# A new hybrid between a European and a Chinese species of *Artemisia* (Asteraceae)

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ABSTRACT

A new hybrid, ***Artemisia* × *wurzellii*** C. M. James & Stace **hybr. nov.**, is described between *A. vulgaris* and the Chinese *A. verlotiorum*. Fifteen localities are known in eastern London, and one in northern West Kent, but there is no convincing evidence that the hybrid arose *in situ* at any of them. Characters distinguishing the three taxa are summarized. Chromosome counts indicate that *A. vulgaris* is a hypodiploid and *A. verlotiorum* a hypohexaploid. *Artemisia* × *wurzellii* has the expected chromosome number 2n = 34 (hypotetraploid).

KEYWORDS: Mugwort, Chinese Mugwort.

## INTRODUCTION

The genus *Artemisia* L. (Asteraceae) is traditionally divided into three to six subgenera or sections, one of which has more recently been recognised as the separate genus *Seriphidium* Fourr. (Bremer & Humphries 1993). Various estimates put the number of species at 300–400, distributed in most temperate parts of the world. In the former U.S.S.R. Poljakov (1961) recognised 116 species in *Artemisia* sensu stricto, with a further 58 in *Seriphidium*. In China, Ling (1988) listed 186 species in *Artemisia* sensu stricto. Tutin *et al.* (1976) recognized 54 native European species in *Artemisia* sensu lato, of which only five reach the British Isles (four in *Artemisia* sensu stricto, one in *Seriphidium*). In addition, 17 species of *Artemisia* and one of *Seriphidium* have been reported as aliens in the British Isles (Clement & Foster 1994).

Hybrids are evidently rare in *Artemisia*, few having been reported. Of these, most are sporadic in occurrence and several are dubious in identity. However, Kawano *et al.* (1995) reported triploid hybrids (2n = 27) between *A. capillaris* Thunb. ex Murray (2n = 18) and *A. japonica* Thunb. ex Murray (2n = 36) in Japan, and found evidence for the existence of backcrosses.

Of the two species relevant to the present paper, *A. verlotiorum* Lamotte is native to S.W. China according to Brenan (1950), while *A. vulgaris* L. is almost circumboreal, being native to both the British Isles and China. Ling (1988) placed the two species in adjacent series of subgenus *Artemisia* section *Artemisia*. *A. verlotiorum* is treated as one of four species in series *Codonocephalae* (Pamp.) Y. R. Ling, and *A. vulgaris* as one of 16 species in series *Artemisianae* Y. R. Ling (but correctly to be known as series *Artemisia*). Diagnostic characters of the series were not given. Ling (1988) also gave a much wider distribution for *A. verlotiorum* in southern and south-eastern Asia.

*Artemisia verlotiorum* occurs as a naturalized alien in many parts of Europe as well as in Australia and South America (Ryves 1984), presumably originating as an escape from herb-gardens. Bini Maleci & Bagni Marchi (1983) reported on a morphological-anatomical comparison of *A. verlotiorum* and *A. vulgaris* growing near Florence. The early occurrences in Britain were listed by Brenan (1950), who also provided a detailed description and bibliography. The first record was from Hounslow, Middlesex, made by C. G. Green in 1908 (OXF), and in the 1940s it was recorded widely in metropolitan Surrey and Middlesex, many of the new sites being discovered by D. H. Kent (Brenan 1950). By 1962 it was known as far north and west as W. Norfolk and Dorset respectively (Perring & Walters 1962), and today it occurs north to Easterness and Moray in northern Scotland (Vice-county Census Catalogue data in B.S.B.I. Database at Leicester). It is still most common, however, in the Greater London area, where it occurs on all kinds of rough ground, often with *A. vulgaris* very close by.

The putative hybrid between these two species was first found by B.S.W. in August 1987 on an overgrown railway bank by Northumberland Park Station, Tottenham, Middlesex (Wurzell 1988). Between then and 1995 B.S.W. discovered 13 additional localities for the putative hybrid in eastern London, and one other has been reported there (see below). Although these localities occur in three hectads (TQ/3.7, TQ/3.8 and TQ/3.9) and three vice-counties (Surrey, Middlesex, S. Essex), and come within a few hundred metres of W. Kent, the total area of known distribution in London covers only about 14 × 7 km. Elsewhere it has been recorded only in one outlying locality in W. Kent (see below).

