Festuca spp.	—	—	—	—	3	—	—	25	—	—	—	—	7	—	—	6	3	—	10	—	1	7	3
Filipendula ulmaria	7	2	—	3	13	4	—	25	—	3	—	3	7	7	—	6	10	—	13	7	4	10	6
Fumaria officinalis	40	9	7	27	20	11	13	14	30	27	28	10	10	7	32	56	65	30	23	3	28	12	23
Gagea minima	—	—	—	—	—	—	—	—	—	—	—	3	—	—	—	—	—	—	3	—	+	1	+
Galeopsis bifida	—	—	—	3	—	7	—	11	3	—	—	67	17	—	—	91	23	15	7	7	17	7	14
G. speciosa	—	—	13	—	—	89	66	4	—	—	—	83	—	4	—	78	23	6	—	3	24	13	21
Galeopsis spp.	98	100	60	97	97	4	97	100	100	100	93	80	90	96	87	97	94	97	100	90	84	96	88
Galium palustre	—	12	—	—	—	4	3	11	—	—	—	—	7	—	—	3	—	—	—	13	1	6	2

Taxon	1969		1972						1973						1974						1972—1974		
	P	L	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	I	II	C
G. uliginosum	—	—	—	—	—	4	9	—	—	—	—	—	—	—	3	3	—	—	3	—	1	2	1
G. vaillantii	56	14	13	53	17	7	6	7	43	60	59	3	33	—	—	6	71	24	—	7	30	9	23
Galium spp.	—	5	—	3	—	4	—	—	7	—	3	—	3	—	6	3	—	—	—	—	2	1	2
Gnaphalium uliginosum	23	74	3	3	57	74	44	61	40	23	17	70	57	48	—	13	13	15	27	60	27	49	34
Heracleum sibiricum	—	—	—	—	—	—	6	18	—	—	—	—	—	—	—	—	—	—	—	—	—	4	1
Hieracium spp.	2	7	—	—	17	11	—	25	—	10	—	—	14	22	—	—	—	—	—	—	3	10	5
Hypericum maculatum	—	—	—	3	—	—	3	—	—	—	—	—	3	—	—	3	6	—	—	—	1	1	1
Juncus bufonius	—	—	—	—	—	—	3	14	—	—	—	30	13	11	—	3	—	3	—	3	3	8	4
Knautia arvensis	—	—	—	—	—	—	9	—	—	—	—	—	20	—	—	—	—	—	—	—	—	5	2
Lamium hybridum	19	—	—	10	—	—	3	—	7	13	48	3	—	—	3	3	55	9	3	—	13	2	9
L. purpureum	16	—	3	20	3	4	6	—	17	23	28	3	—	—	16	6	77	15	3	—	18	2	13
Lapsana communis	72	5	33	80	43	30	88	29	80	70	62	50	90	—	65	25	84	70	43	—	58	42	53
Lathyrys pratensis	21	7	—	17	47	7	6	18	—	20	—	3	23	7	—	34	19	3	3	10	13	11	12
Leontodon autumnalis	9	28	7	—	7	15	13	82	—	3	3	7	20	26	—	16	3	3	30	33	5	34	14
Linaria vulgaris	—	—	—	—	—	—	—	4	7	—	—	3	—	—	—	—	13	—	—	—	2	1	1
Lolium spp.	—	—	—	—	—	—	—	4	—	—	—	—	3	—	—	—	—	—	—	—	—	1	+
Luzula spp.	5	47	—	—	—	—	—	18	—	—	—	—	7	22	3	—	—	—	—	—	+	8	3
Matricaria spp.	95	77	97	93	97	85	47	86	90	97	97	83	70	56	68	100	100	64	73	90	89	70	83
Mentha arvensis	—	—	—	—	—	4	—	—	—	—	—	—	—	—	—	—	—	—	—	3	+	1	+
Myosotis arvensis	91	42	37	83	70	56	84	79	63	87	83	87	90	52	42	69	74	64	63	63	68	72	69
M. stricta	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3	3	—	—	1	—	+
Myosurus minimus	60	21	70	17	47	44	19	46	17	20	62	47	17	30	16	16	48	24	7	13	36	22	31
Phleum pratense	21	9	—	17	—	4	47	89	—	13	—	63	47	59	—	56	19	3	37	40	16	52	29
Phragmites communis	—	—	—	—	—	—	—	—	—	—	3	—	—	—	—	3	6	—	—	—	1	—	1
Pimpinella saxifraga	—	—	—	—	—	—	3	—	—	—	—	—	3	—	—	—	—	—	—	—	—	1	+
Plantago major	14	23	—	—	—	—	9	36	—	—	—	7	—	4	3	6	32	—	13	3	4	11	6
Plantago spp.	—	—	—	—	—	—	—	—	—	—	7	—	3	—	—	—	—	—	—	—	1	1	1
Poa annua	9	2	—	—	13	—	31	32	—	10	—	20	20	4	—	3	10	3	3	—	5	15	8
P. pratensis s. lat.	—	23	—	43	7	19	81	86	13	23	7	53	57	78	3	38	29	18	37	50	21	65	35
P. trivialis	—	—	—	—	—	—	84	39	—	7	31	90	33	—	—	6	—	6	—	7	12	27	17
Poa spp.	47	56	—	3	13	19	—	7	—	20	21	—	—	—	—	6	29	—	7	—	9	2	7
Polygonum aviculare s. lat.	86	98	80	80	80	96	66	75	87	80	72	77	60	81	84	88	90	82	53	47	83	64	76
P. convolvulus	84	84	63	73	53	56	66	46	77	87	86	33	80	33	74	84	94	67	20	40	71	48	63
P. hydropiper	—	—	—	—	7	—	13	11	3	7	—	30	37	—	—	9	3	9	—	—	6	10	7
P. lapathifolium	28	91	—	23	—	48	34	61	37	20	—	17	60	56	—	50	45	9	30	70	21	52	31
Potentilla anserina	—	—	—	—	—	7	—	—	—	10	—	—	—	—	—	—	3	—	—	—	2	—	1
P. erecta	—	—	—	—	—	—	3	4	—	—	—	—	—	4	—	—	—	—	—	—	—	2	1
P. norvegica	—	—	—	—	—	—	16	36	—	—	—	—	—	11	—	—	—	—	—	—	—	10	3
Potentilla spp.	—	—	—	3	—	—	—	4	—	—	—	—	—	—	—	—	3	—	—	—	1	1	1
Prunella vulgaris	—	5	—	—	—	—	6	25	—	—	—	—	13	—	—	3	—	—	—	—	+	7	3
Ranunculus acris s. lat.	—	26	—	3	3	7	28	57	—	7	—	33	33	15	3	3	3	—	—	13	5	24	11
R. auricomus coll.	5	19	—	7	3	26	34	54	13	—	—	43	27	—	—	—	—	6	3	7	9	21	12
R. repens	42	79	7	40	46	22	91	96	53	37	41	57	77	78	16	50	68	9	63	80	37	87	51
Raphanus raphanistrum	—	—	3	3	3	15	56	7	—	3	—	10	—	—	3	9	19	9	7	3	7	12	9
Rhinanthus minor	—	—	—	—	—	—	—	—	—	—	—	3	3	—	—	—	—	—	—	—	+	1	1
Rorippa palustris	—	16	—	—	—	—	—	11	—	3	—	—	10	7	—	9	—	—	—	20	1	8	3
Rubus arcticus	—	14	—	—	—	—	9	—	—	—	—	—	3	4	—	9	—	—	—	3	1	5	2
Rumex acetosa s. lat.	—	30	—	7	7	48	38	54	—	—	—	3	13	19	—	38	—	—	10	37	9	28	15
R. acetosella s. lat.	14	9	—	—	3	4	59	89	3	10	3	20	57	74	3	6	6	3	13	27	5	53	21
R. longifolius	7	33	—	—	—	4	25	57	—	13	—	10	3	11	—	13	10	—	7	10	4	18	8
Rumex spp., sorrels	—	—	—	—	6	—	—	—	—	3	—	—	—	—	—	—	10	—	—	—	2	—	1
Sagina procumbens	7	16	—	10	—	—	34	39	27	13	—	67	40	52	—	6	—	6	—	—	11	27	16
Salix spp.	—	—	—	—	3	—	—	11	—	—	—	—	—	—	—	—	—	—	—	—	+	2	1
Scleranthus annuus	19	—	—	—	10	—	6	7	—	20	7	10	17	—	—	19	3	—	—	—	6	5	6
Scutellaria galericulata	—	—	—	—	—	—	—	4	—	—	—	—	—	—	—	—	—	—	3	7	—	2	1
Secale cereale	2	14	7	10	30	—	—	—	—	87	—	13	—	—	—	3	16	—	—	—	14	—	9
Senecio vulgaris	—	—	—	—	—	—	—	—	—	—	3	—	—	—	—	—	6	—	—	—	1	—	1
Sonchus arvensis	30	9	17	27	33	7	13	29	27	37	3	17	30	—	10	34	87	18	3	—	27	12	22
S. asper	16	14	—	—	—	—	—	—	—	—	—	—	—	—	—	—	90	3	3	—	8	1	6
Spergula arvensis	30	79	17	7	17	56	47	43	50	10	—	50	33	44	19	53	23	6	37	57	26	43	31
Stachys palustris	—	—	—	3	—	—	6	4	3	—	3	—	3	—	3	—	6	—	—	—	2	2	2
Stellaria graminea	5	30	—	7	—	—	3	25	—	7	3	7	10	22	3	13	3	—	7	7	4	12	6
S. media	93	70	43	63	63	78	94	68	90	83	100	63	77	52	61	81	94	73	53	77	74	70	73
Taraxacum spp.	47	33	33	70	67	44	78	89	20	83	21	50	57	33	6	78	61	24	50	30	47	56	50
Thlaspi arvense	37	26	27	33	40	63	47	46	3	33	3	17	33	26	3	25	45	39	7	23	28	30	29
Trifolium hybridum	5	2	—	—	—	—	3	—	60	—	3	—	—	—	3	—	—	—	—	3	6	1	4

Taxon	1969		1972						1973						1974						1972—1974		
	P	L	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	I	II	C
T. pratense	14	14	3	10	—	11	3	25	—	20	—	7	3	15	16	19	23	9	13	3	11	10	11
T. repens	67	65	13	30	43	67	25	75	3	60	38	43	50	56	6	50	35	6	33	57	33	49	38
Trifolium spp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	6	10	—	—	—	1	—	1
Tussilago farfara	30	—	—	10	30	15	16	18	3	40	3	7	13	—	—	38	26	15	3	—	16	8	13
Urtica dioica	—	9	—	—	—	—	9	11	—	3	3	10	—	—	—	3	—	—	3	—	2	4	2
Veronica agrestis	—	—	—	—	—	—	—	—	—	—	—	27	—	—	—	—	—	3	—	—	2	—	2
V. arvensis	—	5	—	—	—	—	3	—	—	47	10	—	17	—	—	16	6	—	3	—	7	4	6
V. chamaedrys	40	5	10	33	3	22	9	32	10	7	3	13	3	—	3	—	—	—	3	7	9	9	9
V. serpyllifolia	35	47	7	23	—	26	72	86	60	47	28	90	53	48	—	31	10	18	30	13	28	50	35
V. verna	—	—	—	—	—	—	13	14	—	—	—	7	27	—	—	—	—	—	—	—	+	9	3
Veronica spp.	—	—	—	—	—	—	—	7	—	—	—	—	—	—	—	6	10	—	—	—	—	2	1
Vicia cracca	23	26	3	3	17	19	9	36	13	17	14	7	30	19	3	22	6	9	10	—	11	17	13
V. hirsuta	12	5	—	—	—	—	—	11	—	—	17	17	40	—	—	9	26	—	—	3	6	10	7
V. sepium	—	—	—	—	—	—	3	21	7	—	—	3	23	—	—	3	—	—	—	17	1	11	4
Vicia spp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	6	3	—	—	1	—	1
Viola arvensis	98	81	57	97	83	81	97	89	100	97	97	93	100	78	84	100	94	91	87	70	89	87	89
V. palustris	—	12	—	3	—	—	6	14	7	—	3	—	10	—	—	—	—	—	—	10	1	7	3
V. tricolor	—	—	—	—	—	—	3	—	—	—	—	—	37	—	—	—	—	—	—	—	—	7	2
V. riviniana	—	—	—	—	—	4	—	4	—	—	—	—	—	—	—	3	—	—	—	—	1	1	1
Undetermined dicotyledons	—	—	3	17	100	4	72	29	23	100	7	43	40	15	55	6	87	9	7	13	38	29	35
Undetermined monocotyledons	—	—	—	—	73	—	—	4	33	33	—	—	20	—	10	—	6	—	7	3	13	6	11

Frequencies of the taxa found in one region ( ) only:
(P) *Arctium* sp. 2, *Cerastium* sp. 5
(1) *Acer platanoides* 3
(2) *Viola montana* 7
(3) *Alnus incana* 3, *Populus tremula* 3, *Rubus saxatilis* 3
(4) *Campanula rotundifolia* 4, *Solidago virgaurea* 4
(5) *Campanula glomerata* 3, *Carex nigra* 3, *Deschampsia flexuosa* 3, *Melampyrum* sp. 3, *Ranunculus polyanthemos* 3, *Rhinanthus* spp. 9, *Ribes rubrum* 3, *Succisa pratensis* 6, *Vicia tetrasperma* 16
(6) *Cirsium palustre* 4, *Comarum palustre* 4, *Dryopteris spinulosa* 4, *Euphrasia brevipila* 4, *Geum rivale* 25, *Maianthemum bifolium* 7, *Oxalis acetosella* 4, *Picea abies* 7, *Trientalis europaea* 4
(7) *Brassica rapa* 10, *Festuca ovina* 3
(8) *Arenaria serpyllifolia* 3, *Fragaria vesca* 3, *Medicago sativa* 7, *Triticum aestivum* 3
(10) *Galeopsis ladanum* 3, *Thalictrum* sp. 3
(11) *Anthoxanthum odoratum* 17, *Convolvulus arvensis* 3, *Equisetum fluviatile* 3, *Glechoma hederacea* 3, *Juncus filiformis* 3, *Juncus* spp. 7, *Lysimachia vulgaris* 7, *Moehringia trinervia* 10, *Pinus silvestris* 10, *Potentilla argentea* 3
(12) *Callitriche* sp. 3, *Ranunculus flammula* 7
(14) *Daucus carota* 3, *Silene cucubalus* 6
(15) *Arabidopsis thaliana* 3, *Avena fatua* 3, *Corydalis solida* 3, *Sonchus oleraceus* 6
(17) *Caltha palustris* 3
(18) *Lathyrys palustris* 3, *Poa palustris* 3

the soil is higher in the east than in the west, 3) the land has been above water level longer in the east, 4) the variation in habitat is greatest in the east, 5) less time has passed since burning-over in the east, 6) cultivation patterns are smaller in the east than in the west, so that species in close plant stand types usually occur in winter cereal, and 7) herbicides have been used for a shorter time and in smaller quantities in the east. The last-mentioned factor is probably the most important element in reducing the number of species in the west.

