Watsonia, 8, 277–288 (1971).

A cytotaxonomic study of *Lamiastrum galeobdolon* (L.) Ehrend. & Polatschek in Britain

S. WEGMÜLLER

Nidau, Switzerland

ABSTRACT

An account is given of the distribution and variation of the diploid and tetraploid subspecies of *Lamiastrum galeobdolon* (L.) Ehrend. & Polatschek in Britain. The tetraploid subspecies is the common plant; the diploid has been found in two localities only, both in N. Lincolnshire. The taxonomic distinction between the two subspecies is shown to be difficult, and the discriminatory value of several characters is considered in detail.

INTRODUCTION

Until recently, the Yellow Archangel was classified either as a species of the Linnaean genus *Lamium* under the name *Lamium galeobdolon* (L.) Nath. or in the genus *Galeobdolon* Adanson (1763) as *G. luteum* Hudson. Both of these treatments are to be found in the numerous Floras of Britain. Lindley (1835), Babington (1843), Irvine (1858) and the authors of the older county Floras adopt the former treatment, while the latter course is followed by Hudson (1778), Withering (1830), Deakin (1845), Clapham, Tutin & Warburg (1962) and the authors of the more recent county Floras.

On the evidence of new research into Bentham's Sectio IV Galeobdolon (Adans.) Benth. (Bentham 1832–36, 1848), Polatschek (1966) came to the conclusion that the treatment of this plant as a monotypic genus was justified. He pointed out that the generic name *Galeobdolon* was invalid, being a *nomen superfluum*, since Heister in 1759 had validly published the name *Lamiastrum* in the *Enumeratio* of Fabricius under the heading of the pre-Linnaean genus *Galeobdolon* Dill. The new generic name *Lamiastrum* Heister ex Fabr. with the single species *Lamiastrum galeobdolon* (L.) Ehrend. & Polatschek was used in the second edition of the *Excursion Flora of the British Isles* by Clapham, Tutin & Warburg (1968).

According to previous studies, and in particular to more recent cytotaxonomic investigations in northern and central Europe (Turesson 1938, Polya 1949, Gutermann 1962, Gadella & Kliphuis 1963, Dersch 1964, Polatschek 1966), the collective species *Lamiastrum galeobdolon* includes at least three taxa, one tetraploid and two diploid, which are defined as subsp. *montanum* (Pers.) Ehrend. & Polatschek, subsp. *galeobdolon* and subsp. *flavidum* (Herm.) Ehrend. & Polatschek respectively.

In Britain, the Yellow Archangel extends over wide areas of England and Wales (Perring & Walters 1962). It is rare in Cornwall and near the west coast of Wales and in the East it is absent from Breckland and Fenland. The northern limit of its unbroken distribution is in a line from the Humber to Morecambe Bay. Several isolated localities in southern Scotland recorded in the *Flora of the British Isles* (Clapham, Tutin & Warburg 1962) are considered as 'doubtfully native'.

During a preliminary investigation carried out in the Botany School, Cambridge, partly as a class exercise for the Part II Course in 1967 and 1968, some British material of known wild origin was brought into cultivation and examined cytologically. Several tetraploids were found, and two samples, kindly collected locally by Mrs M. and Miss A. Smith of Willoughby, near Alford, Lincolnshire, were found to be diploid. This material provided the basis for the present study, which aims to examine the different forms of the collective species *Lamiastrum galeobdolon* in England and Wales, to determine their chromosome numbers, to assess the extent of variation in the characters of the taxa, and to establish whether fundamental morphological differences are related to the ploidy level. During the summer of 1969 plants collected in England and Wales were grown in the experimental area of the University Botanic Garden at Cambridge. Chromosome counts were prepared as follows: the root-tips were pretreated for 3 or 4 hours with a saturated solution of 1-Bromo-Naphthalene, fixed in alcohol—acetic acid 'glacial' 3:1, hydrolyzed for 7–9 minutes in 10% HCl at a temperature of 60°C, then stained in aceto-carmine and finally squashed. The voucher specimens of the plants examined have been placed in the Herbarium of the Cambridge Botany School (**CGE**), and stocks of living material are held in the University Botanic Garden, Cambridge.