Living and herbarium material of the putative hybrid was sent by B.S.W. in 1987 to Leicester, where it was studied by C.M.J. and C.A.S. in 1987 and 1988, and since then by C.A.S. This paper presents the evidence for its putative parentage and describes the hybrid as *A.* × *wurzellii*.

## MATERIALS

Living plants of the putative hybrid were obtained from the original locality at Northumberland Park Station, Middlesex (TQ/34.91) and from near Walthamstow Marshes, S. Essex (TQ/35.87); of *A. verlotiorum* from Tottenham, Middlesex (TQ/34.90), and Abersoch, Caerns. (SH/31.27); and of *A. vulgaris* from Tottenham, Middlesex (TQ/34.90), near Bromsgrove, Worcs. (SO/98.68), and central Leicester, Leics. (SK/59.04).

Herbarium material of the two species in **LTR** was also used for comparative purposes.

## METHODS

Stem sections were cut on a freezing microtome at 25 µm thick from a mid-region of the stem, which was about 5 mm wide at that point.

Chromosome counts were obtained from root-tip mitoses using standard squash techniques. Pre-treatment was with 0.002M 8-hydroxyquinoline at 4° C for 24h, fixation in ethanol : ethanoic acid (3:1) for 2h, hydrolysis with 5M HCl for 6–10 min at room temperature, and staining with aceto-orcein.

## RESULTS

Brenan (1950) provided a full description of *A. verlotiorum* and a detailed table contrasting it with *A. vulgaris*. All these differences are not repeated here, but the ones that were found to be most useful in separating the two species and in recognizing intermediates (hybrids) are covered below (see also Table 1).

### VEGETATIVE MORPHOLOGY AND ANATOMY

The putative hybrids are generally intermediate between the parents in overall appearance, although most of the characters of the leaves are difficult to quantify precisely. This is partly because it is not easy to designate strictly comparable leaves on different plants, and partly because of variation (mainly temporal and developmental, perhaps also environmental). We found it essential to compare only the *middle stem-leaves of mature flowering shoots*. Such leaves, in

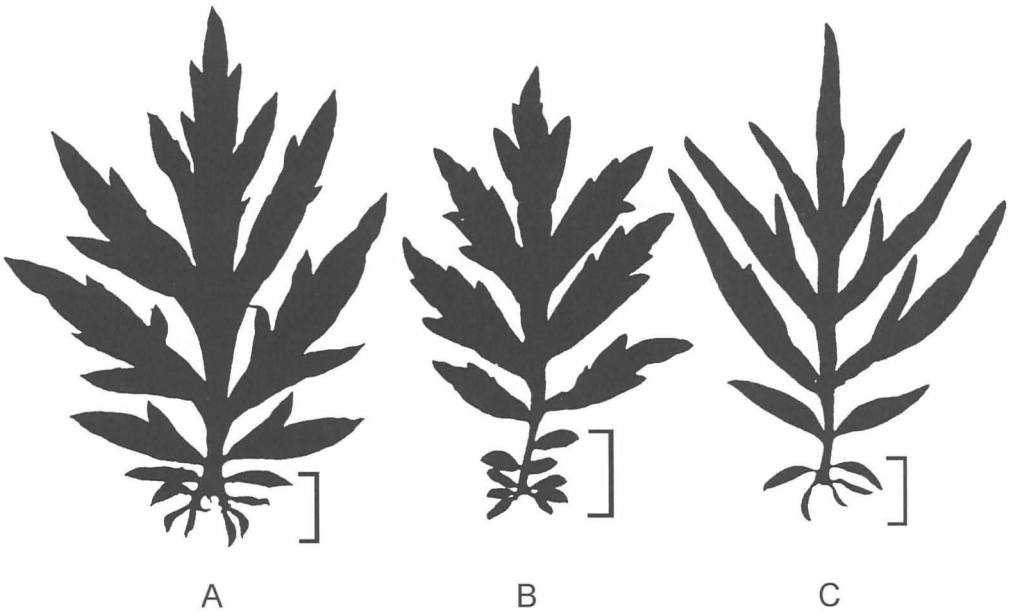


FIGURE 1. Middle stem-leaves of mature flowering shoots of (A) *Artemisia vulgaris*, (B) *A.* × *wurzellii* and (C) *A. verlotiorum*. The petiolar pectinations are delimited with ']'.