Many of the weeds growing in winter cereals are species which germinate in the autumn, like winter cereals, and overwinter in the seedling stage (Table 4). Some individuals of plants that germinate in autumn die during the winter. Of the most common species, those that fit best into this rhythm include *Bromus secalinus*, *Capsella bursa-pastoris*, *Centaurea cyanus*, *Galium vaillantii*, *Lamium hybridum*, *L. purpureum*, *Lapsana communis*, *Myosotis arvensis*, *Thlaspi arvense*, *Tri-*

Table 4. Frequency classification of weed taxa occurring among winter cereals.

Frequency	%	Annuals	Winter annuals	Biennials	Perennials	Total
Very frequent	65—100	3	4	—	—	7
Frequent	33— 64	3	2	—	10	15
Fairly frequent	17— 32	5	3	—	6	14
Scattered	9— 16	4	3	—	11	18
Fairly rare	5— 8	4	4	1	6	15
Rare	3— 4	4	4	1	11	20
Very rare	+— 2	8	12	4	67	91
Total		31	32	6	111	180

pleurospermum inodorum and *Viola arvensis*. Many other species, too, such as *Stellaria media*, germinate in the autumn, but most individuals die during the winter. Individuals of all the species germinating in the autumn also germinate in the spring, but these individuals remain small in size, produce less seeds and, in fact often die because the winter cereals — especially rye and other competing plants — strangle them.

Many plants classified as annuals also germinate in the autumn. These include *Galeopsis bifida*, *G. speciosa* and *Spergula arvensis*, but their seedlings die in the winter and in the spring new individuals germinate and develop rapidly. The individuals of several species of this kind remain small in size, however, and even die, especially in rye stands. The individuals of other, e.g. *Galeopsis*, species are able to compete quite well with cereal stands however. Annuals can thus be harmful winter cereal weeds, though they are not usually as harmful as winter annuals.

The biennials *Anthriscus silvestris*, *Barbarea vulgaris* and *Erophila verna* have very little importance in winter cereal cultivation. These species are unable to grow in winter cereals as biennials, only as winter annuals. In this case they are small in size and not harmful.

Perennials play the main role in winter cereals (Table 4). Of these, the seeds of many species, such as *Dactylis glomerata*, *Festuca pratensis*, *F. rubra*, *Luzula multiflora*, *Phleum pratense*, *Poa pratensis*, *P. trivialis*, *Ranunculus repens*, *Rumex acetosa*, *R. acetosella*, *Trifolium pratense* and *T. repens* germinate either in the autumn or in the spring, and the individuals are small in size. However, because they resist shading and competition they do quite well among winter cereals. Several individuals of these species can be older plants which have survived tilling and they may become large plants that compete with the cereal. Seedlings and older individuals of *Phleum pratense* and *Trifolium pratense* were recorded in 1973 and 1974 in all the fields. It was then found that both seedlings and older individuals of *P. pratense* occurred on 10 % of the fields. There were *T. pratense* seedlings on 7 % of the fields, but older plants only on 3 %. Though the percentages are small, they show the trend very clearly.

There are also perennials in winter cereals, occurring mainly in the form of individuals above one year old. These include, *Achillea millefolium*, *A. ptarmica*, *Aegopodium podagraria*, *Agropyron repens*, *Chamaenerion angustifolium*, *Equisetum arvense*, *E. palustre*, *E. silvaticum*, *Filipendula ulmaria*, *Lathyrus pratensis*, *Sonchus arvensis*, *Stellaria graminea*, *Taraxacum* spp., *Tussilago farfara*, *Urtica dioica*, *Vicia cracca* and *Vicia sepium*. Some of these, e.g. *Agropyron repens* and *Sonchus arvensis*, are very harmful weeds. However, perennials are not as common as the winter annuals and annuals that have adjusted best to winter cereal cultivations.

3.2 Density

Table 5 shows the number of plants or shoots of taxa per square metre found in the sample areas in southwest Finland, mid-Finland and the country as a whole. In this sub-division, regions 2—4, 7—10 and 13—16 are counted as southwest Finland and regions 5, 6, 11, 12, 17 and 18 as mid-Finland. At least 102 taxa of the 190 taxa identified in winter cereal cultivations (Table 3) were in the sample areas. The others were either so rare or, as in some cases, the sample areas included such young individuals that it was impossible to identify even their genus. The number of individuals and shoots not identified — 11,05 per m² — was only 3,9 % of the total individuals and shoots occurring in the sample areas (i.e. 285,90 per m²). Most — 92,9 % — of those not identified were young dicotyledon seedlings, and the bulk of these — 57 % — were in the mid-Finland zone, though only 34,7 % of the sample areas were in this zone. This primarily indicates that the plants in the more northerly zone had not grown big enough to be identified (as they had in the more southerly zone) by the census stage. This finding was endorsed in July—August, when another visit was made to identify the plants in all the sample areas.

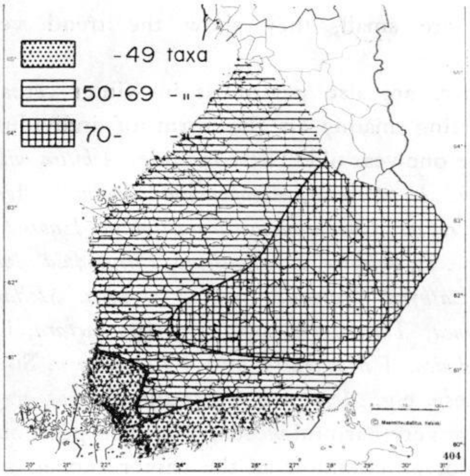

Fig. 5. Number of taxa occurring in all sample areas of the survey regions for various parts of the area of winter cereal cultivation.

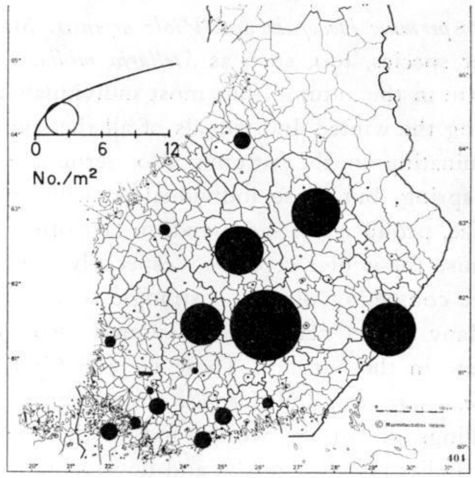

Fig. 6. *Achillea millefolium.*

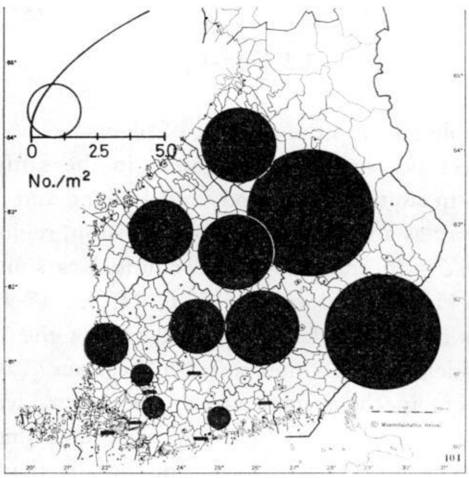

Fig. 7. *Achillea ptarmica.*

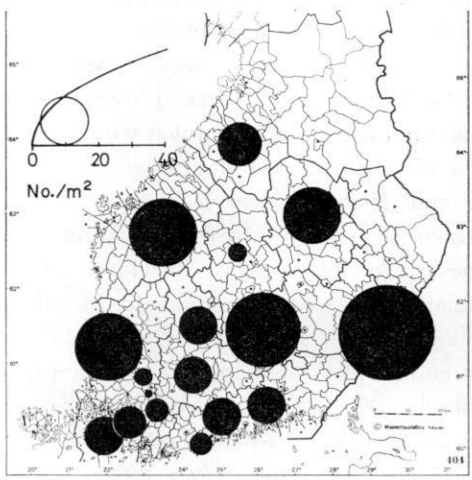

Fig. 8. *Agropyron repens.*

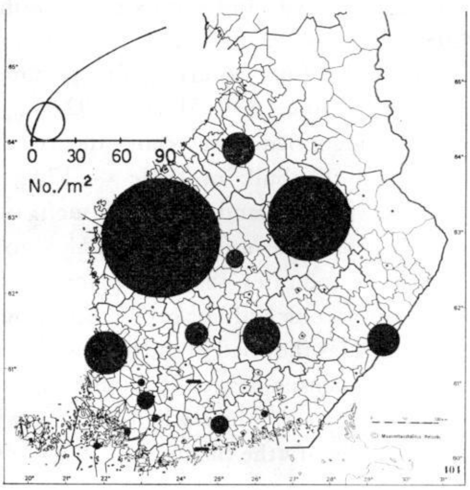

Fig. 9. *Agrostis* spp.

