

A large population of *Plagiobothrys scouleri* (Boraginaceae) in north-east Scotland, and notes on occurrences elsewhere in Britain

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ABSTRACT

The alien *Plagiobothrys scouleri* (Hook. & Arn.) I. M. Johnst., White forget-me-not, was first observed in Britain in 1974, and has now been recorded in eight vice-counties. Several populations have been short-lived, but in Hampshire and North Aberdeenshire (v.cc 11 and 93) persistent large colonies exist in open habitats that regularly flood. Details are given about all British records, a common feature being occurrence in sown grass, which implies that *P. scouleri* is a seed impurity. Morphological variation between colonies is assessed. The North Aberdeenshire colony occupies a large dune slack at St. Fergus across which gas pipelines have been laid, and it is believed that restoration work led to *P. scouleri* being introduced; the plant is now abundant over the whole extent of the c. 5 ha “winter loch”. The sequence of events permitting spread at St. Fergus, and the plant communities in which *P. scouleri* occurs there, are described.

KEYWORDS: White forget-me-not, dune slack, alien, seed impurity.

INTRODUCTION

Plagiobothrys scouleri (Hook. & Arn.) I. M. Johnst. (Boraginaceae) is an introduced annual with small white flowers very similar to those of *Myosotis*. Clement & Foster (1994) describe it as a persistent grass-seed alien, locally abundant on silt and gravel at Setley and Beaulieu in S. Hampshire (v.c. 11), and also recorded in new-sown grass and other disturbed ground elsewhere in Britain. We have now found it in great abundance on silty sand within a large dune slack behind sand dunes at St. Fergus, North Aberdeenshire (National Grid ref: NK102542, v.c. 93), on the north-east coast of Scotland.

The plant was first seen with certainty in this locality in 1991. In that year, and subsequently in 1994 and 1999 (Gimingham & Lane 1994, 1999), botanical surveys of the site were carried out by P.L., as part of a monitoring programme of the restoration of the dune systems affected by gas pipeline landfalls, commissioned and funded by the St. Fergus Dunes Management Committee (now named the St. Fergus Coastal Environment Committee). The Dunes Management Committee

(DMC) evolved from an environmental liaison group set up in the early 1970s by the Geography, Zoology and Botany Departments of the University of Aberdeen. This group helped to establish the DMC which was constituted by the operators of the four North Sea Gas Terminals and Aberdeenshire Council, with Professor W. Ritchie as its Senior Ecological Advisor; the DMC has been serviced by the University of Aberdeen and its commercial company Aberdeen University Research & Industrial Services (AURIS).

In 1991 and 1994 the plant was treated simply as an unusual white-flowering form of *Myosotis ramosissima*, even though it was present in abundance in 1994. However, specimens were collected and dried, and after finding the plant again in quantity in 1999 its distinct nature was realised. It was then identified as *Plagiobothrys scouleri* by D.W. and subsequently confirmed by E.J.C. It is possible that the plant had been seen in earlier surveys by other workers who recorded several species of *Myosotis* in the area in 1977, 1980 and 1983, but the first year in which we can be certain of its presence is 1991.

MORPHOLOGY OF THE ST. FERGUS POPULATION

The plants are annual, with several to numerous ascending or sub-erect stems, as shown by silhouettes of a range of specimens (Fig. 1). Detailed drawings are provided in Fig. 2; this shows a typical plant and a dwarf variant that flowered early.

The stems are mostly 10–15 cm tall but occasionally reach 20 cm; they bear adpressed hairs. The leaves are linear, mostly 3–5 cm long and 2–3 mm wide, but on the tallest stems one or two lower leaves may attain 10 × 0.4 cm; the leaves are mainly alternate on the upper stems but are opposite at the three lowest stem nodes. The foliage is evenly clothed with short hairs spreading at about 45°. The flowers are borne in false racemes; these bear a few bracts chiefly below, and are tightly coiled at the top. The corollas are very small, c. 2–3 mm in diameter, and the calyces are divided to three-fifths or three-quarters their length, the sepals extending slightly beyond the petals. The flowers are white with a yellow eye at the top of the corolla tube and scarcely visible. Flowering occurs from June to early September. The four nutlets (length 1.4–1.9 mm) are dark olive-green or brown and rugose, with their abscission scar just slightly lateral of the base.