both parents and hybrid, conform to a basic pattern in which a single more or less trifid terminal lobe decurrently connects with three pairs of variously incised lateral lobes which, in their turn, lead downwards to a much smaller group of pectinate appendages (here called "petiolar pectinations") attached to that lowest section of the midrib that serves as the petiole (Fig. 1). The leaves of *A. verlotiorum* have narrower primary lobes with fewer secondary lobes and serrations than those of *A. vulgaris*, giving the impression that the former has longer leaf-lobes (although this is often not so). There is, however, overlap, and the putative hybrids overlap with both parents as well. Brenan (1950) found the same: "Segments of upper leaves *usually comparatively* short, lanceolate to oblong or linear" (*A. vulgaris*); "Segments of upper leaves conspicuously elongate, linear-lanceolate to linear" (*A. verlotiorum*) (our italics). Bini Maleci & Bagni Marchi (1983) also expressed the differences in only comparative terms: "Foglie *polimorfe*; quelle *tipiche* pinnatofide con lobi larghi, dentati ed auricole sviluppate" [leaves polymorphic, typically with wide, dentate lobes] (*A. vulgaris*); "Foglie *polimorfe*; quelle *tipiche* pinnatofide con lobi stretti ed allungati, non dentati ed auricole poco sviluppate" (*A. verlotiorum*) (our italics). We found the best discriminators to be the length:breadth ratio of, and the number of serrations on, the main apical segment of a middle stem-leaf of a mature flowering shoot (Table 1). Even so, there is some overlap in ranges, and the putative hybrids are closer to *A. vulgaris* than to *A. verlotiorum* in the leaf segment length:breadth ratio.

The petiolar pectinations (Fig. 1) also provide a useful field character for detecting the hybrid. In *A. verlotiorum* they are narrow and few, but in each population of the hybrid so far examined they are broader, shorter, more abruptly acute and more numerous (Table 1); thus they have served well to distinguish these two rhizomatous taxa at a glance. The constancy of this feature in the hybrid might well indicate that we are here dealing with a single clone. Sexually reproducing *A. vulgaris*, in contrast, presents petiolar pectinations ranging between or even beyond those of the other two taxa in shape and number.

*Artemisia verlotiorum* is more strongly aromatic than *A. vulgaris*, and Bini Maleci & Bagni Marchi (1983) found that the former had 4–5 times as high a density of glands on the lower leaf-surface (c. 20/mm$^2$ compared with 6–7/mm$^2$). However, the very dense hair-covering present in both species, and the difficulty of removing it, render this character of limited practical use in identification.

According to the material we have examined, the nature of the stem pith (i.e. the tissue interior to the ring of vascular bundles) differentiates the two species. In both, the pith region comprises a central area of large, thin-walled, lignified cells (white in the fresh state) surrounded by a zone of smaller, even thinner-walled, non-lignified, chloroplasted cells (green in the fresh state). In *A. vulgaris* the white pith occupies a much greater proportion of the whole than in *A. verlotiorum*, and in the putative hybrid the situation is almost exactly half-way between the two. We found this to be the best single quantitative character separating the two species and the putative hybrid (Table 1), but it should be remembered that we have not examined a large number of specimens. Brenan (1950) also noted this character, but only in terms such as "relatively broad". He also claimed that the young stem of *A. verlotiorum* was more deeply furrowed than that of *A. vulgaris*, but this was not confirmed by our observations.

The two species have an obviously different growth-habit, *A. verlotiorum* being extensively rhizomatous and *A. vulgaris* clump-forming (with very short rhizomes). The putative hybrid more closely resembles *A. verlotiorum* in this respect; both can, in favourable circumstances, become quite invasive.

There are fairly reliable differences between the inflorescences of the two species. In *A. vulgaris* the inflorescence is more branched, with longer, straighter branches, and leafy only at the base, whereas in *A. verlotiorum* the branches are fewer and usually somewhat recurved, and the inflorescence is conspicuously leafy almost to its apex. The putative hybrid is intermediate in these characters, especially in inflorescence leafiness, although many more measurements would have to be made before ranges could be allotted with confidence to the three taxa.