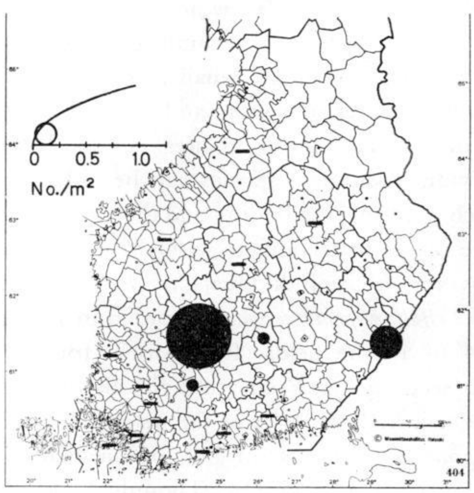

Fig. 10. *Alchemilla vulgaris.*

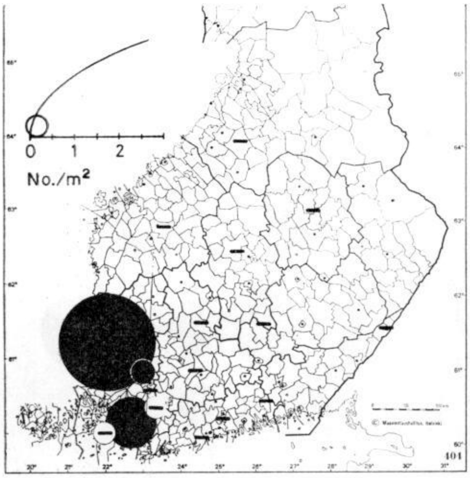

Fig. 11. *Alopecurus aequalis.*

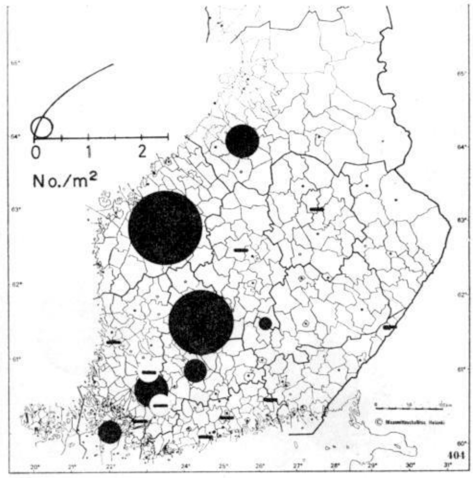

Fig. 12. *Alopecurus geniculatus.*

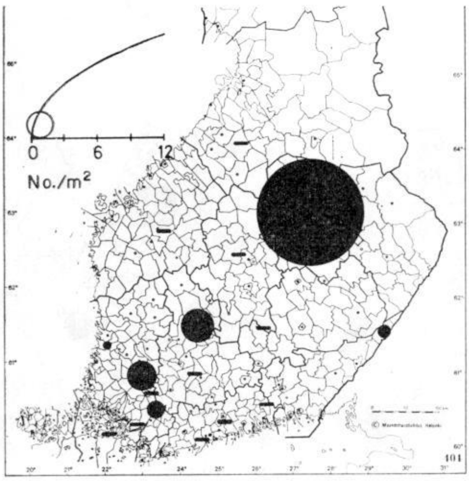

Fig. 13. *Arabidopsis thaliana.*

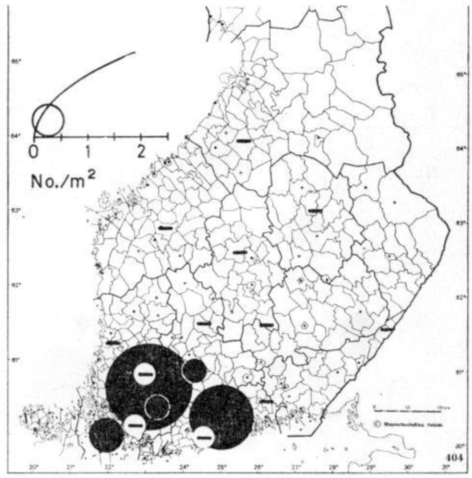

Fig. 14. *Atriplex patula.*

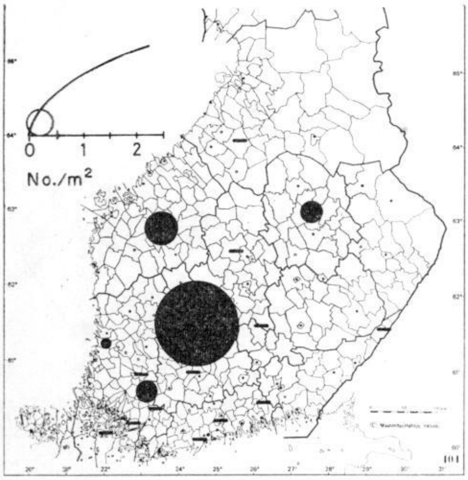

Fig. 15. *Barbarea vulgaris.*

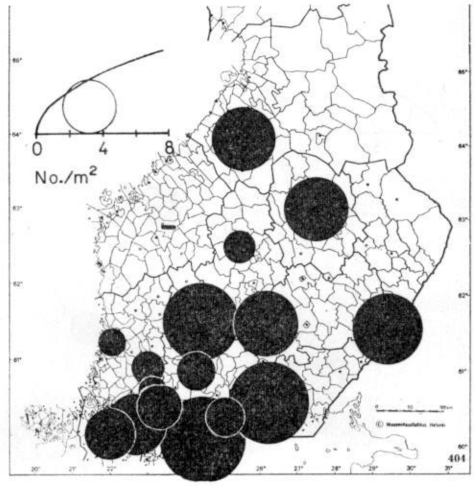

Fig. 16. *Capsella bursa-pastoris.*

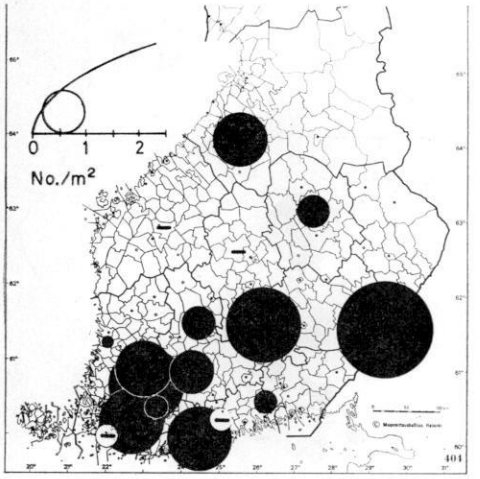

Fig. 17. *Centaurea cyanus.*

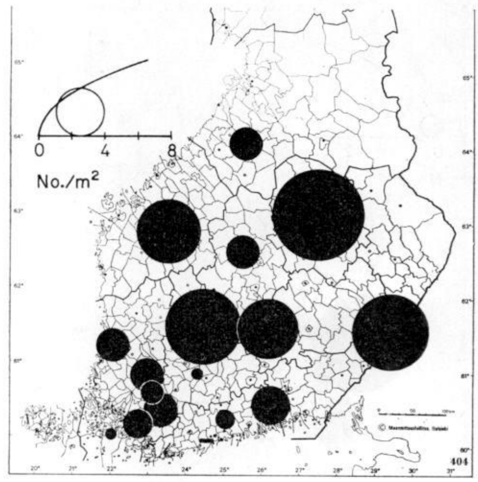

Fig. 18. *Cerastium caespitosum.*

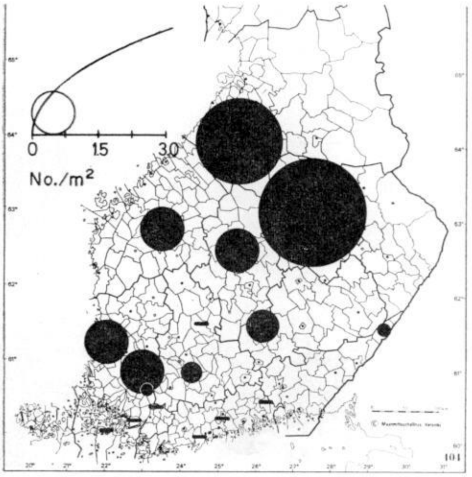

Fig. 19. *Chamaenerion angustifolium.*

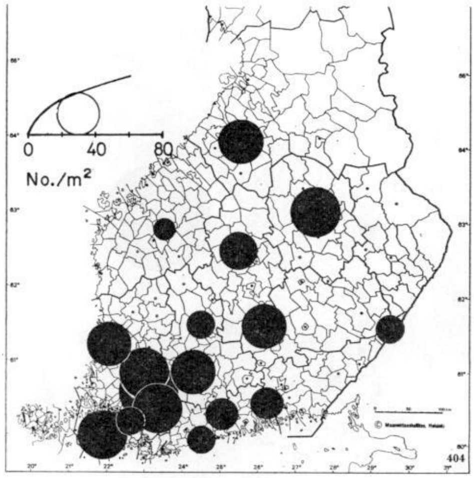

Fig. 20. *Chenopodium album.*

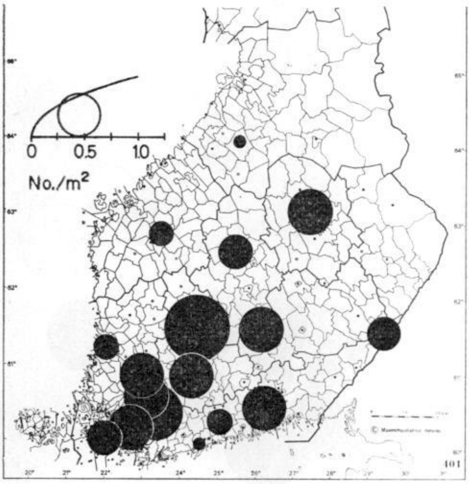

Fig. 21. *Cirsium arvense.*

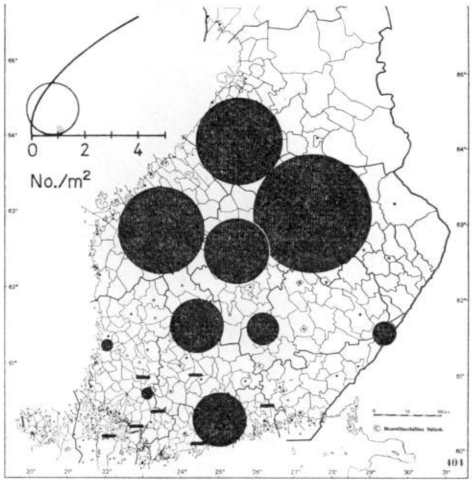

Fig. 22. *Deschampsia caespitosa.*

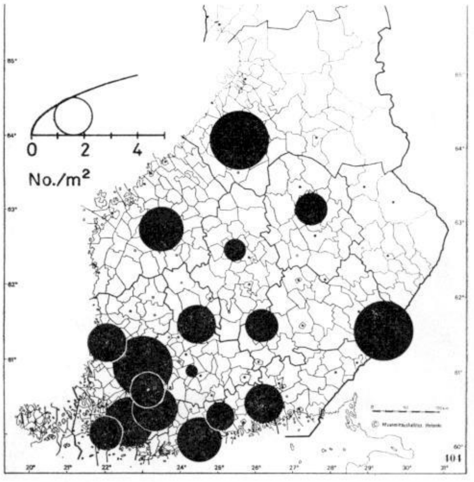

Fig. 23. *Equisetum arvense.*

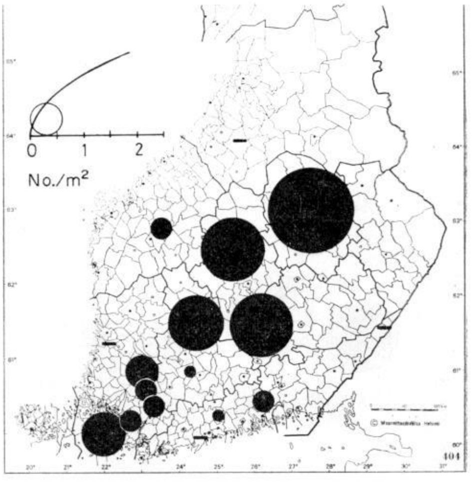

Fig. 24. *Equisetum silvaticum.*

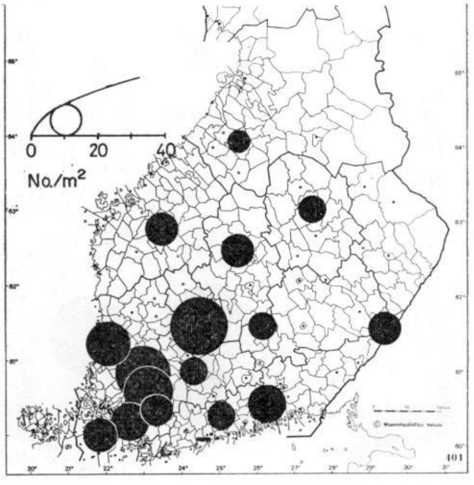

Fig. 25. *Erysimum cheiranthoides.*

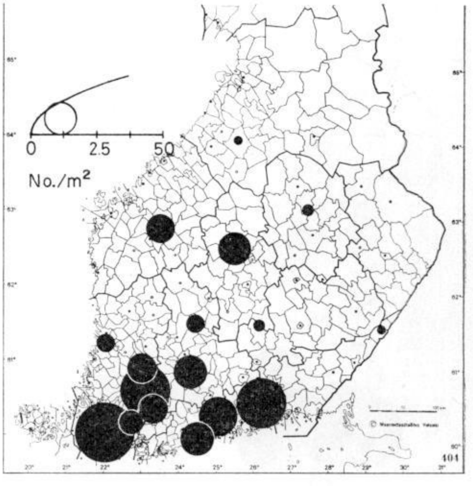

Fig. 26. *Fumaria officinalis.*

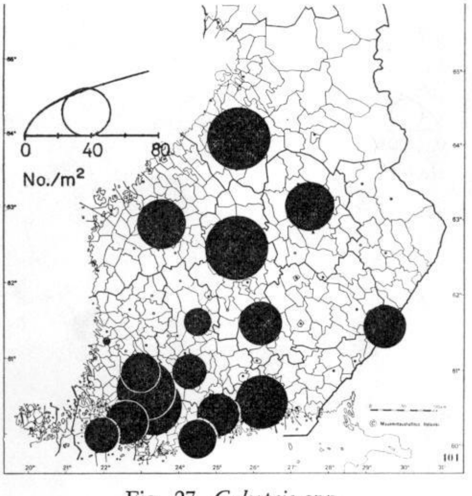

Fig. 27. *Galeopsis* spp.

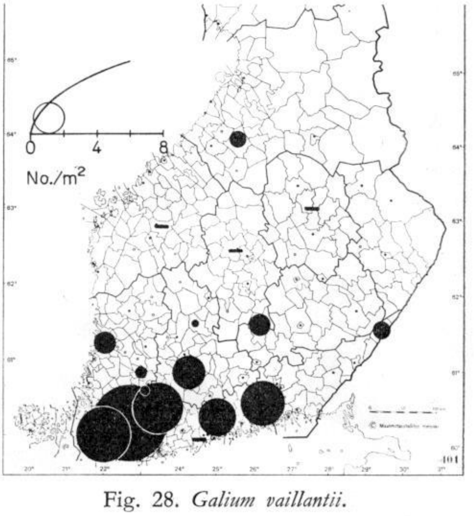

Fig. 28. *Galium vaillantii.*

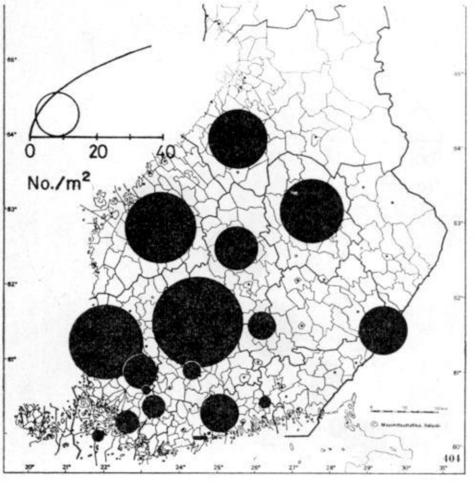

Fig. 29. *Gnaphalium uliginosum.*

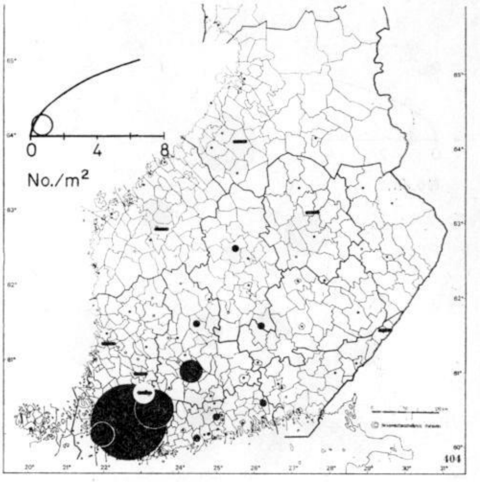

Fig. 30. *Lamium hybridum.*

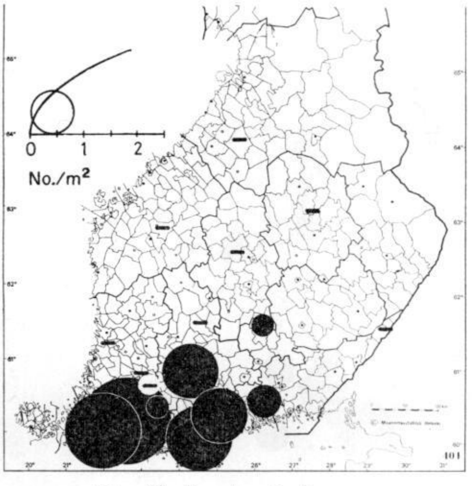

Fig. 31. *Lamium purpureum.*

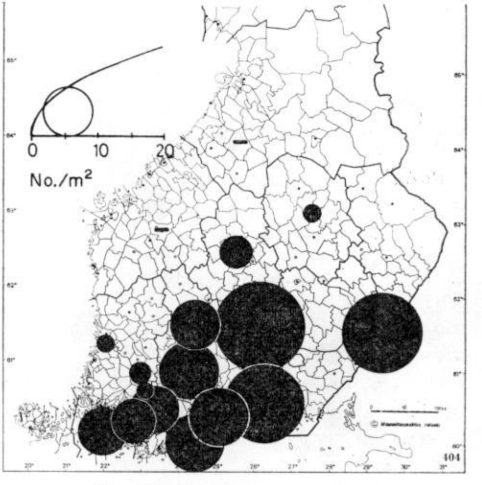

Fig. 32. *Lapsana communis.*

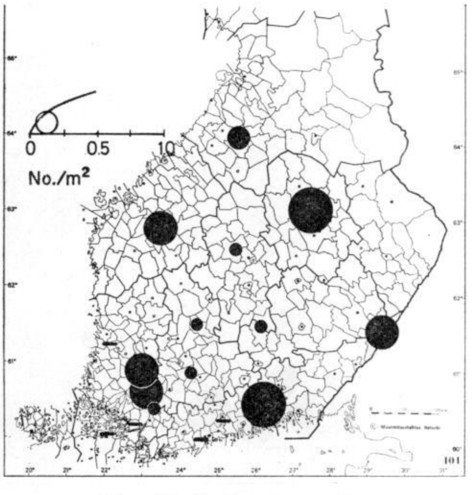

Fig. 33. *Lathyrus pratensis.*

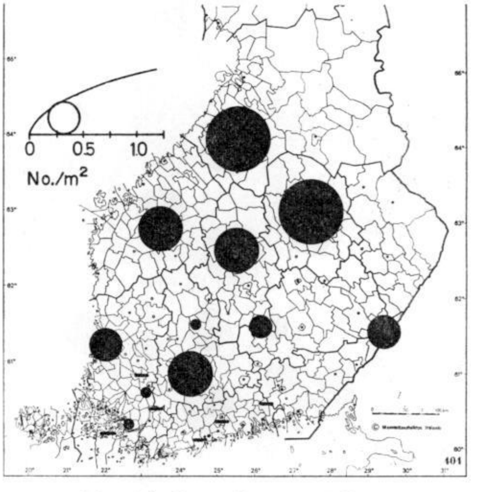

Fig. 34. *Leontodon autumnalis.*

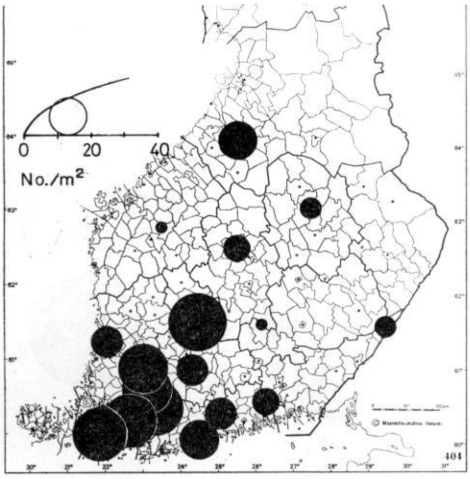

Fig. 35. *Matricaria* spp.