TAXONOMY AND NOMENCLATURE

Persoon (1795) was the first to differentiate two Yellow Archangels when he described alongside his *Pollichia vulgaris* a new species, *Pollichia montanum*. Later, he regarded them as varieties (1807). Babington (1843) in his *Manual of British Botany* under *Lamium galeobdolon* described two different taxa, these being '*Galeobdolon montanum* Reich.' and '*Galeobdolon luteum* Reich.', but he added that he had not seen the latter in Britain – 'in our plant the lower leaves are coarsely and even doubly serrate'. Reichenbach (1830–32) had mentioned both taxa in his *Flora germanica excursoria* and referred especially to subsp. *montanum*. Druce (1927) remarks correctly in *The Flora of Oxfordshire*: 'Our plant is not *Galeobdolon luteum* Reichb., but *Galeobdolon montanum* Reichb., with small bracts.' On the whole, most authors of British Floras have not taken into account the division of the species.

Turesson (1938) recognised two different ploidy levels in *Lamiastrum galeobdolon* and equated these with the two taxa. Dersch (1964) came to the conclusion that the two taxa could only be given the rank of subspecies since variation in different characters shows overlapping. Polatschek (1966) agreed with these conclusions and clarified the nomenclature.

CHROMOSOME COUNTS

Numerous chromosome counts have been published for both subspecies from central and northern Europe. These are as follows:

subsp. *galeobdolon*: $2n = 2x = 18$
Turesson (1938), Southern Sweden and Latvia; Polya (1949), Hungary; Dersch (1964), Germany.

subsp. *montanum*: $2n = 4x = 36$
Jörgensen (1927), unlocalised; Turesson (1938), Munich; Gutermann (1962), Southern Germany; Gadella & Kliphuis (1963), Netherlands; Dersch (1964), Germany; Polatschek (1966), Austria and Czechoslovakia.

Polatschek (1966) in a survey provides more detailed information about his individual localities.

The chromosome counts (see Appendix) of plants from England and Wales include both diploids and tetraploids and agree with those already published.

Figure 1 shows the localities of the plants examined. In spite of intensive investigations, diploid plants could only be found in two localities, both in north Lincolnshire. Plants from localities further west in the same vice-county are tetraploid.

Special attention was paid to the *Lamiastrum* localities in Surrey and West Kent on greensand areas, since Britton (1926) mentions the two varieties growing side by side in Surrey. However Britton incorrectly interpreted Persoon's