HABITAT OF THE ST. FERGUS COLONY

Plagiobothrys scouleri was very abundant in 1999, 2000 and 2001, in an open community in the St. Fergus slack. The substrate consists of a mixture of silt and fine-grained sand particles, but will be referred to as silty sand; it is mapped as the “sandy area” in Fig. 3.

The St. Fergus dune slack lies between the coastal fringing dune (which rises to about 12–16 m) and a more irregular line of old dunes to landward (Fig. 3) which abut onto a steep escarpment (an old low cliff line, rising to c. 18 m above sea level), beyond which the Terminal complex has been built on a flat plateau. The slack extends for approximately 1200 m and is about 120 m wide at its widest. Its surface lies about 2 m above sea level, and in winter most of the slack is flooded by fresh water, forming a “winter loch”. The duration of this flooding varies from year to year, but on average 75% of its area is continuously flooded for around 6 weeks, although the part in which *Plagiobothrys scouleri* is most abundant floods for a shorter period. A section of the south of the slack (Fig. 3) has its surface higher, is rarely flooded, and has a closed turf lacking *Plagiobothrys*.

Before 1974, when work on the first pipeline crossings began, a lush turf of *Agrostis stolonifera*, *Hydrocotyle vulgaris*, several *Carex* species including *C. maritima*, and other plants, occupied much of the exposed area of the winter loch once the standing water disappeared in spring. In 1974 and again in 1976 this turf was disrupted in places by the construction of two pipeline corridors through the dunes and across the dune slack in its central part (Fig. 3). In 1976 an area of slack which abutted the cutting was used for the temporary storage of excavated material including much sand and silt. Since then there has been a gradual decrease in the extent of the lush-turf community, with greater amounts of relatively unvegetated silty sand remaining after the winter inundations (Fig. 3). This has been tentatively linked to a lowering of the water table and a decrease in the extent and duration of winter flooding, particularly during the 1980s (Soulsby & Malcolm 1997). It is also possible that some sand has been deposited into the dune slack from the



FIGURE 1. Silhouettes of *Plagiobothrys scouleri* specimens collected at St. Fergus on (a) 14 June 2000 and (b) 5 August 1999.

main dune ridge, or has been spread from the pipeline corridors which after restoration had their surface level slightly higher than the surrounding slack. By 1991, quite a large extent of almost bare muddy sand was visible in summer, and this has been progressively colonised by the open plant community containing *Plagiobothrys scouleri* described below. By 1999, this habitat and its associated plant community occupied almost all the ground regularly flooded in winter.