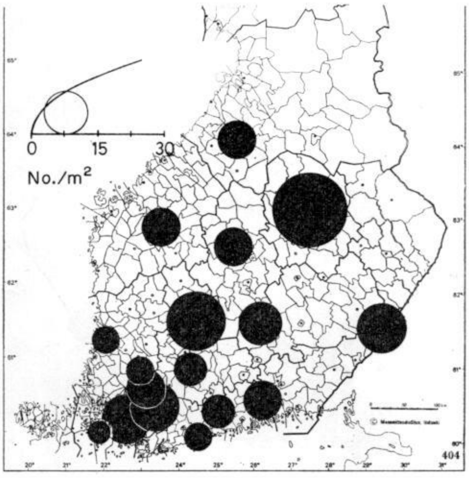

Fig. 36. *Myosotis arvensis.*

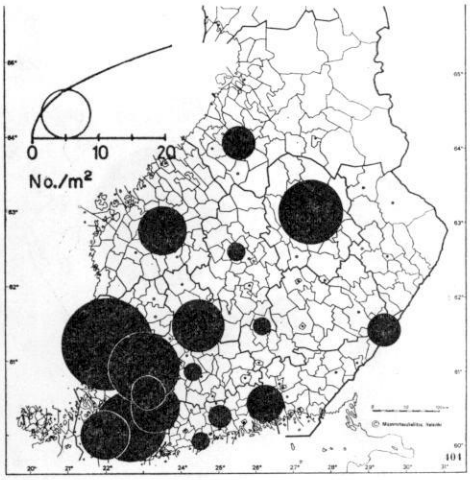

Fig. 37. *Myosurus minimus.*

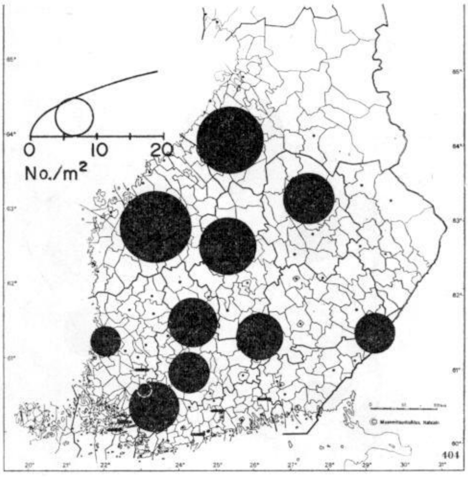

Fig. 38. *Phleum pratense.*

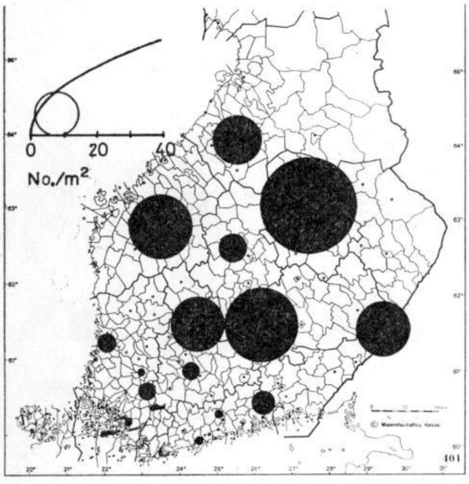

Fig. 39. *Poa pratensis.*

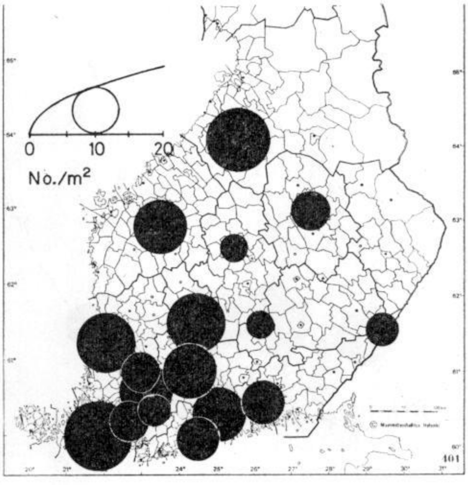

Fig. 40. *Polygonum aviculare.*

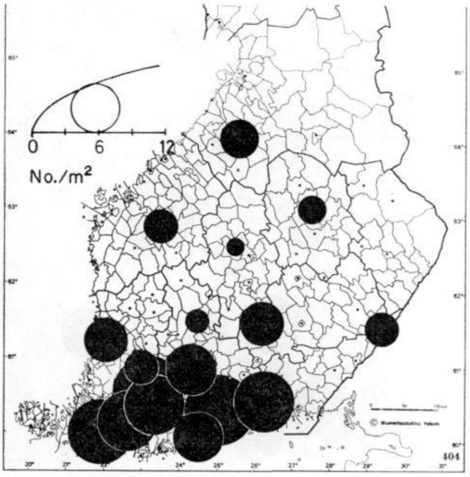

Fig. 41. *Polygonum convolvulus.*

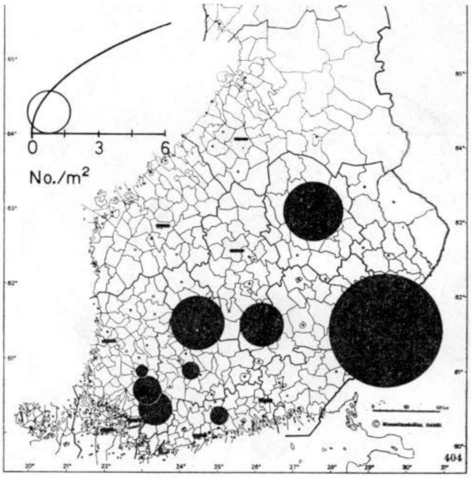

Fig. 42. *Polygonum hydropiper.*

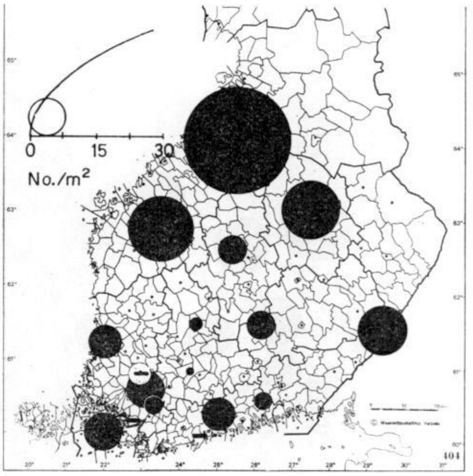

Fig. 43. *Polygonum lapathifolium.*

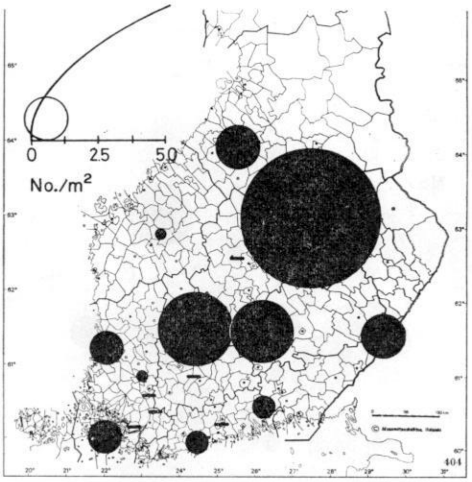

Fig. 44. *Ranunculus acris.*

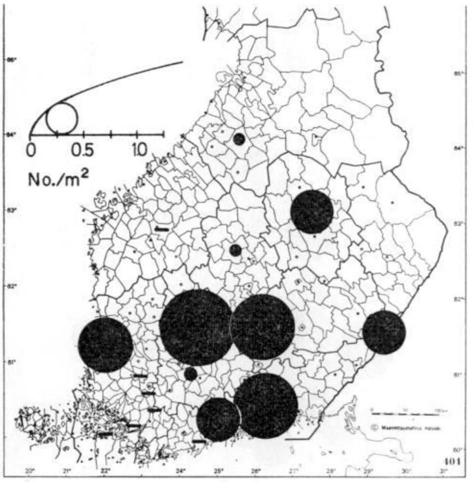

Fig. 45. *Ranunculus auricomus.*

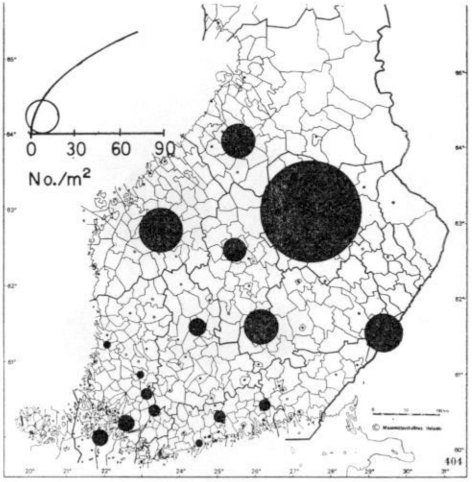

Fig. 46. *Ranunculus repens.*

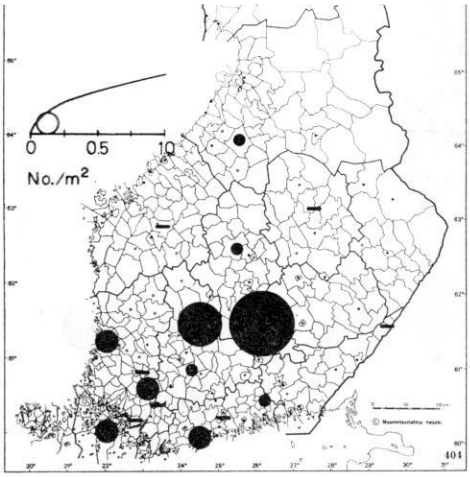

Fig. 47. *Raphanus raphanistrum.*

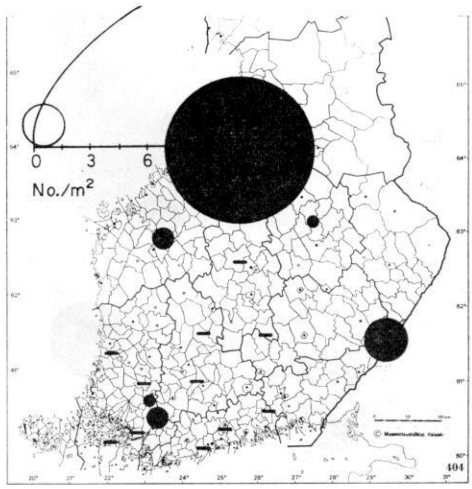

Fig. 48. *Rorippa palustris.*

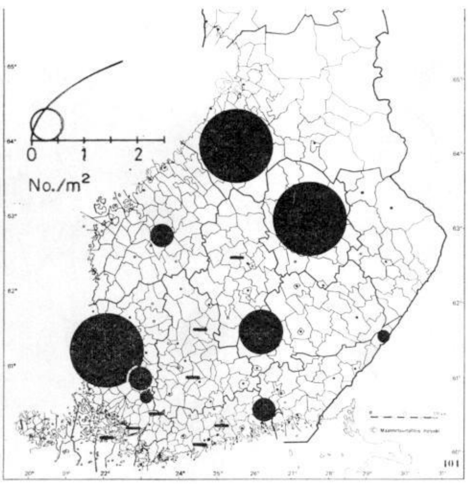

Fig. 49. *Rumex acetosa.*

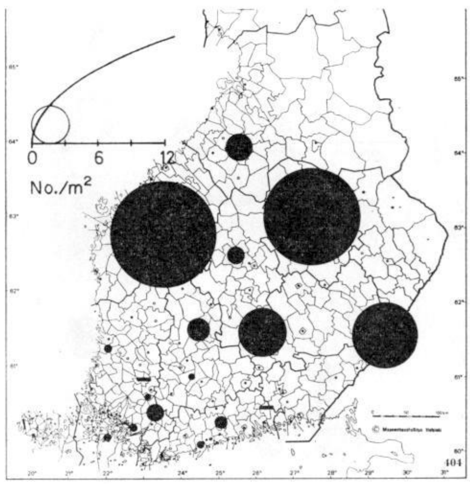

Fig. 50. *Rumex acetosella.*

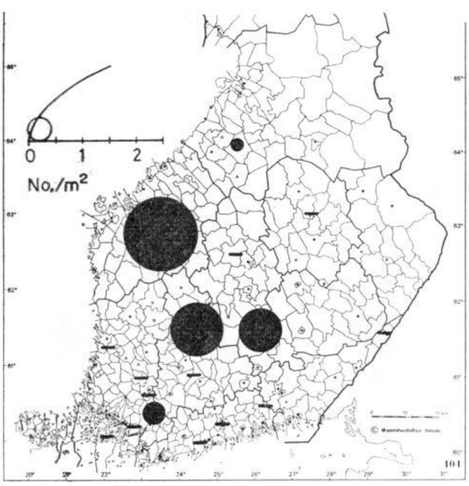

Fig. 51. *Rumex longifolius.*

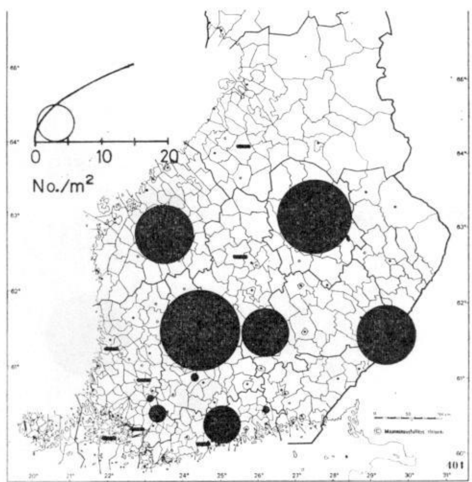

Fig. 52. *Sagina procumbens.*

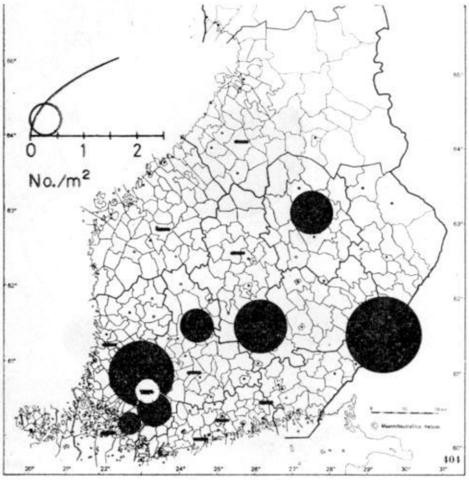

Fig. 53. *Scleranthus annuus.*

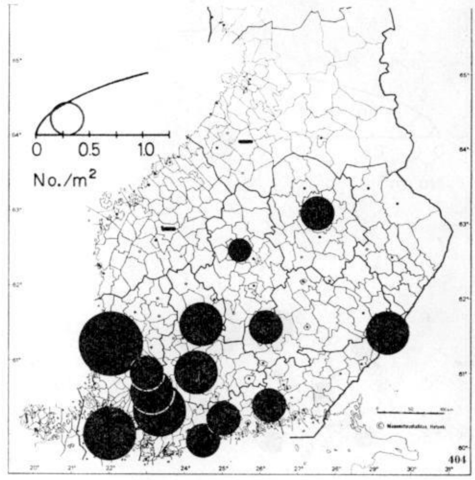

Fig. 54. *Sonchus arvensis.*

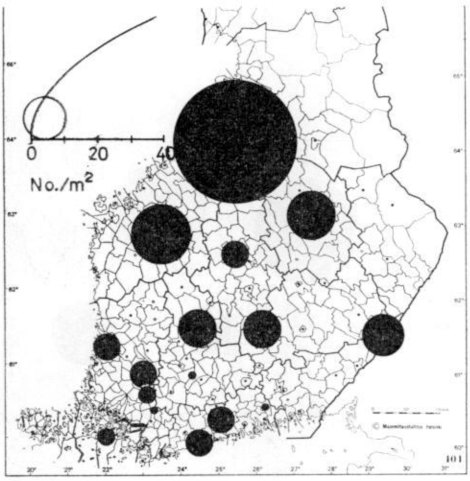

Fig. 55. *Spergula arvensis.*

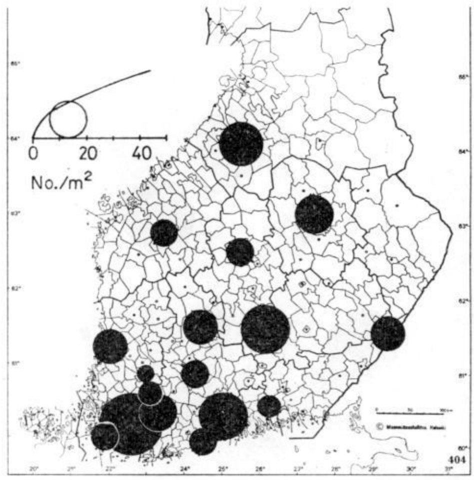

Fig. 56. *Stellaria media.*

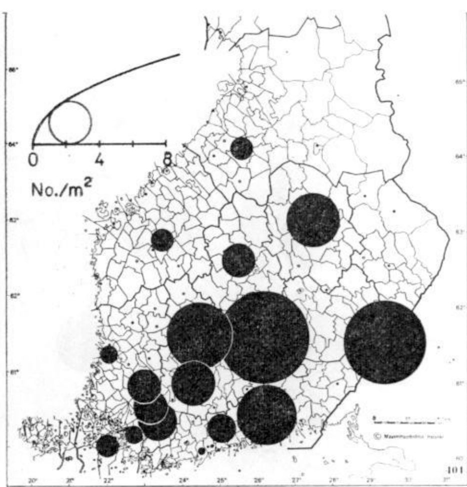

Fig. 57. *Taraxacum* spp.

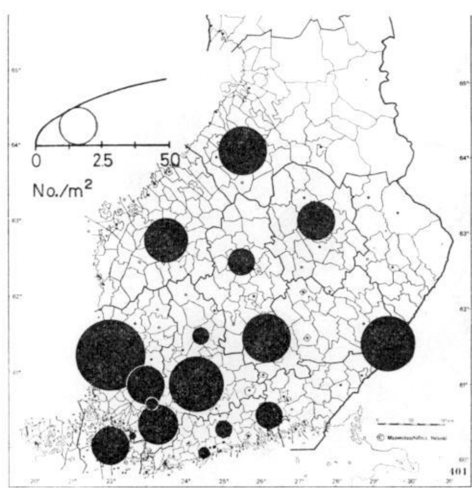

Fig. 58. *Thlaspi arvense.*

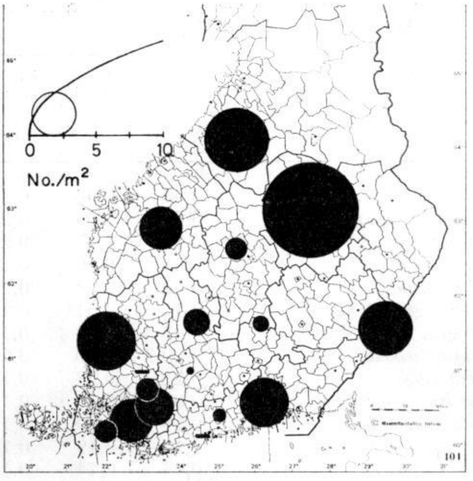

Fig. 59. *Trifolium repens.*

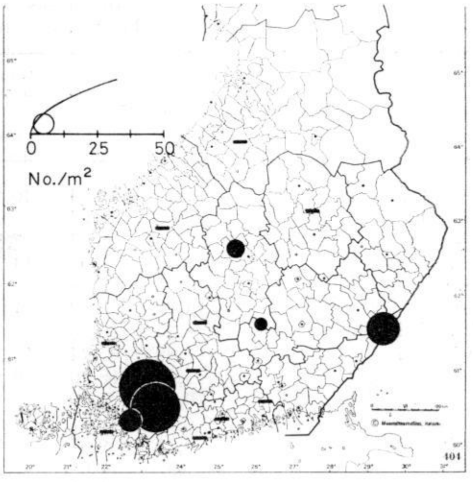

Fig. 60. *Veronica arvensis.*

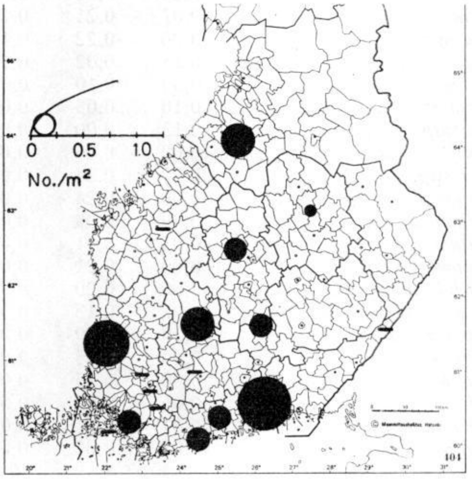

Fig. 61. *Veronica chamaedrys.*

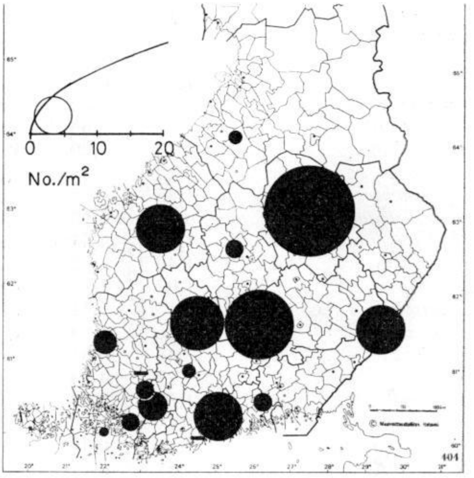

Fig. 62. *Veronica serpyllifolia.*

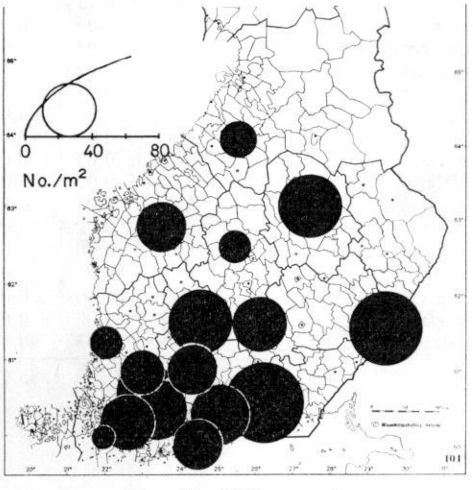

Fig. 63. *Viola arvensis.*

Table 5. Numbers of individual plants or shoots of various weed taxa per m² of sample area found in the two zones, southwest Finland and mid-Finland, and the country as a whole.

No. of fields	South-west Finland 333	Mid-Finland 177	Whole country 510
Galeopsis spp.	29,17	49,74	36,48
Viola arvensis	27,52	28,84	27,99
Chenopodium album s. lat.	28,00	25,43	27,35
Matricaria spp.	18,66	6,01	14,29
Stellaria media	12,07	12,78	12,26
Erysimum cheiranthoides	14,30	7,52	11,87
Unidentified dicotyledons	6,14	16,76	10,26
Agrostis spp.	1,88	27,74	10,25
Agropyron repens	5,11	18,20	9,57
Polygonum aviculare s. lat.	10,42	7,49	9,37
Gnaphalium uliginosum	6,79	12,27	8,41
Myosotis arvensis	5,71	9,85	7,11
Poa pratensis s. lat.	1,57	17,65	7,10
Phleum pratense	2,91	13,58	6,68
Ranunculus repens	0,89	18,22	6,68
Lapsana communis	5,78	6,34	6,12
Polygonum convolvulus	7,14	2,67	5,62
Myosurus minimus	6,50	3,60	5,28
Galeopsis speciosa	5,60	2,33	4,27
Spergula arvensis	1,01	10,17	4,18
Polygonum lapathifolium	1,18	9,02	3,87
Veronica serpyllifolia	1,52	7,68	3,61
Poa trivialis	2,33	5,00	3,38
Capsella bursa-pastoris	3,17	3,39	3,27
Sagina procumbens	1,85	6,05	3,25
Achillea millefolium	0,73	5,50	2,44
Cerastium caespitosum	1,19	4,41	2,27
Taraxacum spp.	1,48	3,53	2,24
Trifolium repens	1,07	3,47	1,84
Rumex acetosella s. lat.	0,10	5,11	1,76