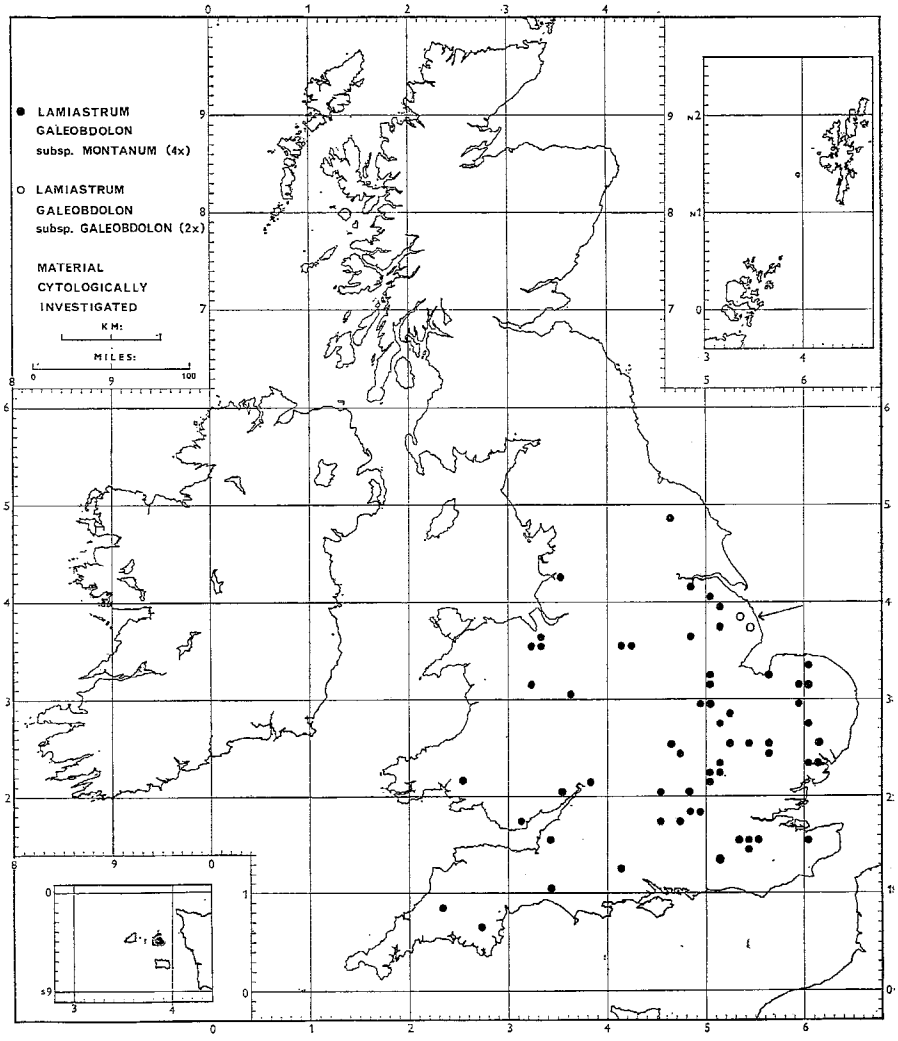

FIGURE 1. Distribution of cytologically investigated material of *Lamiastrum galeobdolon* in England and Wales.

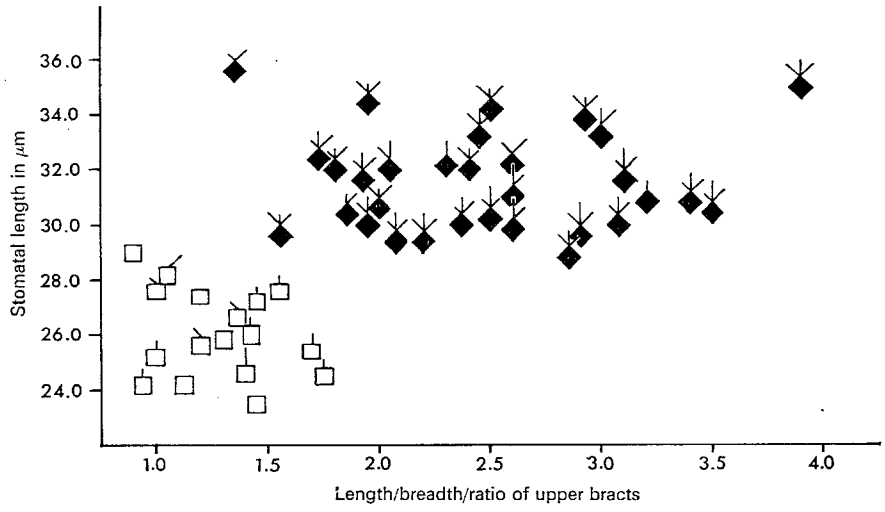

FIGURE 2. Scatter diagram of stomatal length and the length/breadth ratio of the upper bracts.

Key

Lamiastrum galeobdolom subsp. *galeobdolon* (2*x*) .. □

subsp. *montanum* (4*x*) .. ◆

No. of flowers per whorl
- up to 8 .. .. .. ◆
- more than 8 .. .. ◆

Margin of the upper bracts
- crenate or crenate-serrate .. ◆
- serrate-crenate .. ◆
- serrate .. .. .. ◆

Stolon leaf-base shape
- truncate .. .. .. ◆
- cordate .. .. .. ◆
- rounded or shortly attenuate .. ◆

taxa, and the material collected in this area proved to be uniformly tetraploid.