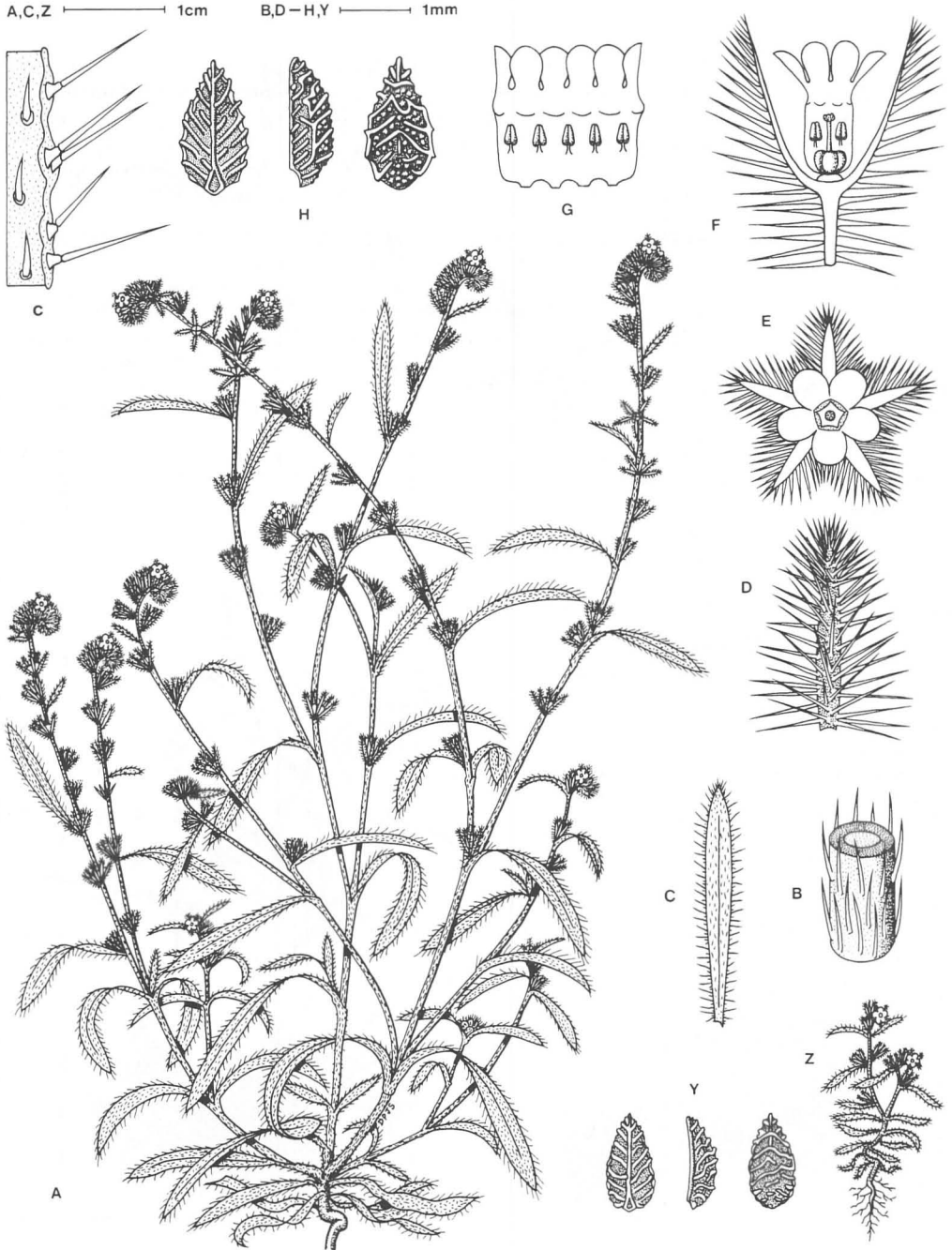


FIGURE 2. Drawings of two plants of *Plagiobothrys scouleri* and selected plant parts. A – habit of typical plant, B – section of stem, C – cauline leaf, D – outside view of calyx lobe, E – plan view of flower at early stage with petals small, F – cross-section through calyx and corolla at anthesis, G – corolla opened-out, H – nutlet (adaxial, lateral and abaxial views, from left to right), Y – nutlet from small early-flowering variant, Z – small early-flowering variant.

THE PLAGIOBOTHRYUS COMMUNITIES AT ST. FERGUS

Cover assessments recorded in 1999 for two sub-types of the slack community differentiated by degree of openness are given in Table 1. *Juncus bufonius* is generally dominant, reaching a cover of c. 30–50%. Other prominent species are *Callitriche stagnalis*, *Gnaphalium uliginosum*, *Sagina procumbens*, *Barbula convoluta*, *Bryum algovicum* and *Bryum argenteum* (Table 1). Locally, in hollows and old ditches dug c. 60 years ago, *Agrostis stolonifera* has substantial cover, quadrats from these areas being grouped as the less-open community (Table 1). *Plagiobothrys scouleri* has