Equisetum arvense	1,66	1,94	1,74
Galeopsis bifida	2,46	0,01	1,61
Poa annua	0,23	4,28	1,57
Thlaspi arvense	1,31	2,08	1,56
Trifolium pratense	1,49	0,60	1,18
Fumaria officinalis	1,36	0,41	1,05
Galium vaillantii	1,52	0,17	1,04
Achillea ptarmica	0,15	2,36	0,90
Arabidopsis thaliana	0,21	2,05	0,81
Unidentified monocotyledons	0,63	1,14	0,79
Juncus bufonius	0,71	0,73	0,71
Deschampsia caespitosa	0,15	1,71	0,67
Festuca rubra	0,12	1,84	0,66
Polygonum hydropiper	0,20	1,48	0,65
Centaurea cyanus	0,50	0,81	0,62
Ranunculus acris s. lat.	0,22	1,22	0,55
Lamium hybridum	0,82	0,02	0,52
Trifolium hybridum	0,18	0,96	0,45
Betula spp.	0,75	0,01	0,45
Veronica arvensis	0,56	0,24	0,45
Chamaenerion angustifolium	0,08	1,10	0,42
Cirsium arvense	0,46	0,33	0,41
Lamium purpureum	0,62	0,02	0,41
Poa spp.	0,43	0,37	0,41
Rorippa palustris	0,01	1,11	0,40
Equisetum silvaticum	0,18	0,71	0,36
Sonchus arvensis	0,47	0,17	0,36
Ranunculus auricomus coll.	0,33	0,37	0,34
Festuca pratensis	0,07	0,81	0,33
Rumex acetosa s. lat.	0,18	0,58	0,30

No. of fields	South-west Finland 333	Mid-Finland 177	Whole country 510
Secale cereale	0,44	0,00	0,28
Leontodon autumnalis	0,09	0,64	0,27
Scleranthus annuus	0,16	0,47	0,27
Atriplex patula	0,34	0,00	0,22
Veronica verna	0,02	0,54	0,20
Alopecurus geniculatus	0,14	0,31	0,19
Carex spp.	0,02	0,53	0,19
Alopecurus aequalis	0,29	0,00	0,17
Barbarea vulgaris	0,22	0,08	0,17
Rumex longifolius s. lat.	0,08	0,36	0,17
Veronica chamaedrys	0,19	0,09	0,15
Lathyrys pratensis	0,12	0,19	0,14
Trifolium spp.	0,14	0,14	0,14
Raphanus raphanistrum	0,10	0,18	0,13
Hieracium spp.	0,16	0,12	0,13
Brassica campestris	0,24	0,02	0,12
Stellaria graminea	0,07	0,21	0,11
Luzula spp.	0,06	0,22	0,10
Erophila verna	0,15	0,02	0,10
Vicia cracca	0,09	0,10	0,09
V. hirsuta	0,10	0,08	0,09
Sonchus asper	0,13	0,00	0,08
Alchemilla vulgaris coll.	0,09	0,06	0,08
Festuca spp.	0,00	0,24	0,08
Epilobium palustre	0,00	0,24	0,08
Viola palustris	0,09	0,09	0,08
Equisetum palustre	0,05	0,11	0,07
Epilobium spp.	0,00	0,21	0,07
Filipendula ulmaria	0,00	0,20	0,06
Aegopodium podagraria	0,02	0,13	0,06
Chenopodium polyspermum	0,10	0,00	0,06
Alopecurus pratensis	0,00	0,15	0,05
Galium palustre	0,00	0,15	0,05
Atriplex spp.	0,06	0,02	0,05
Prunella vulgaris	0,01	0,11	0,04
Anthriscus silvestris	0,01	0,07	0,03
Chrysanthemum leucanthemum s. lat.	0,01	0,08	0,03
Potentilla norvegica	0,00	0,12	0,03
Viola tricolor	0,00	0,11	0,03
Plantago major	0,02	0,03	0,02
Tussilago farfara	0,03	0,03	0,02
Campanula patula	0,00	0,08	0,02
Campanula spp.	0,00	0,08	0,02
Gagea minima	0,04	0,00	0,02
Rubus arcticus	0,00	0,07	0,02
Vicia sepium	0,01	0,04	0,02
Anthemis spp.	0,04	0,00	0,02
Artemisia vulgaris	0,01	0,04	0,02
Urtica dioica	0,01	0,02	0,01
Galium spp.	0,02	0,00	0,01
Cardaminopsis suecica	0,01	0,03	0,01
Vicia spp.	0,02	0,00	0,01
Dactylis glomerata	0,00	0,02	0,00
Veronica spp.	0,00	0,03	0,00
Total	234,03	387,00	285,90

The most common plants and those growing most densely were usually the same. The density of the annuals, winter annuals or the perennials occurring as seedlings was, however, usually greater than that of the equally common older perennials. The species growing more densely were usually winter annuals or annuals. Those growing less densely were often perennials — usually species occurring in winter cereals as seedlings, and those growing least densely of all, perennials occurring as old individuals.