CAPITULUM CHARACTERS

The capitula of *A. vulgaris* are usually obovoid-campanulate (i.e. widest distally), whereas those of *A. verlotiorum* are usually ovoid-ellipsoid (i.e. not wider distally than elsewhere), as pointed out by Brenan (1950) but using a different terminology. The difference, however, is not marked and is

TABLE 1. CHARACTERS DIFFERENTIATING *ARTEMISIA VULGARIS*, *A. VERLOTIORUM* AND THEIR HYBRID, *A.* × *WURZELLII*

| | *A. vulgaris* | *A.* × *wurzellii* | *A. verlotiorum* |
|---|---|---|---|
| Length:breadth ratio of apical segment of mid-stem leaf | 5·0–6·1 | 4·4–7·0 | 9·5–15 |
| No. of serrations on apical segment of mid stem-leaf | 6–10 | 3–5 | 1–2 |
| Petiolar pectinations | 2–8 on each side, lanceolate, acuminate, 5–6 × as long as wide | (4)5–6(8) on each side, ovate to obovate or narrowly so, acute, 2–4(5) × as long as wide | 2–3 on each side, lanceolate to narrowly so, acuminate, 5–7 × as long as wide |
| White pith as % diam. of total pith | 80–89 | 54–69 | 33–38 |
| Growth habit | tufted | rhizomatous | rhizomatous |
| No. of leaves in top 20 cm of infl. | 9–17 | 18–24 | 25–32 |
| Capitulum shape | obovoid-campanulate | ovoid-ellipsoid | ovoid-ellipsoid |
| Length & breadth of capitulum (mm) | 3·1–3·7 × 2·1–2·5 | 1·8–2·4 × 1·6–1·8 | 3·5–4·2 × 2·4–3·0 |
| Width of 'bisexual' florets (mm) | 0·25–0·3 | 0·2–0·3 | 0·4–0·51 |
| No. of stamens in 'bisexual' flowers | 5 | 0 | 5 |
| Receptacle shape | conical | ± spherical | low-domed |
| Flowering time | July-September | October | October-November |
| Seed-set in Britain | yes | no | no |
| Chromosome no. | 2n = 16 (? also 18) | 2n = 34 | 2n = 50, 52 (? also 48, 54) |

difficult to quantify. The putative hybrid is much closer to *A. verlotiorum* in this respect. Brenan's measurements for the two species broadly agree with the ranges seen by us, but the capitula of the putative hybrid are smaller than in either species (mean 2·1 × 1·7 mm) (Table 1).

Differences in both the peripheral female and inner bisexual florets in the two species were also recorded by Brenan (1950). There are usually some additional abortive bisexual florets right in the centre of the capitulum. Brenan found (2) 5–22 and (0) 2–6 (11) bisexual florets for *A. vulgaris* and *A. verlotiorum* respectively, but our figures (5–8 and 4–8) did not confirm these differences; our range for the putative hybrid was 4–7. Our results do, however, confirm a difference in the widths of the bisexual florets of the two species (Table 1); the putative hybrid has narrower florets than in either parent.

Like Brenan (1950), we found no differences in the numbers of glands on the outside of the corollas of the two species, although Bini Maleci & Bagni Marchi (1983) (and others earlier) claimed that they were more abundant in *A. verlotiorum* (the more aromatic species).

We did find a slight difference in the shape of the receptacle in the two species. In *A. vulgaris* it is elongated-conical whereas in *A. verlotiorum* it is low-domed; the putative hybrid is closer to the latter but often higher-domed (sub-spherical).

PHENOLOGY AND FERTILITY

*Artemisia vulgaris* is a late-summer flowerer, reaching anthesis mainly from July to September in southern England. *A. verlotiorum* flowers distinctly later, from October to November, and in many years is damaged by frost before anthesis. The natural flowering periods of the two species do not overlap, but plants of *A. vulgaris* that are cut down in summer will often produce late-flowering stems, and, in the absence of frosts, undoubtedly both species could be in flower simultaneously. The putative hybrid, when growing in the same general area as the two species, reaches flowering at an intermediate time, mostly in October (two to four weeks before *A. verlotiorum*). Its flowering stems are, however, very frost-susceptible and often do not reach anthesis in the wild.

Presumably due to its late flowering *A. verlotiorum* has not been found to produce ripe fruits in this country. No fruits have been found on the putative hybrid. The florets of the putative hybrid in the position of the bisexual florets of the parental species are much reduced, without the conspicuously distally dilated corolla found in its two parents, and anthers are completely lacking; only a reduced ovary, style and stigma in a very reduced corolla are present. Hence the putative hybrids are probably totally male-sterile.