TABLE 1. ASSOCIATES OF PLAGIOBOTHRYUS SCOULERI IN OPEN COMMUNITIES AT THE ST. FERGUS DUNE SLACK

	Domin-scale assessment of cover in 1 m ² quadrats																		
	Open community of silty-sand areas										Less-open community of hollows, ditches								
<i>Agrostis stolonifera</i>	2	2	3	3	1	/	1	2	2	3	6	5	6	2	1	3	5		
<i>Barbula convoluta</i>	2		3	/	/		2	2	2	2	2	1	3		2	2	2	2	
<i>Bellis perennis</i>												/			2				
<i>Bryum algovicum</i>	2		3	/	2	2	2	2	2	2	2	2	3	1	2	2	2	2	
<i>Bryum argenteum</i>	2		3	/	2	2	2	2	2	2	2	2	3		/	2	2	2	2
<i>Bryum cf. bicolor</i>																		2	
<i>Callitriche stagnalis</i>	2				2	2	2	3							2	3	3	2	2
<i>Capsella bursa-pastoris</i>				/															
<i>Cardamine pratensis</i>						/													
<i>Carex arenaria</i>				/									4						
<i>Cerastium fontanum</i>				1						+									
<i>Chenopodium rubrum</i>					2	/													
<i>Cirsium arvense</i>												+						/	
<i>Cirsium vulgare</i>					+	+	/			+		+		+	+				
<i>Climacium dendroides</i>				/								2	2						
<i>Equisetum palustre</i>					+		/	2				/			+				1
<i>Festuca rubra</i>														/					
<i>Gnaphalium uliginosum</i>	3	3	3	3	4	2	3	3				3	3	3	2		3	4	3
<i>Juncus articulatus</i>					+														
<i>Juncus bufonius</i>	8	3	6	3	9	8	3	7	3	4			+	3	6	6	3	9	3
<i>Myosotis laxa</i>	3	1	3	3			+	+	+	/		1	1	2	+	3	3	1	3
<i>Myosotis scorpioides</i>										+									
<i>Odontites vernus</i>				/				+								/			
<i>Persicaria maculosa</i>	/			1					/						/				
<i>Plagiobothrys scouleri</i>	3	/	+	4	2	1	2	+	8	7		1	1	4	3	3	3	1	/
<i>Plantago major</i>	3	2	+	2	3	2	1	2	2	/		3	2	3	2	3	3	2	
<i>Poa pratensis</i>	/			/	2	1	1		2	2				3	2	3	1		2
<i>Potentilla anserina</i>	2	2	2	1	+	/	+	1	1	+		1	2	2	+	1	3	1	2
<i>Ranunculus repens</i>				1															
<i>Rhytidadelphus squarrosus</i>				/															
<i>Riccia cavernosa</i>					2	2	3	1		3		/		1	2	3	3	2	3
<i>Rumex crispus</i>												/							
<i>Sagina procumbens</i>	3	3	3	4	2	2	3	3	3	3		3	7	3	2	3	3	4	3
<i>Senecio jacobea</i>		+	/	+		/	+		/			1						+	+
<i>Veronica anagallis-aquatica</i>	+	/	2	2	1	1	+	1	1	2		1	2	1	+		+	1	/
Bare ground	3	9	3	5	3	5	7	5	3	3		3		2	6	3	3		

DOMIN VALUES:

- 9 = cover >75%
- 8 = cover 50–75%
- 7 = cover 33–50%
- 6 = cover 25–33%
- 5 = cover 10–25%
- 4 = cover 5–10%
- 3 = scattered, cover small
- 2 = very scattered, cover small
- 1 = scarce, cover small
- + = isolated single plant
- / = present near quadrat

Nomenclature follows Stace (1991) for vascular plants, Smith (1978) for mosses and Paton (1999) for liverworts unless otherwise given in the text.