On the basis of the number of individuals, the importance of perennials in winter cereals is usually more difficult to decide than that of annuals. Some species, e.g. *Trifolium pratense* and *Phleum pratense*, usually occur as seedlings, and others, e.g. *Agropyron repens* and *Sonchus arvensis*, as large, old individuals. As far as *Trifolium pratense* and *Phleum pratense* are concerned, this matter is clarified by the census taken in all the sample areas in 1973 and 1974, according to which 99,6 % of the individuals of the former and 82,7 % of the latter were seedlings. Most of the *Ranunculus repens* individuals were also seedlings, but only a small proportion of the individuals of e.g. *Agropyron repens*, *Cirsium arvense* and *Sonchus arvensis* were seedlings.

Figures 6—63 show the concentrations of the most dense taxa and some taxa of regional or other interest in the various survey regions.

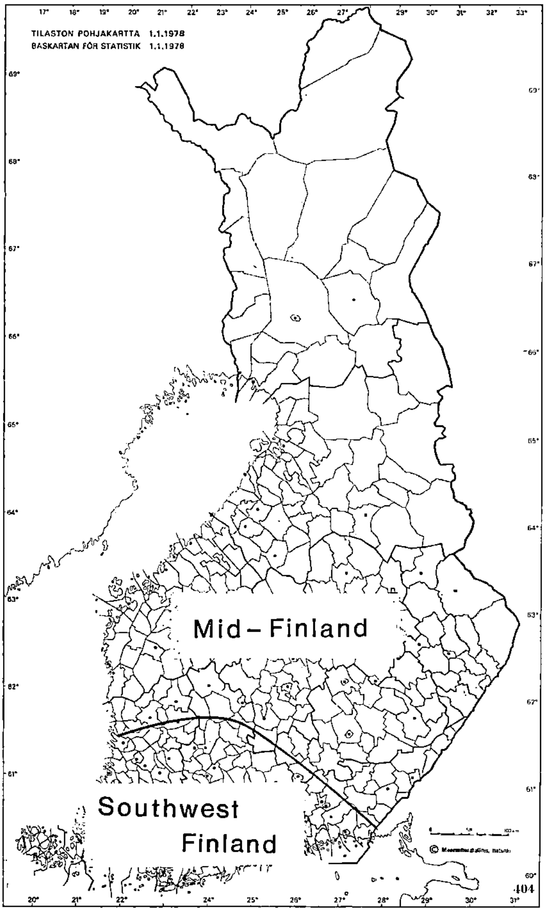

Fig. 64. Weed-based phytogeographical division into winter cereal sections.

3.3 Division into sections

In dividing the country into sections using the Sörensen method, the boundaries were drawn where regional similarities were smallest. Using this procedure, the area under winter cereals was divided in two (Figure 64):

Section I. Southwest Finland, encompassing regions 1—4, 7—10 and 13—16. Species typical of this zone include *Lapsana communis*, *Matricaria* spp., especially *Matricaria (Tripleurospermum) inodora*, *Polygonum convolvulus*, *Ranunculus auricomus* and *Sonchus arvensis*. A few of the species typical of this section only occur in greater abundance in the southwestern parts of the zone. These include *Atriplex patula*, *Fumaria officinalis*, *Galium vaillantii*, *Lamium hybridum*, *Lamium purpureum* and *Veronica arvensis*. Table 5 shows the plant densities of the species typical of this section compared with their densities in the mid-Finland section. The species typical of the southwestern Finland section are generally winter annuals and annuals and usually grow in rather dry, clay soils or in coarse, mineral soils long under cultivation. The population of each species is highest among cereals sown after the spring cereals, especially wheat, the winter cereals, potato and root crops. Since many of the species in this group can withstand the most commonly used MCPA herbicide rather well, they are often more abundant on fields treated with herbicides. Use of the combine harvester has also raised the plant density of a few of the species in this group. The species in this group cannot generally withstand a prolonged grassland stage, but are moderately successful in open patches in young grassland.

Section II. M i d - F i n l a n d, encompassing regions 5, 6, 11, 12, 17 and 18. Species typical of this section are *Achillea millefolium*, *A. ptarmica*, *Agropyron repens*, *Agrostis* spp., especially *A. tenuis*, *Cerastium caespitosum*, *Galeopsis* spp., *Leontodon autumnalis*, *Myosotis arvensis*, *Poa pratensis s. lat.*, *P. trivialis*, *Ranunculus repens*, *Rumex acetosella*, *Sagina procumbens*, *Spergula arvensis* and *Veronica serpyllifolia*, whose densities are shown in Table 5 and on the maps. Also closely allied with this group are *Deschampsia caespitosa* and *Chamaenerion angustifolium*. The species typical of the mid-Finland section are generally perennials. They occur on recent cultivations and are often abundant on cultivations close to farm buildings. The species appear to favour rather moist moraine and humus soils. Many occur in abundance on old, sparse grasslands, especially in places where the crop rotation is dominated by grass. The plant numbers are highest among other crops, too, when they are cultivated after grasses especially, but at times also after winter cereals, oats or barley.

4. DISCUSSION

This part of the survey and the preliminary survey already showed that for practical reasons winter cereal weed surveys should be conducted in early summer during the normal herbicide treatment season. On the other hand, it became clear that the weed species and the plant densities of the various species cannot be fully identified at so early a stage of development. The species and the numbers of each particular species should therefore be identified again later in the summer.

The most abundant winter cereal weed species were West European—Siberian species (34 %), among which the West European—Middle Siberian species accounted for 18 %, the West European—South Siberian species for 8 % and the West European—North Siberian species for 8 % of the total number of species (see Hultén 1950). Of these species, however, only a few, such as *Agrostis tenuis*, *Lapsana communis*, *Myosotis arvensis*, *Tripleurospermum inodorum* and *Viola arvensis*, were common or very common. The second most abundant group of species comprised the boreal-circumpolar species (18 %), of which *Equisetum arvense*, *Erysimum cheiranthoides* and *Gnaphalium uliginosum* were the most common. The third most abundant range group comprised the circumpolar species, whose countries of origin are unknown and whose distribution has been strongly culturally affected. Such species accounted for 13 % of the total, and many of these were among the most common species in winter cereal cultivations, including *Achillea millefolium*, *Agropyron repens*, *Capsella bursa-pastoris*, *Cerastium caespitosum*, *Chenopodium album*, *Polygonum aviculare*, *P. convolvulus*, *Ranunculus repens* and *Stellaria media*. The fourth most abundant group comprised European or European—West Siberian species (9 %) among which *Galeopsis bifida*, *Poa pratensis*, *Trifolium repens* and *Veronica chamaedrys* were common. Representatives of many ranges (e.g. even a group as large as the subatlantic) did not occur as weeds in winter cereal cultivations. This may be due to environmental demands, for example, and Finland's recent cultivation history, to which the plant species concerned have not yet managed to adapt themselves.

In processing the material it became apparent that winter cereals in Finland are too excessively heterogenic a group for their weeds to be treated as a single group when aiming at efficient control. In a general survey, however, this can be done, thus giving basic information on the weed flora affecting winter cereals and their abundance in various parts of the country. In future, the weed flora among winter rye and winter wheat, and their ecology should be dealt with separately.

The survey also showed that research into winter cereal weeds has been badly neglected and should be stepped up by looking into e.g.

1) the population dynamics of weeds, e.g. wintering and competition in wheat and rye,
2) the underground and surface biomasses of weeds in rye and wheat,
3) weed control results and economic significance in practical cultivations using various eradication methods,
4) the significance of various weeds for cultivated plants, and
5) the plant communities of wheat and rye cultivations and their use in intensifying weed control.

The number of weed species occurring among winter cereals was fewer than those occurring among spring cereal (see Mukula et al. 1969). The difference in weed plant densities was even greater. There was an average of only 286 plants or shoots per sq.m among winter cereals, as against 550 among spring cereals (Mukula et al. 1969). This may be due to many reasons, e.g. 1) winter cereal cultivations are located on soils in which the content of germinating weed seeds is probably lower than in spring cereal cultivations (see Paatela and Erviö 1971), 2) weed germinability is highest following tilling, but winter cereal cultivations are tilled in the autumn when germinability is lower than in the spring, 3) most (and with several species all) of the seedlings germinating in the autumn die during the winter season, 4) in the spring a smaller porportion of the seeds of many species germinate in winter cereal cultivations than in spring cereal cultivations, 5) winter cereals, particularly rye, strangle many seedlings more effectively than spring cereals in both the autumn and the spring, 6) the large-growing weeds germinating in the autumn in winter cereal cultivations may prevent germination of spring-germinating weeds and kill off weak spring-germinating seedlings, 7) earth encrustation, especially on clay soils, prevents sprouting of spring-germinated plants.

The division into sections on the basis of winter cereal weeds was relatively easy to carry out from the data given by the computer. The most problematical was region 10, which might also have been transferred to the mid-Finland section, but which nevertheless was best located in the southwest Finland section. The regional division is preliminary and is open to modification once more data from additional regions become available. In re-examining the division, additional information should be obtained, especially for Finland's western and eastern parts.

The reasons underlying creation of the sections shown in Figure 64 are partly a consequence of temperature and the oceanic-continental factor. The thermal growing season is long (165—180 d) and the thermal autumn long (60—80 d) in the southwest Finland zone (Kolkki 1966). The thermal winter is short (110—145 d) (Kolkki 1966) and the thickness of the snow cover only 25—50 cm (Keränen and Korhonen 1952). The volume of water formed by melting snow is small, and as rainfall is scarce in the early summer, plants suffer early in the growing season owing to a shortage of water.

The boundary formed by climatic factors is sharpened by the boundaries formed by soil factors, which largely coincide with the sectional boundary. These are the dominant types of soil in the tillage layer of cultivations, either clay or fine-sandy soils in the southwest Finland section. Clay soils account for 5—60 %, fine-sandy soils often for over 30 %, but moraine soils and peat soils for under 10 %. The exchangeable calcium content is over 1 400 mg/l, pH often over 5,7, exchangeable potassium content 140—230 mg/l, exchangeable magnesium content over 220 mg/l, exchangeable manganese content under 8,0 mg/l and the acid-soluble copper content often over 7,1 mg/l (Kurki 1972).

The sharpest changes in cultural factors regulated by climatic and soil factors coincide largely with the boundary between the southwest and mid-Finland sections. These include population density, the age of cultivations and the proportions of the land area accounted for by cultivations, which are substantially larger in southwest Finland than in mid-Finland. The cultivation season in southwest Finland lasts 190—210 d (Cajander 1922).

Southwest Finland is an area of wheat and root crop cultivation where both combine harvesters and herbicides have been used more frequently and longer than in mid-Finland (Mukula and Ruuttunen 1969). Many native plant species and cultural arrivals, too, have spread to Finland from the southwest and advanced right up to the northeastern boundary of southwest Finland. By means of cultivation techniques, particularly herbicides, the abundance of these and other species of plants has been much reduced in recent decades precisely in southwest Finland.

Characteristic features of the mid-Finland section include the brevity (140—165 d) of the thermal growing season, the brevity of the thermal autumn (50—60 d), the length of the thermal winter (145—175 d) and the thickness of the snow cover (50—80 cm). Consequences of the long and snowy winter include an upset plant energy balance, poor condition, and damage caused by overwintering parasitic fungi. In this section, plants do not suffer from spring drought as badly as in the southwest Finland section.

The soil types prevailing in the tillage layer of cultivations are moraine, fine-sandy and organic soils, and in soil terms the cultivations in the mid-Finland section are more variable than those in southwest Finland. The exchangeable calcium content is about 800—1 400 mg/l, pH under 5,7, exchangeable potassium content 80—140 mg/l, exchangeable magnesium content under 220 mg/l, exchangeable manganese content 8—14 mg/l and acid-soluble copper content often under 7,0 mg/l (Kurki 1972).

In the mid-Finland section, cultivations account for under 15 % of the land area with the exception of the Ostrobothnian region, where they occasionally account for over 15 %, as they do throughout the southwest Finland section. The cultivation season in mid-Finland is 160—190 d, and the section is typical hay and pastoral grassland.