CHROMOSOMES

Clear chromosome counts (Fig. 2) were made from *A. vulgaris* from London, Birmingham and Leicester (all 2n = 16), *A. verlotiorum* from London and Caernarvonshire (2n = 52 and 50 respectively), and the putative hybrid from both London sites (2n = 34) (Table 2). The numbers of chromosomes possessing satellites in these three taxa were two, six and four respectively.

TABLE 2. CHROMOSOME NUMBERS OF *ARTEMISIA* TAXA IN THE PRESENT STUDY

| Species<br>Locality | Chromosome number |
|---|---|
| *Artemisia vulgaris* | |
| Rough ground, Tottenham, London, Middlesex, v.c. 21 | 2n = 16 |
| By Tardebigge Canal, east of Bromsgrove, Worcs., v.c. 37 | 2n = 16 |
| On waste ground, central Leicester, Leics., v.c. 55 | 2n = 16 |
| *Artemisia verlotiorum* | |
| By public toilets, Abersoch, Lleyn, Caerns., v.c. 49 | 2n = 50 |
| Rough ground, Tottenham, London, Middlesex, v.c. 21 | 2n = 52 |
| *Artemisia* × *wurzellii* | |
| Railway bank, Tottenham, London, Middlesex, v.c. 21 (locality 14) | 2n = 34 |
| Rough ground, near Walthamstow Marshes, London, S. Essex, v.c. 18 (locality 11) | 2n = 34 |

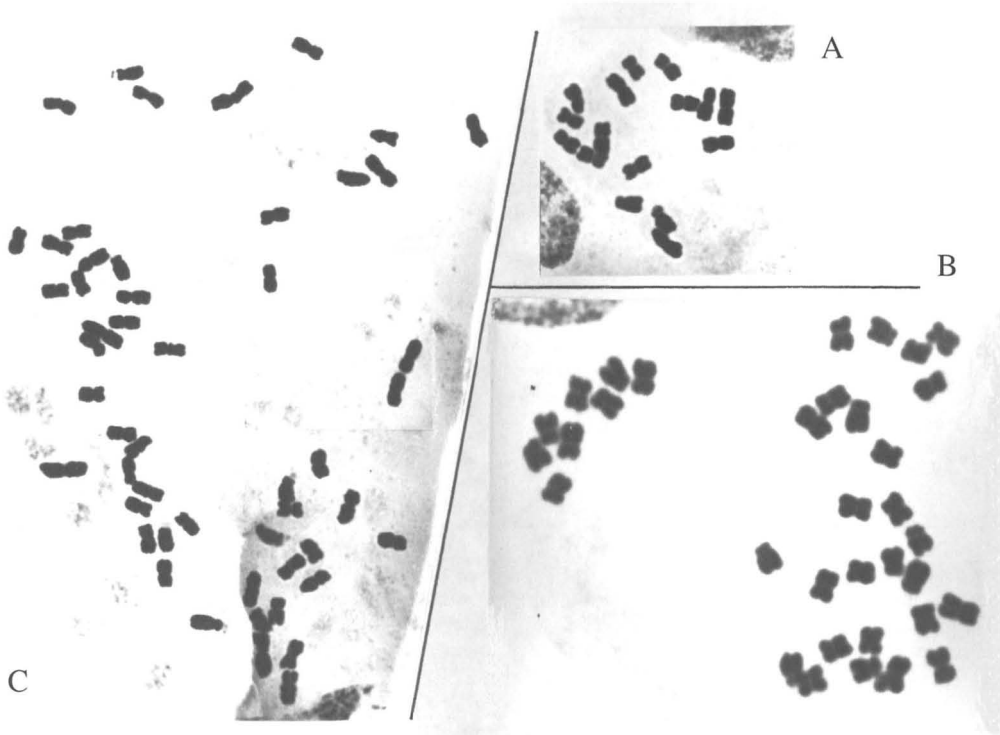


FIGURE 2. Chromosomes of: A. *Artemisia vulgaris* (2n = 16), B. *A.* × *wurzellii* (2n = 34) and C. *A. verlotiorum* (2n = 52), from Tottenham, London, v.c. 21. Magnification × 1755.