When collecting the specimens, special attention was also paid to plants with intermediate characters, but no triploid hybrids could be identified. This observation agrees with the findings of Dersch (1964).

MORPHOLOGY

Plants of the two different ploidy levels were examined carefully, concentrating on the following morphological characters: number of whorls per inflorescence; number of flowers per whorl; shape and margin of bracts and stolon leaves;

hairiness of the stem; size of flowers; length of pollen and stomata. An attempt was made to establish as far as possible the degree of variation of the individual characters. Tables 1–3 show, that as in the results of Dersch (1964), single characters cannot be used to distinguish the two subspecies.

TABLE 1. INFLORESCENCE CHARACTERS

	Number of whorls per inflorescence				Maximum number of flowers per whorl		
	2	3	4	5 or more	5 or 6	7 or 8	more than 8
subsp. *galeobdolon* $2n = 2x = 18$	3·7	59·3	22·2	14·8	51·9	44·9	3·7
subsp. *montanum* $2n = 4x = 36$	2·7	15·2	33·9	48·2	8·9	14·3	76·8

Values expressed as a percentage of 27 plants from 5 populations of subsp. *galeobdolon* and of 112 plants from 63 populations of subsp. *montanum*. All material collected in the field.

POLLEN SIZE

The average pollen-length derived from 100 measurements of 12 plants of both taxa gave the following results:

subsp. *galeobdolon* (2*x*) 32·31 – 34·82 μm
subsp. *montanum* (4*x*) 33·46 – 38·35 μm

A separation of the two subspecies on the basis of the pollen size is not possible, a result which agrees with that of Polatschek (1966).

STOMATAL LENGTH

The lengths of 50 stomata from the uppermost pair of stem leaves and the lowest pair of bracts were measured and the averages calculated.

	subsp. *galeobdolon*	subsp. *montanum*
Number of plants examined	30	60
Number of averages (n_1, n_2)	30	60
Range of averages	23·48 – 29·66 μm	28·77 – 37·59 μm
Means ($\bar{x}_1$, $\bar{x}_2$)	26·118 μm	31·237 μm
Variance (σ_1^2, σ_2^2)	2·583	2·293
Standard deviation (σ_1, σ_2)	1·607	1·514
Range within σ	24·51 – 27·72 μm	29·72 – 32·75 μm
Range within 2σ	22·90 – 29·33 μm	28·21 – 34·26 μm
Difference of the means ($\bar{x}_2 - \bar{x}_1$)	5·119 μm	
Standard deviation of the difference of means (σ_d)	0·352	

The difference between the two means is significant.

The averages of stomatal length have been used along with the length/breadth ratio of upper bracts (Table 2) to construct a scatter diagram (Fig. 2).

TABLE 2. SHAPE OF UPPER BRACTS (LENGTH / BREADTH RATIO)

	1·0–	1·2–	1·4–	1·6–	1·8–	2·0–	2·2–	2·4–	2·6–	2·8–	3·0–	3·2–	3·4–	3·6–	3·8–
subsp. *galeobdolon* $2n = 2x = 18$	6·7	36·6	43·3	6·7	6·7										
subsp. *montanum* $2n = 4x = 36$		0·9	2·7	8·1	13·5	14·5	9·0	22·5	6·3	6·3	9·0	4·5	0·9	0·9	0·9

Values expressed as a percentage of 30 plants from 5 populations of subsp. *galeobdolon* and of 111 plants from 63 populations of subsp. *montanum*. All material collected in the field.