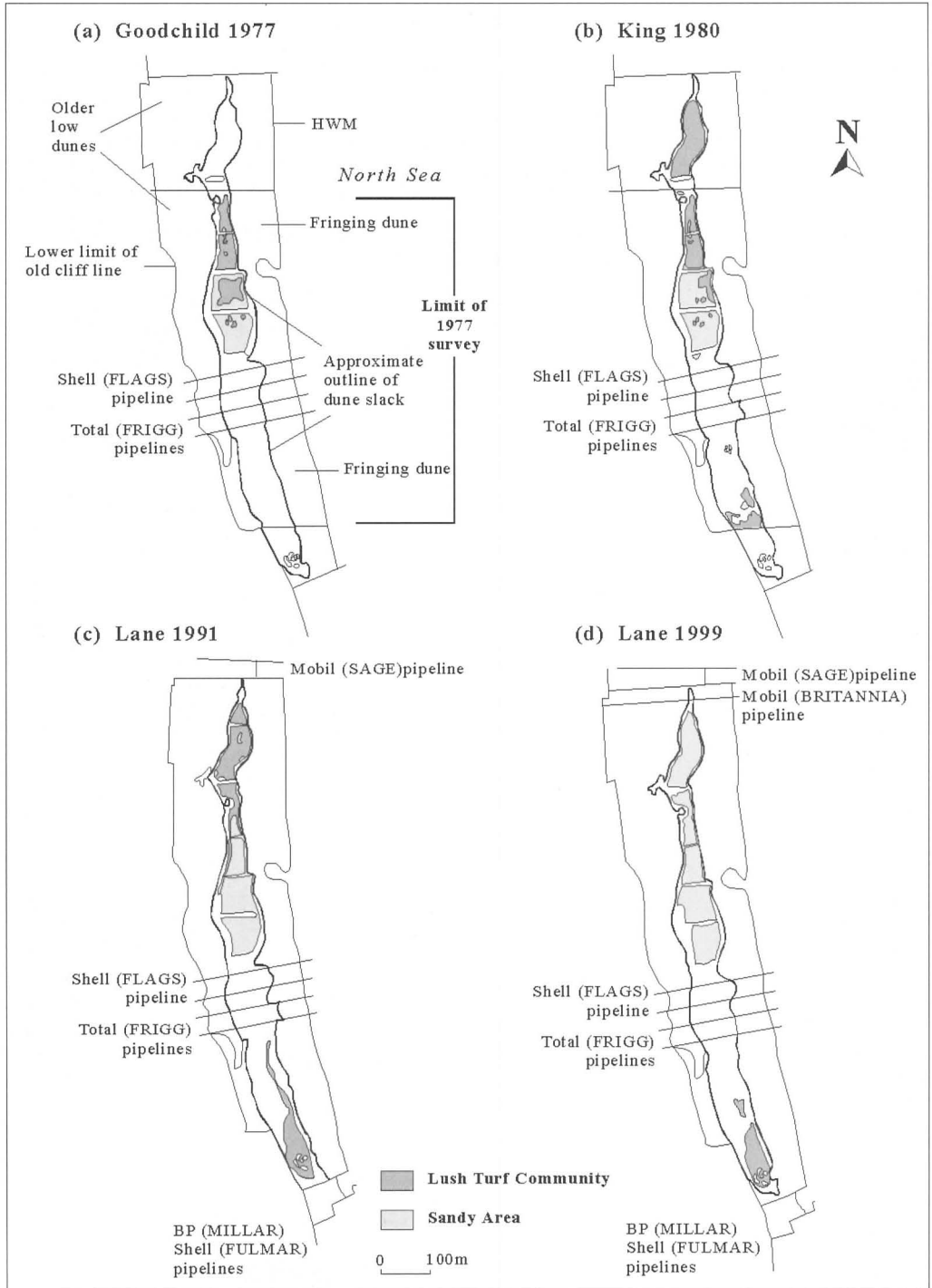


FIGURE 3. The St. Fergus dune slack colonised by *Plagiobothrys scouleri*, and changes in the distribution of “lush turf” and “sandy area” habitats from 1977 to 1999; unmarked areas within the outline of the slack carry several other habitat types.

an average cover of c. 15% in the two community sub-types, with small-scale variation (between 1 m² areas) and some large-scale variation across the slack: in two areas of c. 1 ha in the west central section of the slack it reached an average cover of c. 75% in 1999, 2000 and 2001. Both open communities are moderately rich in species, with altogether 35 plant species in the 18 1-m² quadrats recorded; numbers of species per m² ranged from 10 to 24 and averaged 16 (Table 1). An interesting characteristic species is *Riccia cavernosa*, which tends to form large patches and is in places very conspicuous. This liverwort was probably present in small amounts in the years before 1990, but was first noted in considerable abundance in 1991. It is now dominant in certain parts of the western (inland) margin of the winter-loch, where it forms large clusters in slight hollows, *Plagiobothrys scouleri* being relatively scarce there.

P. scouleri also occurs sparsely in almost closed vegetation at the margins of the slack and where the surface is slightly raised. The main species in these communities are *Agrostis stolonifera*, *Plantago major*, *Poa pratensis*, *Potentilla anserina* and *Veronica anagallis-aquatica*, indicating that they are related to the lush-turf community that formerly was extensive in the dune slack. In this vegetation, which becomes more closed as the season progresses, the individual plants of *Plagiobothrys* have a more erect form than the compact rosettes with half-prostrate stems usual in the open communities, and they flower more freely. The presence of some quite large individuals of *P. scouleri* in mid July 2000 in these situations suggests plants establish earlier in the year than in the lower parts of the slack that experience longer submergence.