## DISCUSSION AND CONCLUSIONS

### IDENTITY OF PUTATIVE HYBRIDS

Despite the paucity of quantitative data demonstrating the intermediacy of the putative hybrids, there is strong circumstantial evidence that they are indeed hybrids between *A. verlotiorum* and *A. vulgaris* (Table 1).

Their overall appearance is convincingly intermediate; this is particularly indicated by the width and serration of the leaf-lobes, especially the apical leaf-segment of the middle stem-leaves, and by the leafiness of the inflorescence. The pith anatomy and capitulum shapes are also intermediate between those of the two putative parents, as is the flowering time in London. The putative hybrids are totally male-sterile, no anthers being formed, a condition never observed in either parent.

The fact that other characters separating the two species are not intermediate in the putative hybrid (e.g. rhizome growth, capitulum shape and size, petiolar pectinations) does not argue against its hybrid origin, since this situation is common in nature. Hybrids are rarely exactly intermediate in every diagnostic character, due to the varied genetic backgrounds of the observed phenotypes.

Nevertheless, probably the most convincing evidence of hybridity comes from the chromosome numbers. In our London material *A. verlotiorum* had 2n = 52, *A. vulgaris* had 2n = 16, and the putative hybrids had the expected 2n = 34 (26 + 8).

In Asteraceae tribe Anthemideae, and in the genus *Artemisia*, the diploid number 2n = 18 is by far the commonest reported chromosome count (Bolkhovskikh *et al.* 1969, and later plant chromosome number indices). Tetraploids with 2n = 36 and hexaploids with 2n = 54 are also well distributed in *Artemisia*, but several aneuploid counts, such as 2n = 16, 14 and 34, exist in addition. Hence our plants of *A. vulgaris* should probably be viewed as aneuploids, 2n = 2x – 2 = 16, where x (the base number) = 9.

The majority of reported counts of *A. vulgaris* are 2n = 16 (widespread in Europe and in North America, Russia, India and Japan), but there are a few 2n = 18 counts (India and Caucasus) as well. The single previous British count, from Surrey, was 2n = 16 (Morton 1977). Most previous counts of *A. verlotiorum* are hexaploids with 2n = 54 (from Italy, Germany, Japan and Russia), but there are also two, presumably aneuploid, counts of 2n = 48 from China and Spain. Our counts of 2n = 50 and 52 for *A. verlotiorum* are new numbers for this species, and neatly complete the reducing aneuploid series 54, 52, 50, 48.

It thus appears that both *A. vulgaris* and *A. verlotiorum* exist as both euploid and reducing aneuploid cytotypes. On known evidence of the range of chromosome numbers of the two parental species, hybrids could occur with chromosome counts of 2n = 32, 33, 34, 35 or 36. The number of satellited chromosomes that we recorded in the three taxa confirm their suggested ploidy levels.

FORMAL DESCRIPTION OF HYBRID

The evidence presented above leads us to conclude that the intermediate plants are hybrids between *Artemisia vulgaris* and *A. verlotiorum*. They are described below after their discoverer, B. S.W.

**Artemisia × wurzellii** C. M. James & Stace, **hybr. nov.**

Hybrida inter *A. vulgarem* et *A. verlotiorum* intermedia sed ab ambabus floribus sterilibus (anantheris) et capitulis minoribus (1·8–2·4 mm longis) differt. Caules medulla viridi et medulla alba magis minusve aequicrassa. Folia caulina media segmentis apicalibus 4·4 – 7 × longioribus quam latis.

HOLOTYPUS: Overgrown railway bank, Northumberland Park Station, Tottenham, Haringey, London, Middlesex, map reference TQ/34.91. 2 October 1987, *B. S. Wurzell s.n.* (**LTR**).

ORIGIN AND DISTRIBUTION OF *ARTEMISIA* × *WURZELLII*

Since the original discovery in 1987, B.S.W. has found 13 additional sites for *A.* × *wurzellii* in eastern and south-eastern London.