TABLE 3. CHARACTERS OF UPPER BRACTS AND STOLON LEAVES

	Upper bracts						Stolon leaves						
	margin				teeth		margin				base		
	cr	cr–s	s–cr	s	close together	widely separated*	cr	cr–s	s–cr	s	cordate	truncate	rounded or shortly attenuate
subsp. *galeobdolon* $2n = 2x = 18$	7·7	30·8	46·1	15·4	80·8	19·2	66·7	20·8	12·5	—	20·8	70·8	8·4
subsp. *montanum* $2n = 4x = 36$	—	2·4	29·0	68·6	33·8	66·2	11·6	29·5	41·1	17·8	36·6	15·2	48·2

Abbreviations: cr = crenate s = serrate cr–s = crenate–serrate

* See Fig. 3.

Values expressed as a percentage of 26 plants from 5 populations of subsp. *galeobdolon* and 124 plants from 63 populations of subsp. *montanum*. All material collected in the field.

The morphology of the two subspecies is compared in the following Table.

TABLE 4. COMPARISON OF THE CHARACTERS OF BOTH SUBSPECIES IN BRITAIN

	subsp. *galeobdolon* (2*x*)	subsp. *montanum* (4*x*)
habit	plant usually 15–45 cm	plant, more vigorous 20–60 cm
hairiness of the stem	stem, especially at the base, with deflexed, appressed hairs mainly on the angles	stem, especially at the base, with deflexed scattered hairs on the flat areas and on the angles
stolon leaves:		
shape	orbicular or ovate; base truncate or cordate	ovate, rarely orbicular; base shortly attenuate, rounded or cordate
margin	regularly crenate or crenate-serrate; terminal tooth rounded	irregularly serrate-crenate to serrate; terminal tooth acute
upper bracts:		
shape	ovate; 1/b ratio 1·0–2·0	narrowly or broadly lanceolate, rarely ovate; 1/b ratio (1·2–)1·8–3·5
margin	regularly crenate or bicrenate or serrate; often deeply incised	serrate or biserrate or serrate-crenate; teeth usually widely separated; terminal tooth long and acute
number of whorls per inflorescence	2–4 (5)	(3) 4–7(–10)
number of flowers per whorl	up to 8	more than 8
length of flowers (measured from the base of calyx)	17–21 mm	18–25 mm
stomatal length (see p. 281)	22·9–29·3 μm	28·2–34·3 μm

Many intermediate forms occur (Fig. 3). Poorly developed plants from tetraploid populations can often look very similar to the diploid plants, especially when the bracts are crenate. On the other hand, diploid plants with sharply serrate subtending bracts can resemble tetraploids. Thus, although a positive decision on the basis of a combination of characters is usually possible there exist cases which demand measurements of stomatal length or even an analysis of chromosome numbers for a precise identification.

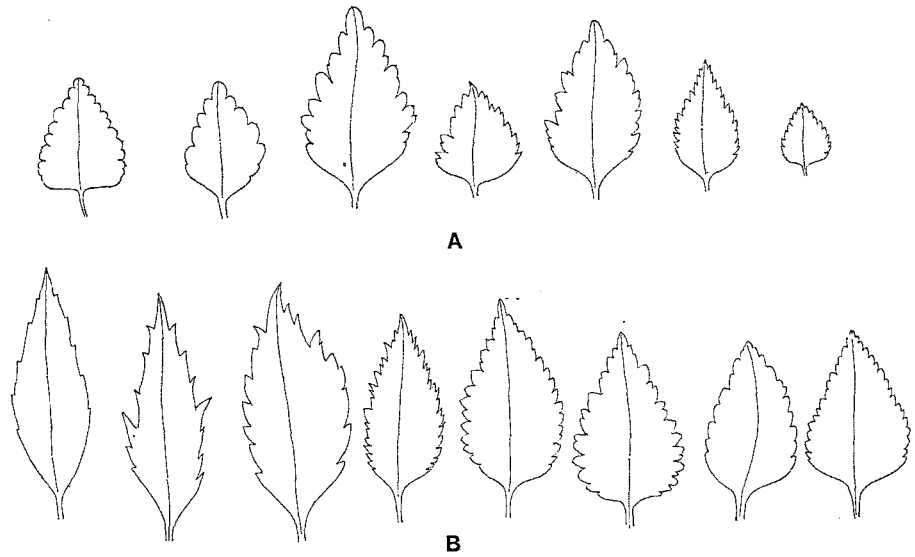

FIGURE 3. Variation in shape and marginal teeth of upper bracts.
A. Range of examples of subsp. *galeobdolon*.
B. Range of examples of subsp. *montanum*.