It is evident that the population of *Plagiobothrys scouleri* has been extending over the past ten years from the two locations where it was originally abundant, and by 2000 there were plants throughout the whole open area of silty sand that floods each winter. In the past few years the centre of the basin has been progressively colonised, and towards the edges of the slack there have been in early summer conspicuous bands of densely packed seedlings, probably resulting from the grounding of floating seeds when the water level falls from its winter peak (Fig. 4).

Specimens from the St. Fergus slack collected at different stages of growth and illustrating the different growth forms are kept in **herb. D. Welch** and **ABD**, and more material is in **herb. E.J.C.**

SOURCE OF THE ST. FERGUS COLONY

It is generally held that *P. scouleri* has been introduced to British sites from western N. America with grass seed. It is likely, although we have no definite evidence, that it also came to St. Fergus with grass seed, because, after backfilling the pipeline trenches across the dunes and winter-loch, the corridors were reseeded with commercial grass seed mixtures. The two pipelines that cross the winter loch area were seeded in 1974 and 1976, immediately following their construction. Other pipelines at St. Fergus were constructed and sown in 1984 and 1990, but these pass just beyond the northern and southern ends of the winter loch and do not cross the loch itself (Fig. 3). It has not proved possible to obtain the lot numbers of any of the seed mixtures used on these occasions, but northwest America is a major source of imported grass seed and the inoculation could have occurred on one (or more) of these dates.

A second probable alien, *Chenopodium rubrum*, is present in the St. Fergus slack, this species only occurring as a casual in northern Scotland. It has, however, been observed in reseeded roadsides in Lanarkshire (v.c. 77) (Dickson, Macpherson & Watson 2000), and E.J.C. believes grass seed the likely source. *Chenopodium rubrum* has a wide world distribution and is common in western North America although considered an introduction (Williams 1969).

OTHER POPULATIONS RECORDED IN BRITAIN

Plagiobothrys scouleri has previously been recorded in the British Isles from 9 hectads in seven vice-counties, as detailed below, the first record dating from 1974 (v.c. 109). No Irish records have been located.

South Wiltshire (v.c. 8)

Salisbury, SU13, road-building site, found by Mrs F. D. Richards (Clement 1976).