Since many climatic, edaphic and cultural factors vary sharply along the same boundary between the southwest and mid-Finland sections, it is clear that the boundary is also reflected in the weed species of cultivations and especially in the abundance of the species, as is apparent from, for example, the range maps. A sectional boundary has earlier been found to lie in much the same place in the case of the weed flora of spring cereal cultivations (Mukula et al. 1969, M. Raatikainen and Pietiläinen 1969) and the weed flora of hay grassland (M. Raatikainen and T. Raatikainen 1975). The boundary is also seen in the fertility districts made by Linkola (1922, 1932, 1936) and in Kujala's (1936) vegetation zone division. The boundary has since also been clearly ascertained for natural forest and peatland plant flora (Kujala 1964) and for peatland vegetation (Eurola 1962). Kalliola (1973) considers the boundary so well defined that he has separated from southern Finland a southwestern subdivision, whose southeastern boundary is practically identical with the southeastern boundary of southwest Finland as described in this survey. The boundary concerned is not distinguished in anywhere near all the geographical divisions in Finland. The boundary is not generally considered a zonal boundary determined by temperature factors, but a section boundary determined primarily by humidity and soil factors. It is primarily as such that it should be understood in this survey, too, though temperature factors do nevertheless play a part in defining the boundary. Studies in Sweden have also come up with a weed flora composition among winter cereals similar to that found in Finland, and there, too, regional differences similar to those found in Finland have been observed (Granström 1956). In both countries it may be concerned with the same southern and middle boreal zone vegetation (see Ahti et al. 1968).

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SELOSTUS

Syysviljojen rikkaruoholajit, niiden yleisyys ja yksilötiheys

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Maatalouden tutkimuskeskuksen kasvinviljelylaitoksen toimesta aloitettiin v. 1969 esitutkimukset syysviljojen rikkaruoholajiston ja sen koostumuksen selvittämiseksi. Tarkoituksena oli perustietojen saaminen rikkaruohojen torjuntaa varten. Aikaisemmin oli selvitetty kevätviljapeltojen ja heinänurmien rikkaruoholajit, niiden koostumus ja siinä viime aikoina tapahtuneet muutokset. Syysviljojen rikkakuoholajistosta ei esitutkimusten tekoaikana ollut juuri mitään julkistettuja tietoja.

Esitutkimuksessa v. 1969 selvitettiin tutkimukseen otettavien tutkimusalueiden määrä, koko syysviljalohkojen määrä tutkimusalueella, lohkolta tarvittavien osanäytteiden määrä, näytealojen peittäminen rikkaruohoruiskutusten ajaksi sekä kysely-, haastattelu- ja havainnointitutkimukseen tarvittavan lomakkeen sisältö.

Varsinainen tutkimus tehtiin v. 1972—74. Kunakin vuonna tutkittiin kuusi aluetta (taulukko 2 ja kuva 3). Joka alueelta tutkittiin 27—33 syysviljalohkoa, joksi määriteltiin se syysviljapellon osa, joka oli kylvetty saman viljelykasvin jälkeen ja sijaitsi samalla maalajilla. Joka lohkolta rajattiin satunnaisotannalla neljä 0,25 m^2:n osanäytealaa (kuva 4), jotka peitettiin 1,5 × 1,5 m:n muovikelmulla ruiskutuksen ajaksi. Kesäkuun 1.—18. päivien välisenä aikana käytiin laskemassa osanäytealoilta rikkaruohojen kappalemäärä tai versojen määrä lajeittain. Lisäksi merkittiin muistiin kaikki lohkolla tavatut putkilokasvilajit.

Tutkituilta 540 syysviljalohkolta löydettiin ainakin 190 putkilokasvilajia (taulukko 3). Lajimäärä oli suurin Itä-Suomessa ja pienin Etelä-Suomessa (kuva 5). Yleisimmät lajit ja niiden frekvenssiprosentit olivat (a) kevätyksivuotisista jauhosavikka 89, pillikkeet 88, peltoukonnauris 76, pihatatar 76 ja kiertotatar 63, (b) syysyksivuotisista pelto-orvokki 89, sauniot 83, pihatähtimö 73, peltolemmikki 69 ja linnunkaali 53 ja (c) monivuotisista peltokorte 51, rönsyleinikki 51 ja voikukat 50.

Syysviljoissa oli keskimäärin 256 kasviyksilöä tai versoa/m^2. Kaikkien näyteruuduilla esiintyneiden lajien yksilömäärät esitetään taulukossa 5, ja kuvissa 6—63 on merkittävimpien tiheydet eri alueilla. Tiheimmässä kasvaneet kevätyksivuotiset kasvilajit ja niiden yksilötiheydet (kpl/m^2) olivat seuraavat: pillikkeet 36, jauhosavikka 27, peltoukonnauris 12, pihatatar 9, savijäkkärä 8 ja kiertotatar 6. Tiheimmässä kasvaneet syysyksivuotiset kasvilajit ja niiden yksilötiheydet olivat pelto-orvokki 28, sauniot 14, pihatähtimö 12, peltolemmikki 7 ja linnunkaali 6. Tiheimmässä kasvaneet kestorikkakasvit ja niiden versotiheydet olivat seuraavat: röllit 10, juolavehnä 10, niittynurmikka 7, timotei 7 ja rönsyleinikki 7.

Rikkaruoholajien esiintymisen ja tiheyden perusteella syysviljojen viljelyalue jaettiin kahteen alueeseen (kuva 64):

1) Lounais-Suomen alue, jolle tyypillisiä lajeja olivat yleisimmin käytettyä MCPA-hävitettä melko hyvin kestävät avoviljelysten lajit kuten linnunkaali, saunakukka ja pihatatar sekä kestorikkakasveista peltovalvatti ja

2) Väli-Suomen alue, jolle tyypillisiä lajeja olivat monivuotiset nurmiviljelysten lajit kuten siankärsämö, ojakärsämö, juolavehnä, nurmirölli, nurmihärkki, syysmaitiainen, nurmikat, rönsyleinikki, ahosuolaheinä ja orvon tädyke. Tyypillisiä kertarikkakasveja olivat pillikkeet, peltolemmikki ja peltohatikka.

Syyt edellä esitettyjen alueiden syntyyn ovat etupäässä lämpötilan, mereisyyden-mantereisuuden, maaperätekijöiden ja kulttuuritekijöiden aiheuttamia.

Tutkimuksesta myöhemmin julkaistavissa osissa tarkastellaan lajistoa ja torjuntaa viljalajeittain.

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Seria ANIMALIA NOCENTIA N. 102 — Sarja TUHOELÄIMET n:o 102

AN IMPROVED REARING METHOD FOR CHRYSOPA CARNEA STEPH.

UNTO TULISALO

TULISALO, U. 1978. **An improved rearing method for Chrysopa carnea Steph.** Ann. Agric. Fenn. 17: 143—146. (Agric. Res. Centre, Inst. Pest Inv., SF-01300 Vantaa 30, Finland.)

The method consists of a rearing cabinet with a mixed population of *Sitotroga cerealella* and *Chrysopa carnea*. Once a month *Chrysopa* eggs are spread into the *Sitotroga* rearing cabinet. Adult lacewings are collected from the roof of the cabinet after their emergence. The yield of adults in one generation was 10—20 % of used eggs.

Index words: mass-rearing, *Chrysopa carnea*, *Sitotroga cerealella.*

INTRODUCTION

Following Finney's innovation (1948) the mass-rearing of the green lacewing has been modified a number of times (FINNEY 1950, VANDERZANT 1969, 1973, HAGEN and TASSAN 1970, RIDGWAY et al. 1970, TULISALO and KORPELA 1973, HASSAN 1974, 1975, MORRISON et al. 1975, MORRISON and RIDGWAY 1976, TULISALO and KURPPA 1976). Nowadays, rearing is generally accomplished by using the MORRISON and RIDGWAY method (1976) whereby adults are fed an artificial diet and the larvae are reared on the eggs of *Sitotroga cerealella*. Many attempts have been made to devise an artificial diet for the larvae, but so far they have not led to practical application (HAGEN 1950, VANDERZANT 1969, 1973, HAGEN and TASSAN 1970, PONOMAREVA 1971, ABASHKIN and YAZLOVETSKII 1977). Today the green lacewing is reared for pest control purposes in the USSR and in the USA, but still on an experimental scale.

The rearing method described in this report was developed over a number of years on the basis of experience gained in rearing green lacewings for various pest control experiments. The main aim was to develop a method of producing *Chrysopa* eggs for pest control purposes, which would involve a minimum of work and employ cheap raw materials.

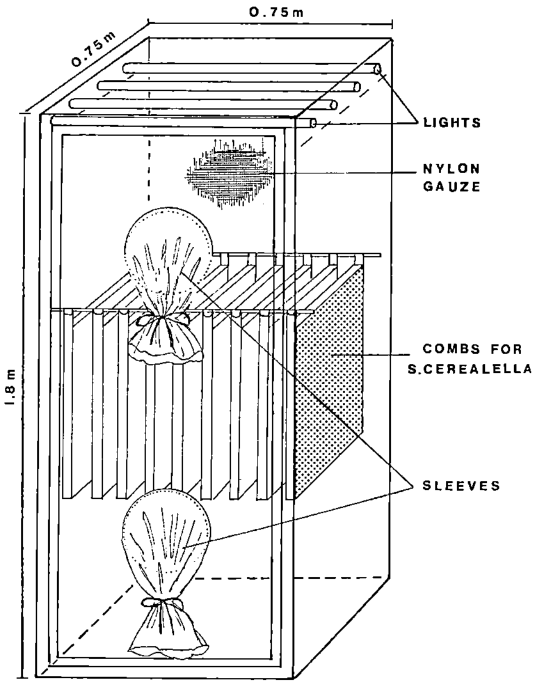
EQUIPMENT AND PROCEDURE

From the earliest attempts, the adults in the rearing cage have been fed on Food »Wheast»®, yeast hydrolysate, mixed with sugar and water, and this method is still in practice. However, the rearing of the larvae has undergone great changes over the years. The adults of the following generation are produced in rearing cabinets as a mixed population together with *Sitotroga cerealella* (Fig. 1). The cabinets measure 1,8 m high, 0,75 m deep and 0,75 m wide. Each »comb» in the cabinet is filled with 10 kgs of barley which has been treated with dikophole to ward off mites. At this stage *Sitotroga* adults are introduced into the cabinet. As soon as the *Sitotroga* population has increased sufficiently, *Chrysopa* eggs are placed in the cabinet. About 25 000 eggs are strewn over the floor of the cabinet at a time. After an average of 16 days the first *Chrysopa* adults hatch and are collected from the walls and roof of the cabinet with the help of a sucking device.

Most of the lacewings hatch within a period of 3 to 6 days, after which the next batch of *Chrysopa* eggs may be placed in the cabinet.

About twice a week the cabinet is vacuum cleaned through a gauze filter to remove wing-scales. One breeding period is from 6 to 12 months. Thereafter, the cabinet is emptied and cleaned thoroughly.

An attempt was made to keep the temperature at about 27°C, and the relative humidity at as a high a level as possible without causing the formation of mould. The intensity of the roof-lighting was 10 000 lux. The only real work involved in looking after the cabinet is the collecting of the adult lacewings with the sucking device as well as the renewal of the *Sitotroga* brood, twice a year.



DISCUSSION

At first the green lacewing larvae were fed on aphids (Tulisalo and Korpela 1973). This proved to be extremely laborious and so the change was made to *Sitotroga cerealella* eggs for the feeding of larvae. This, however, required the rearing of the *Chrysopa* larvae in separate cells (Morrison and Ridgway 1976) which, for its part, was too time-consuming from the point of view of large-scale production. When it was discovered that *Chrysopa* larvae could also feed on the *Sitotroga cerealella* adults and larvae, the rearing of the larvae of *Chrysopa* was commenced in rearing jars, in which they were given nothing but a *Sitotroga* adult »mass» (Tulisalo and Kurppa 1977).

However, even when using this method, *Sitotroga* food had to be fed to the lacewings several times during their larval stage. Thus, the described mixed-population rearing was arrived at, whereby the larvae of *Chrysopa* require no special tending. The larvae, depending on their stage of development, now feed on the *Sitotroga* eggs, larvae and adults and also on each other. The loss in eggs resulting from this cannibalism is, nevertheless, economically small compared with the savings in labour in the rearing of the larvae.

In the above-mentioned rearing cabinet, about 3 700 *Chrysopa* adults were produced in one rearing cycle. The percentage of hatched adults from those eggs placed in the cabinet varies from 10 % to 20 %.

Thus about 10 % of the adults' total egg production had to be used to reproduce the new generation. It was possible to use the remaining 90 % for pest control experiments. In the event of establishing a large mass-rearing, a larger percentage of the eggs must, of course, be used to yield this increased population.

Green lacewings have now been produced by this method for two years or, in other words, for about 20 generations. The old laboratory strain from the year 1972 and the new strain gathered from nature did not differ from each other in this cabinet rearing. Because the amounts of *Chrysopa* for experiments have not been very large it has not been possible to discover how many thousand eggs one laboratory assistant would be able to produce in a day. On the basis of calculation at least as good a result as that of MORRISON and RIDGWAY (1976) would be achieved. In spite of easier rearing and good pestcontrol results it is still very difficult for the green lacewing to compete economically with pesticides.

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SELOSTUS

Harsokorennon massakasvatusmenetelmä

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Maatalouden tutkimuskeskus

Biologisen tuholaistorjunnan oleellisimpia osia on torjuntaeliön massakasvatus. Harsokorentoa on menestyksellisesti kokeiltu ja käytetty biologiseen tuholaistorjuntaan sekä avomaalla että lasinalaisviljelmillä. Sen massakasvatukseen ei ole kuitenkaan vielä onnistuttu kehittämään teollista ja halpaa tuotantomenetelmää. Tässä tutkimuksessa on kehitetty menetelmä, jossa harsokorennot tuotetaan sekakasvatuksena viljakoin kanssa samassa kammiossa. Kammion viljakennot täytetään ohralla kerran puolessa vuodessa ja istutetaan viljakoikanta tähän ohraan. Kun koit ovat riittävästi lisääntyneet siirretään kammioon harsokorennon munia. Harsokorennon toukat syövät omatoimisesti viljakoiaikuisia, -munia ja -toukkia ja koteloituvat ja aikuistuvat kammioissa. Ainut työtä vaativa hoitotoimenpide on kerätä ajoittain aikuiset harsokorennot imulaitteella kammion katosta. Työn menekki on varsin vähäinen ja laskennallisesti yksi laboratorioapulainen voi tuottaa harsokorentoja päivää kohti enemmän kuin muilla tähän saakka käytössä olleilla menetelmillä.

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RESEARCH REPORT

DETERMINING THE SENSITIVITY OF CEREAL VARIETIES TO COPPER DEFICIENCY IN A POT EXPERIMENT

HILKKA TÄHTINEN

TÄHTINEN, H. 1978. **Determining the sensitivity of cereal varieties to copper deficiency in a pot experiment.** Ann. Agric. Fenn. 17: 147—151. (Agric. Res. Centre, Inst. Agric. Chem. and Phys., SF-01300 Vantaa 30, Finland.)