HABITAT

Lamiastrum galeobdolon sensu lato is a plant of woods and hedges. Subsp. *montanum* favours rich, deep soils above a great variety of underlying rocks. It is widespread in Britain in beech woods, especially over limestone, and in oak-ash woods, where it is frequently found in association with *Mercurialis perennis*, *Endymion non-scriptus*, *Allium ursinum*, *Anemone nemorosa*, *Arum maculatum*, *Primula vulgaris*, *Sanicula europaea*, *Ajuga reptans*, *Asperula odorata* and *Circaea lutetiana*. It is also able to grow on moderately acid soils in *Castanea sativa* coppices and sometimes colonizes disturbed places. In woods where subsp. *montanum* is rare, it is usually found at the eastern or northern margin.

Subsp. *galeobdolon* also flourishes on deep soils in north Lincolnshire. The few populations studied do not allow valid assertions as to its ecological requirements. Therefore, only a few of the observations made on these populations are given here. The plants of the different populations had already flowered by May 13th and had almost ceased to bloom by May 31st. By the beginning of July, two populations were found to be dying off, as they were completely overgrown, by *Pteridium aquilinum* and *Epilobium angustifolium* in one case at the edge of the wood and by *Rubus* in the other. It appears that, on account of their early and quick development, the plants of subsp. *galeobdolon* are able to occupy habitats which later support other species. Turesson (1930) established that subsp. *galeobdolon* flowers earlier than subsp. *montanum*.

DISTRIBUTION

In the Herbaria of the British Museum (Natural History) (**BM**) in London and of the Royal Botanic Gardens, Kew (**K**), specimens of both subspecies have been seen from the following countries:

subsp. *galeobdolon:* southern Sweden; southern Finland; Estonia; western European Russia; Poland; Denmark; central Germany; Czechoslovakia; Hungary, Ukraine; Romania; Yugoslavia; Bulgaria; Greece (Macedonia) and European Turkey.

subsp. *montanum:* central Germany; Holland; Belgium; northern, central, western and south-west France (Pyrenees); north-east Spain (Pyrenees); Switzerland; Austria; Czechoslovakia; southern Poland; Hungary; Yugoslavia (Bosnia, Herzegovina); Greece (Macedonia) and Italy (Apennines).

In Britain, subsp. *galeobdolon* could only be found in north Lincolnshire. This distribution in eastern England recalls that of a few other species occurring both in Scandinavia and Continental Europe, e.g. *Maianthemum bifolium* (L.) Schmidt. Subsp. *montanum* is the widely distributed Yellow Archangel of Britain.

LAMIASTRUM GALEOBDOLON SUBSP. *FLAVIDUM*

This Yellow Archangel without stolons was described by Hermann (1958) and later cytotaxonomically examined by Gutermann (1962), Dersch (1964) and Polatschek (1966). The plant is diploid, the number of chromosomes being $2n=2x=18$. For purpose of comparison two plants of subsp. *flavidum* were grown in the University Botanic Garden at Cambridge and examined (see Appendix). The chromosome number was confirmed on this material. The following stomatal and pollen measurements were obtained:

Coll. No.	Pollen diameter (n=200)	Stomatal length (n=200)
149–67	31·84 μm	24·93 μm
246A–67	32·30 μm	25·75 μm

According to Polatschek, pollen measurements enable the separation of the diploid subsp. *flavidum* and the tetraploid subsp. *montanum*. Measurements of stomatal length produced averages which lie within the range of subsp. *galeobdolon*.