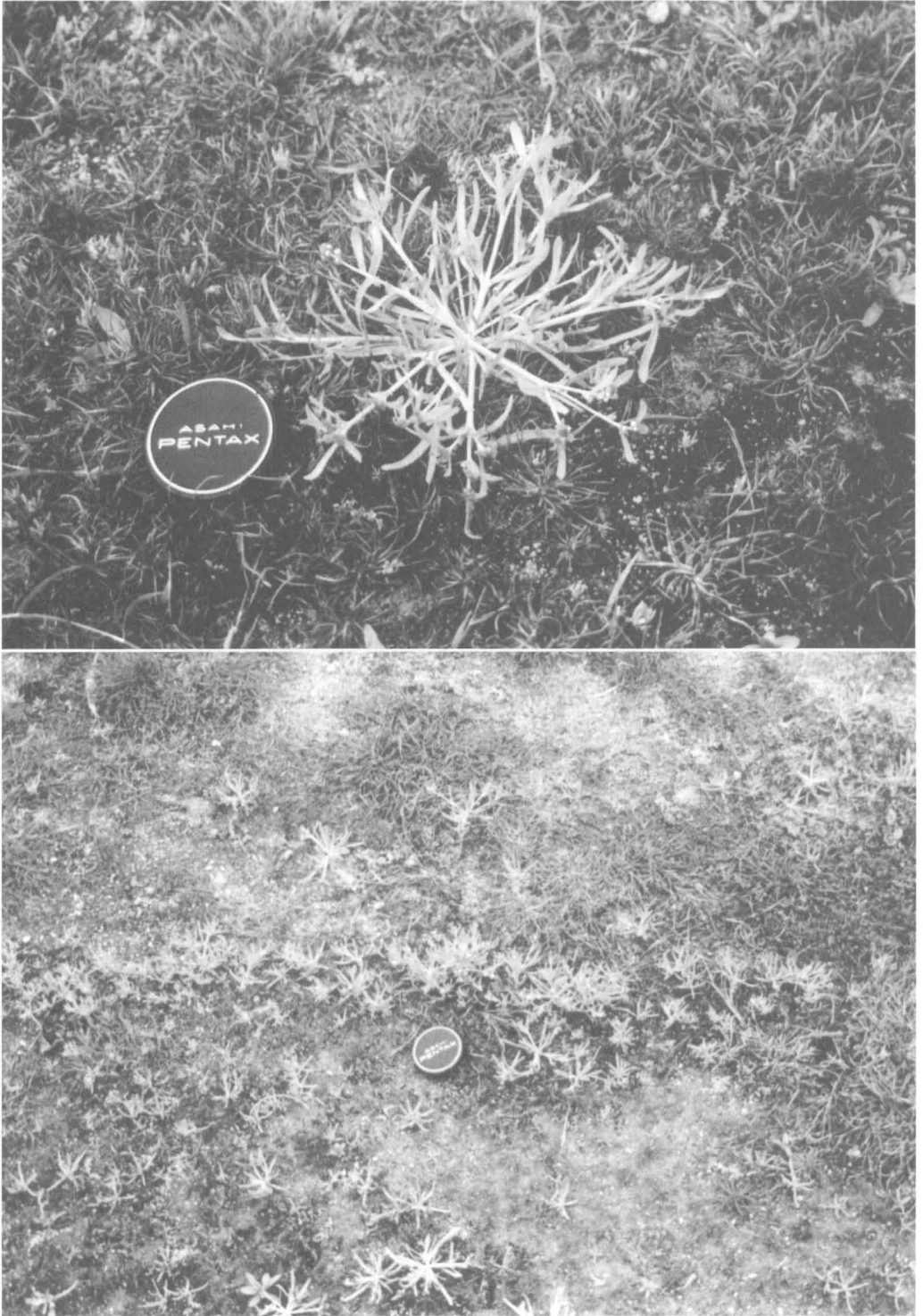


FIGURE 4. A typical plant of *Plagiobothrys scouleri* at St. Fergus (above), and a group of plants including a linear band of seedlings produced presumably from the grounding of seeds at the edge of standing water (below).

South Hampshire (v.c. 11)

Setley, SZ3099. Locally abundant on silt and fine gravel in shallow flood hollows in levelled tip areas, found by A.L. Hale & E.S. Haines in 1982 (Anon. 1988; Brewis *et al.* 1996). Voucher specimen in **WCR**. In May 1985 J. Ounsted independently discovered this colony and estimated a population of about 10,000 plants. The site was also visited by E.J.C. *et al.* in September 1998: very numerous rosettes were observed, some flowering and fruiting, suggesting this population has summer and autumn germination when conditions are suitable.

Beaulieu airfield, SU3500. Bare mud and gravel in shallow flood hollow, recorded by R. P. Bowman in 1987 (Anon. 1988; Brewis *et al.* 1996). Voucher specimens in **BM & WCR**.

Lee-on-the-Solent, SZ5699. A single large and sprawling plant found by D. Allan and E.J.C. in reseeded grassland on a dry low cliff-top in July 1998; it did not reappear in 1999 (E.J.C.). Voucher piece in **herb. E.J.C.**

Berkshire (v.c. 22)

Windsor Great Park, private area near Norfolk Farm, seen by M. F. Gardner in July 1990 and June 1991 "in considerable numbers suggesting that seed had been successfully set the previous year" (Clement *et al.* 1993). Voucher specimens in **herb. E.J.C.**

Buckinghamshire (v.c. 24)

Several plants were observed in SP83 in sown grass in 1990, but have apparently not perpetuated themselves (R. Maycock, pers. comm.). *Downingia elegans* (Douglas ex Lindley) Torrey was also present in the swards, suggesting that the grass seed originated in western North America (Clement 1978; Briggs 1986; Clement & Foster 1994). *Crepis setosa* and *Rorippa palustris* ssp. *hispida* (Desv.) Jonsell were also recorded (R. Maycock, pers. comm.), the latter being probably a first record for the British Isles (and possibly Europe), this subspecies being native in much of North America.

Staffordshire (v.c. 39)

Cannock Chase, in an old quarry on very light sandy soil, found by G. M. Kay in July 1987; "a pathetic scrap", now in **herb. E.J.C.**, was gathered whilst in a dash during a B.S.B.I. field meeting. Several plants were seen in July 2001 on bare mud at two locations: SJ974192 ("Natterjack Toad scrape") and SJ975190 ("Old quarry") (Hawksford 2002), and specimens are deposited in **STO**.