The culture medium in pots was Carex peat with a low copper content. Six different levels of copper were used. The species studied here was oats.

Nip, a brown husked variety with a low yielding capacity, was able to produce grain at a lower level of copper than Pendek. Although these varieties took up nearly the same amounts of copper, the grain yield of Nip was much less responsive to copper application than that of Pendek. Differences between the varieties are most evident in the reduction in grain yield caused by Cu deficiency, and in the minimum copper application required for grain formation.

The grain/straw ratio of the dry matter yield and of the copper yield are more effective indicators of the copper sensitivity of an oat variety than are the copper contents of the grain and straw yields.

Differences between varieties with respect to copper sensitivity can be determined in pot experiments when several levels of copper are used, ranging from the minimum necessary for grain formation to the level necessary for realizing the genetic potential of the varieties.

Index words: Cu uptake, Cu × variety-interaction, Cu fertilization, Cu deficiency

INTRODUCTION

Of the crop-plants cultivated in Finland, the most sensitive to copper deficiency are cereals. Spring grains suffer from copper deficiency more than winter grains (SMILDE and HENKENS 1967, FIBIAN et al. 1977).

Studies have also shown differences in copper requirements between cereal varieties (SMILDE and HENKENS 1967, NAMBIAR 1976 a and b).

A slight copper deficiency causes a decrease in the grain yield alone. Decay of the vascular bundles caused by copper deficiency restricts the flow of water in plants. In cereals this is most evident in the drying of the leaf tips. Other symptoms of copper deficiency are limited formation of panicles or heads and delayed ripening with subsequent profuse tillering in both oats and barley (e.g. RAHIMI 1972, RAHIMI and BUSSLER 1973, TÄHTINEN 1976).

The purpose of this preliminary investigation is to assess the suitability of pot experiments for determining differences in the copper uptake of oat varieties.

MATERIAL AND METHODS

The varieties chosen for the experiment were Nip, a brown husked variety with low growth requirements, and Pendek, which has a white husk, produces a higher yield and is more resistant to lodging. It also has a higher grain protein content and generally higher growth requirements than Nip.

Since optimal conditions for plant growth and yield development were desired, the experiment was made outdoors in pots. This method affords the plants good possibilities of achieving their genetic capacity for growth rate. In field trials, external factors often limit plant growth and in addition the subsoil may affect the result, depending on the depth of the roots (GUPTA and MACLEOD 1970). On the other hand, it has been observed that differences in copper uptake ability of the roots between different varieties are brought out more effectively in a soil culture medium in pots than in a water medium (SMILDE and HENKENS 1967).

Acid ($pH_{(H_2O)}$ 4,2) Carex peat (0,7 kg dry matter per 5-litre pot) served as the substrate. The peat contained Ca 400, P 4,2, K 20 and Mg 80 mg/l of soil, extractable in acid ammonium acetate (KURKI et al. 1965) and Cu 0,3 mg/l of soil, extractable in acid ammonium acetate/0,02 M EDTA (LAKANEN and ERVIÖ 1971).

Acidity of the soil was neutralized by using 5 g Ca ($CaCO_3$) per pot. As basic fertilizer, the following quantities of chemically pure nutrients were added to each pot:

1 000	mg	N	(NH_4NO_3)
400	»	P	($Ca(H_2PO_4)_2 \cdot H_2O$)
1 000	»	K	(KCl)
200	»	Mg	($MgSO_4 \cdot 7H_2O$)
10	»	H_3BO_3	
50	»	$MnSO_4 \cdot H_2O$	
50	»	$ZnSO_4 \cdot 7H_2O$	
10	»	$Na_2MoO_4 \cdot 2H_2O$	
10	»	Fe EDTA	

The copper treatments were 0, 0,1, 0,5, 2,5, 12,5, and 62,5 mg Cu ($CuSO_4 \cdot 5H_2O$).

In each pot were sown 25 grains. In accordance with the Mitscherlich system, the pots were watered daily with de-ionized water to field capacity. The yield was harvested when ripe. The experiment was performed without replications.

RESULT AND DISCUSSION

Various degrees of copper deficiency symptoms were brought about with the copper levels used in the experiment. Where no or insufficient copper was applied deficiency symptoms were marked, and appeared at an early stage in the plant stand, which remained green throughout. Withering of the leaf tips was most apparent in pots which had received 0, 0,1 and 0,5 mg Cu. Panicles did not form without copper and the plant stand did not ripen.

Panicle formation was limited at low levels of copper. The panicles had no grains, and the plant stand did not ripen. Moreover subsequent tillering was profuse, a phenomenon observed in Pendek in previous experiments (TÄHTINEN 1976). The length of the culm increased with increasing application of copper, except in the case of the largest amount applied.

The copper deficiency symptoms in Nip were stronger at the two lowest copper levels than in Pendek.

Copper application had a significant effect on the size of both grain and straw yield of oats (Fig. 1). At low copper levels, increases in the level stimulated only vegetative growth. When oats received sufficient copper for grain formation, the straw yield decreased. The maximum straw yield was thus obtained at a lower level of copper than the maximum grain yield.

The differences between varieties were clearest with the minimum application of copper necessary for grain formation, and in the rate at which

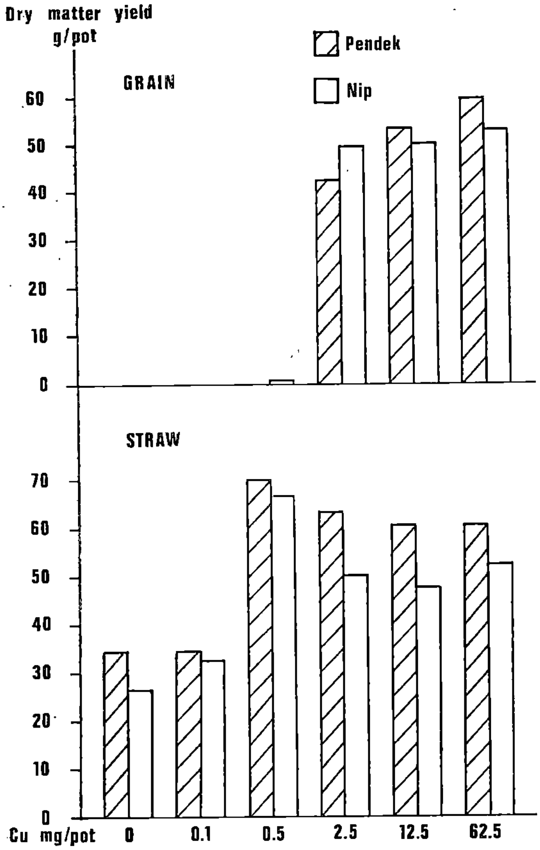

Fig. 1. The effect of different amounts of copper on the grain and straw yield of Pendek and Nip oat varieties.

the grain yield increased with further copper application. In Nip, grain formation began at a lower level of copper application (0,5 mg Cu/pot) than in Pendek. Likewise RADEMACHER (1940) observed in his study that brown oats were less sensitive to copper deficiency than white. With an application of 2,5 mg Cu, Nip was still able to develop a more abundant grain yield than Pendek. However, a higher application of copper did not significantly increase the yield of Nip. In contrast, the grain yield of Pendek rose steadily with increased copper application, and Pendek showed a higher capacity to re-translocate Cu from vegetative parts to grains. This also agrees with the findings of NAMBIAR's (1976 a and b) studies, according to which the cereal genotypes with the highest grain protein in normal grains are the most sensitive to copper deficiency. Other studies indicate that a high nitrogen/copper ratio in normally developed grains renders a variety sensitive to copper deficiency (CHAUDHRY and LONERAGAN 1970, DEKOCK et al. 1971)

At low levels of copper the increase of vegetative growth caused by Cu increments resulted in a reduction of the copper content of the straw yield. When the copper application was increased 5 and 25 times above the minimum required for grain formation, the copper content of the straw and particularly of the grain increased.

In this study, the copper content of the straw was high not only in the plant stands that had received sufficient copper but also in those suffering from a considerable copper deficiency, i.e.

Table 1. The copper content of the grain and straw dry matter, the copper yield, and the grain/straw ratios of the dry matter yield and of the copper yield.

			Cu applied mg/pot					
			0	0,1	0,5	2,5	12,5	62,5
Cu mg/kg	grain	Pendek ..	—	—	—	0,6	2,0	4,5
		Nip	—	—	..	1,3	2,5	4,4
Cu mg/kg	straw	Pendek ..	1,9	1,4	1,1	1,7	2,4	3,2
		Nip	2,4	2,3	1,4	1,9	2,6	3,7
Cu mg	grain	Pendek ..	—	—	—	0,3	1,1	2,7
		Nip	—	—	—	0,7	1,3	2,3
Cu mg	straw	Pendek ..	0,7	0,5	0,8	1,1	1,5	1,9
		Nip	0,6	0,8	0,9	1,0	1,2	1,9
Cu mg	grain + straw	Pendek ..	0,7	0,5	0,8	1,4	2,6	4,6
		Nip	0,6	0,8	0,9	1,7	2,5	4,2
Grain/straw ratio of the D.M. yield		Pendek ..	—	—	—	0,7	0,9	1,0
		Nip	—	—	0	1,0	1,1	1,0
Grain/straw ratio of the Cu yield		Pendek ..	—	—	—	0,3	0,7	1,4
		Nip	—	—	..	0,7	1,1	1,2

the copper content of the straw yield did not reflect a deficiency. Even the copper content of the grain is less closely associated with copper deficiency than is the grain/straw ratios of the dry matter yield, or of the copper uptake (Table 1). The amount of copper in the grain and straw yield clearly increased as more copper was applied to the plants. The copper yield for the varieties studied was nearly the same at each level of application.

As for Pendek, the results support the findings of SCHARRER and SCHAUMLÖFFEL (1960), who state that in cases where there was a copper deficiency the copper yield of the straw was greater than the copper yield of the grain.

Pot experiments permit determination of the reaction of different varieties to copper deficiency and copper uptake, provided that the amounts of copper applied range from the minimum required by the varieties for grain formation to a level in excess of the maximum genetic capacity. A low copper content in the substrate is essential for successful comparison.

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SELOSTUS

Viljalajikkeiden kuparintarpeen toteaminen astiakokeessa

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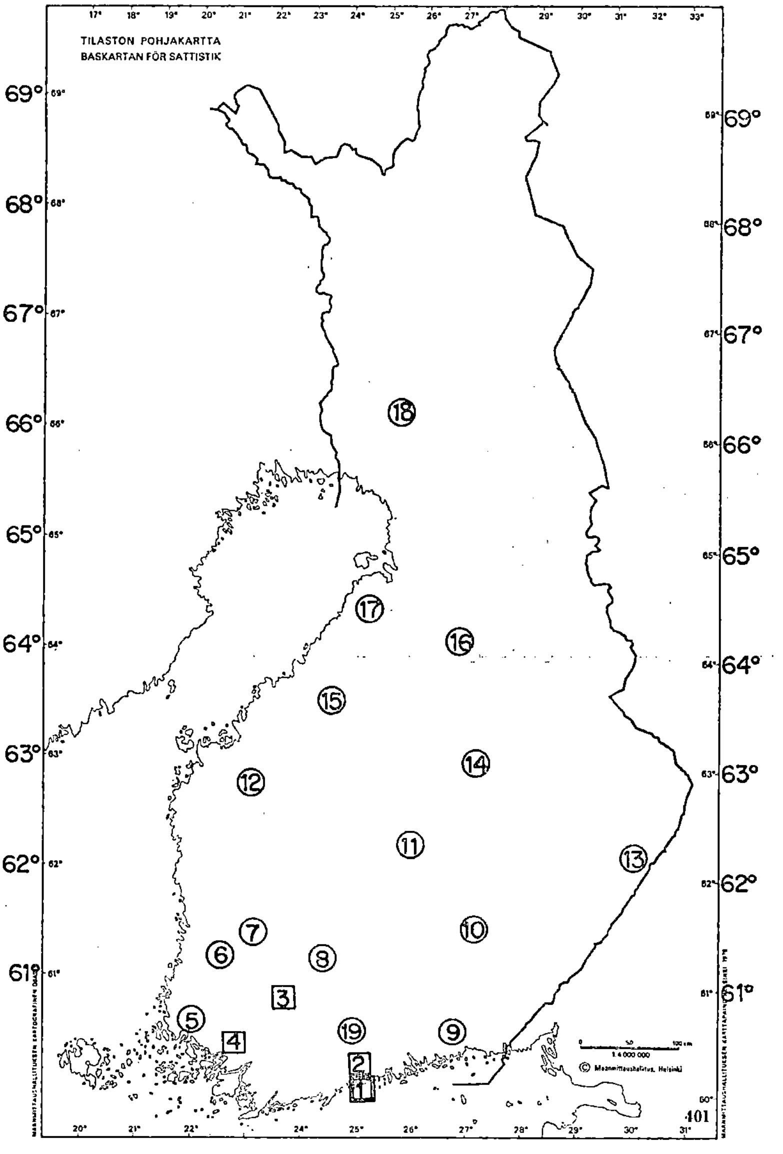
Maatalouden tutkimuskeskus

Kasvualustana oli vähän kuparia sisältävä saraturve, jolle annettiin lannoituksena kuusi eri kuparimäärää.

Heikkosatoinen, ruskeakuorinen Nip tuotti jyviä vähäisemmällä kuparilannoituksella kuin Pendek. Vaikka nämä lajikkeet ottivat lähes yhtä paljon kuparia, lannoitusta lisättäessä Nipin jyväsato ei kuitenkaan lisääntynyt, kun taas Pendekin jyväsato nousi kuparilannoituksen myötä. Lajike-erot näkyivät selvimmin puutteen aiheuttamassa jyväsadon alenemisessa, sen nopeudessa ja jyvänmuodostuksen kuparilannoitustarpeen vähimmäismäärässä.

Jyvä- ja olkisatojen suhde sekä niiden ottamien kuparimäärien suhde ilmaisivat paremmin kauran kuparin puutteen kuin jyvä- tai olkisatojen kuparipitoisuudet.

Astiakokeissa voidaan todeta kuparin puutteen herkkyydessä ilmeneviä lajike-eroja. Tällöin on käytettävä useita kuparimääriä, jotka vaihtelevat jyvien muodostuksen minimitarpeesta kasvun maksimin edellyttämään tasoon saakka.



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