The typical characters of this subspecies are as follows: plant without stolons, bracts ovate to lanceolate, sharply serrate or biserrate, some of the teeth prominently curved, the lowest bracts more than twice as long as the internode below, number of flowers in a whorl more than 10, length of flowers 14–17 mm. Subsp. *flavidum* colonizes scree slopes and other open habitats from the montane up to the subalpine level. The distribution area extends from the southern Central Alps to the Eastern Alps, and south to the Apennines and the northern mountains of Yugoslavia (Polatschek 1966). In the Herbaria (**BM, K**) mentioned above, plants of subsp. *flavidum* have been seen from the following localities:

Central Alps	Italy	Valle di Formazza
	Austria	Gschnitztal
Eastern Alps	Austria	Kärnten, Steiermark
	Yugoslavia	Herzegovina

CROSSINGS

Dersch (1964) pointed to the possibility that subsp. *montanum* could be considered as an allotetraploid descendant of subsp. *galeobdolon* and subsp. *flavidum*, since it possesses characters of both subspecies. The presence of stolons and the greater length of flowers are perhaps from subsp. *galeobdolon*, the number of whorls, the number of flowers per whorl and also the prominent curved teeth of the bracts could be derived from subsp. *flavidum*. Polatschek (1966) supported this hypothesis by his scatter diagram, in which he revealed the intermediate position of subsp. *montanum*. The range of subsp. *montanum* lies geographically and altitudinally for the most part between the areas of subsp. *galeobdolon* and subsp. *flavidum*.

In the course of the summer of 1969 crossings were made in the Cambridge Botanic Garden between the two diploid subspecies and also the tetraploid, but only a few seeds were produced. Germination tests carried out have so far been unsuccessful. Even seeds pre-treated under refrigeration did not germinate, so that no results are yet available.

CONCLUSIONS

1. A cytotaxonomic study of the collective species *Lamiastrum galeobdolon* in England and Wales showed two subspecies with different ploidy levels.
2. The previously published chromosome numbers for subsp. *galeobdolon* ($2n=2x=18$) and subsp. *montanum* ($2n=4x=36$) were confirmed. Triploid hybrids were not found.
3. A separation of the subspecies is possible by a combination of characters, including averages of stomatal length.
4. Subsp. *galeobdolon* was only found in north Lincolnshire. Subsp. *montanum* is the common Yellow Archangel in Britain.

ACKNOWLEDGMENTS

This present study was made during a six months study period from April to September 1969 at the Botany School of the University of Cambridge. I am grateful to Professor P. W. Brian for providing laboratory facilities. I am greatly indebted to Dr S. M. Walters, who suggested this topic and encouraged me by his lively interest. With N. G. Marchant I have had many discussions on taxonomic problems and methods. For his helpful comments on the manuscript I am most grateful. I should also like to thank those people who have kindly collected living specimens and the Biological Records Centre, Monks Wood Experimental Station, Abbots Ripton, Huntingdon for preparing Fig. 1 from my data. My thanks go also to the Swiss National Fund, which by a financial grant made this period of study possible.

REFERENCES

ADANSON, M. (1763). *Familles des Plantes*. Paris.
BABINGTON, C. C. (1843). *Manual of British Botany*. London.
BENTHAM, G. (1832–1836). *Labiatarum Genera et Species*. London.
BENTHAM, G. (1848). *Labiatae*, in DE CANDOLLE, A. P. *Prodromus Systematis Naturalis . . .*, vol. 12, pp. 27–603. Paris.