Surrey, v.c. 17:

1 Roadside, near Stockwell Underground Station, Lambeth, TQ/30.76, 1988, still there 1990, not visited since.

2 Roadside among bushes, near Ruskin Park, Camberwell, Southwark, TQ/32.75, 1990, not visited since.

3 Grassland and scrub, off Neate Street, Burgess Park, Walworth, Southwark, TQ/32.77 & TQ/33.77, 1995, still there 1998.

4 Shrubbery weed by road, Dog Kennel Hill, East Dulwich, Southwark, TQ/33.75, 1992, not visited since.

5 Waste ground, off Tooley Street, by London Bridge Station, Southwark, TQ/33.80, 1988, not visited since.

6 In rough grass, near Straker's Road, Peckham Rye Common, Southwark, TQ/34.75, 1993, not visited since.

7 Shrubbery weed in small park, near Chambers Wharf, Bermondsey, Southwark, TQ/34.79, 1988, not visited since.

8 Disturbed soil, King Stairs Gardens, off Brunel Tunnel Roundabout, Rotherhithe, Southwark, TQ/34.79, 1992, not visited since.

9 By footpath, near Redriff Road, south end of Russia Dock Woodland, Rotherhithe, Southwark, TQ/36.79, 1993, not visited since.

10 In newly landscaped shrubbery, near Salter Road, north end of Russia Dock Woodland, Rotherhithe, Southwark, TQ/36.80, 1993, not visited since.

South Essex, v.c. 18:

11 Rough ground, near Coppermill Lane, off Walthamstow Marshes, Waltham Forest, TQ/35.87, 1987 & 1988, not visited since.

12 Stony waste ground, Bow Creek Ecological Park, Canning Town, Newham, TQ/39.81, 1994, still there 1998.

Middlesex, v.c. 21:

13 Garden weed in new housing estate, Watermint Quay, Clapton, Hackney, TQ/34.88, 1994, still there 1998.

14 Overgrown railway bank, Northumberland Park Station, Tottenham, Haringey, TQ/34.91, August 1987, still there 1998.

In addition, two other records, neither of which we have any reason to doubt, have come to our notice:

15 West Kent, v.c. 16: on rubbish tip, Swanscombe, TQ/60.74, G. Kitchener & M. Keene, 1994, site cleared soon after (*Bull. Kent Field Club* **40**: 35–36 (1995)).

16 Middlesex, v.c. 21: weed in shrubbery, Fair Street, St John's Estate, Bermondsey, TQ/32.78, J. R. Palmer, 1989, comm. J. E. Smith.

The first-discovered colony (no. 14 above) extends for at least 50 m along a railway bank together with common coarse perennials of such habitats, including *Armoracia rusticana*, *Arrhenatherum elatius*, *Calystegia silvatica*, *Rumex obtusifolius* and *Urtica dioica*. *Artemisia vulgaris* occurs close by, but the nearest colony of *A. verlotiorum* is at least 400 m distant on Tottenham Marshes. Moreover, the two parents do not normally overlap in flowering times, and *A. verlotiorum* has not been seen to set seed in this country. *A. vulgaris* might also fail to set seed from flowers opening as late as October. Hence, although the hybrid was at first thought to have arisen spontaneously *in situ*, it seems more likely that it arose elsewhere, perhaps not in Britain, and was inadvertently dumped on the railway bank. All of the other localities are on rough or disturbed ground or in recent habitats created by gardening, and it is very likely that the present distribution is the result of soil and waste being transported by man. One need look no further than *Fallopia japonica* to understand how effective this method of dispersal can be! It is, indeed, possible that all 16 colonies represent a single clone which was introduced, perhaps as a medicinal plant, from southern Europe, where *A. verlotiorum* is widespread and regularly forms fruits (and where the hybrid should be sought), or even from China. On the other hand, the chromosome number of the hybrid indicates that its *A. verlotiorum* parent had 2n = 52, a number not previously reported but characteristic of the Tottenham clone. There are counts of only 2n = 48 and 54 (and 16) for this species from southern Europe (Italy and Spain); such plants could not have produced a hybrid with 2n = 34 by crossing with plants of *A. vulgaris* with 2n = 16. Hence a London origin for the hybrid is certainly possible.

ACKNOWLEDGMENTS

We dedicate this paper to Douglas H. Kent, who was the leading expert on the flora of Middlesex (especially its introduced species), who considerably extended our knowledge of the distribution of *A. verlotiorum* in London, and who was a very good friend to C.A.S. and B.S.W. over many years. We thank Miss A. P. Conolly for providing living material of *A. verlotiorum* from Abersoch.

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