BRITTON, C. E. (1926). Notes on some minor varieties of British plants. *J. Bot., Lond.*, **64**: 327–328.
CLAPHAM, A. R., TUTIN, T. G. & WARBURG, E. F. (1962). *Flora of the British Isles*, 2nd ed. Cambridge.
CLAPHAM, A. R., TUTIN, T. G. & WARBURG, E. F. (1968). *Excursion Flora of the British Isles*, 2nd ed. Cambridge.
DEAKIN, R. (1845). *Florigraphia Britannica*. London.
DERSCH, G. (1964). Zur Cytologie und Taxonomie der Goldnessel (*Lamium galeobdolon* (L.) L.). *Ber. dt. bot. Ges.*, **76**: 351–359.
DRUCE, G. C. (1927). *The Flora of Oxfordshire*. Oxford.
GADELLA, T. W. J. & KLIPHUIS, E. (1963). Chromosome numbers of flowering plants in the Netherlands. *Acta bot. neerl.*, **12**: 195–230.
GUTERMANN, W. (1962). Diploides *Lamium galeobdolon* (*s.l.*) in Bayern (vorläufige Mitteilung). *Ber. bayer. bot. Ges.*, **35**: 43–45.
HERMANN, F. (1958). *Lamium flavidum* nov. spec. in den Bayerischen Alpen. *Ber. bayer. bot. Ges.*, **32**: 145–146.
HUDSON, W. (1778). *Flora Anglica*, 2nd ed. London.
IRVINE, A. (1858). *The illustrated handbook of the British Plants*. London.
JÖRGENSEN, C. A. (1927). Cytological and experimental studies in the genus *Lamium*. *Hereditas* **9**: 126–136.
LINDLEY, J. (1835). *A Synopsis of The British Flora*. London.
PERRING, F. H. & WALTERS, S. M., ed. (1962). *Atlas of the British Flora*. London.
PERSOON, C. H. (1795). Botanische Beobachtungen aus einem Brief des Hr. Persoon an den Herausgeber. *Ann. Bot.* (*Usteri*), **14**: 33–39.
PERSOON, C. H. (1807). *Synopsis plantarum*, vol. 2. Paris.
POLATSCHEK, A. (1966). Cytotaxonomische Beiträge zur Flora der Ostalpenländer, 2. *Öst. bot. Z.*, **113**: 102–112.
POLYA, L. (1949). Chromosome numbers of some Hungarian plants. *Acta Geobot. Hung.*, **6**: 124–137.
REICHENBACH, H. G. L. (1830–1832). *Flora germanica excursoria*. Leipzig.
TURESSON, G. (1930). The selective effect of climate upon the plant species. *Hereditas*, **14**: 110–111.
TURESSON, G. (1938). Chromosome stability in Linnean species. *LantbrHögsk. Annlr*, **5**: 405–416.
WITHERING, W. (1830). *A Systematic Arrangement of British Plants*. London.

APPENDIX

ORIGIN OF MATERIAL

Lamiastrum galeobdolon (L.) Ehrend. & Polatschek
subsp. *galeobdolon* $2n = 18$
v.c. 54 North Lincoln
Welton High Wood

Population 1, mixed *Quercus robur* and *Acer pseudoplatanus* wood	GR 53/454699	No. 31A–69 No. 31B–69
Population 2, mixed forest, under *Acer pseudoplatanus*	GR 53/455700	No. 32A–69
Population 3, edge of wood under *Pteridium aquilinum* and *Epilobium angustifolium*	GR 53/456700	No. 33A–69 No. 33C–69
Population 4, mixed forest, by track	GR 53/455701	No. 138H–68
Burwell – Muckton, roadside	GR 53/370801	No. 71C–69

subsp. *flavidum* (Herm.) Ehrend. & Polatschek $2n = 18$
Austria

Kärnten, Plöckenpass ('locus classicus'), cultivated in the Botanic Garden at Munich	No. 149–67

Yugoslavia

Slovenija, Kämniske Alpe, limestone scrub *c* 1000 m on east side of Krvavec No. 246A–67

subsp. *montanum* (Pers.) Ehrend. & Polatschek $2n = 36$

The chromosomes of 72 specimens of this subspecies, all from England and Wales, have been counted. Their distribution from the following vice-counties is shown in Fig. 1.

Vice-counties 2, 3, 6, 8, 9, 12, 15–17, 19, 20, 22–34, 39–41, 44, 47, 50, 51, 53, 54, 57, 59, 60, 62

Details of these localities have been given to the Biological Records Centre, Monks Wood Experimental Station, Abbots Ripton, Huntingdon.