Caithness (v.c. 109)

Thurso, ND1268. In abundance, observed on a single occasion in newly-sown grass on a roadside verge by the river bridge in June 1974 (Clement 1976; Macpherson & Macpherson 1977; Bullard *et al.* 1977). Specimens in **BM, E, herb. E.J.C.** and **herb. P. Macpherson**.

Shetland (v.c. 112)

Baltasound, HP 6009. Plants observed in reseeded ground outside a new building (Baltasound Leisure Centre) in July 1989 by R. C. Palmer (Walter Scott, pers. comm.). Specimens were checked by E.J.C. and are deposited in **OXF, E** and **SLBI**. The colony has not persisted (W. Scott, pers. comm.).

DISCUSSION

Allocating specific limits to the bewildering variation within the genus *Plagiobothrys* is somewhat arbitrary, and authors have differed widely in their treatments. The self-pollinating races are often apparently very distinct, but extensive searching usually reveals intermediates. In this paper we follow the practical, broad-species concept of Hitchcock *et al.* (1959), but do not uphold their var. *penicillatus* (Greene) Cronq.; this variety they said was separable "with some difficulty", its characters being smaller flowers (mostly 1–2 mm wide, cf. 2–4 mm) and a more prostrate habit. Nutlet characters such as hispidity and ornamentation, often used by C. V. Piper, E. L. Greene and others to define new species, can vary within populations, and are considered to be of little taxonomic significance. Further careful research on native North American populations may eventually reveal that more than one taxon is present in Britain.

British populations of *Plagiobothrys scouleri* are certainly not all uniform, although differences are often more obvious in fresh specimens than dried. The most extreme variant was the single plant at Lee-on-the-Solent. It totally lacked the fulvous coloration of the indumentum of the young inflorescence so prominent on the Thurso plants, and had minute flowers with the corolla tube just equalling the calyx (shrinking to much shorter when pressed), and the corolla only 1.5 mm in diameter with no yellow bosses at the mouth. The style was very difficult to find, being totally hidden between the four nutlets and reaching to only half their length. The procumbent much-branched growth and the narrow leaves (0.5 mm broad) gave the plant an appearance like *Polygonum aviculare*, and it was only found whilst searching on hands and knees for tiny grass-seed aliens. In contrast the Setley plants are almost garden-worthy ornamentals, with flowers uniformly about three times as large as at Lee-on-the-Solent yet also lacking ferruginous indumentum.

As a native, *P. scouleri* grows in moist, often poorly drained soils at low to moderate elevations, and ranges from N. California to British Columbia with easterly extensions as far as Manitoba and New Mexico. It is introduced in Alaska; outside N. America we can track down only a record from Sweden as an ephemeral (Karlsson 1997). There are suitable habitats in New Zealand, but no records yet. Closely related native taxa exist in Chile, but none seems to fall within our complex. One close ally, a native of both N. and S. America, is *P. fulvus* (Hook. & Arn.) I. M. Johnst. which has been provisionally claimed for Britain (Clement & Foster 1994). It differs subtly, basically by having the nutlet attachment scar near its middle, instead of almost basal as in *P. scouleri*.

Grass-seed mixtures are the most likely source of inoculum for the British *Plagiobothrys* colonies, but it is tempting to suggest for St. Fergus, because of its situation amongst extensive semi-natural habitats, that bird introduction has occurred. However no bird migrates from western N. America to Britain, whereas the repeated sowings of grass for the reinstatement of the gas pipeline trenches at St. Fergus gave plenty of opportunities for the establishment of the impurities that are known to occur in grass seed; impurities may be most common when legumes, e.g. clover, are included in mixes as nitrogen fixers. There is good evidence that British grass-seed mixtures often have an origin in NW America, since casual species such as *Downingia elegans* that are native in this region are regularly observed in new-sown grass; Clement & Foster (1994) give more examples of such species. *Agrostis exarata* Trin. is a further example for which secondary introduction is apparently impossible: it is not known established elsewhere in the world away from its home in NW America and extreme E. Asia (Ryves *et al.* 1996).

From its native distribution, *Plagiobothrys scouleri* is likely to persist in Britain only where winter water-bodies dry out to mud or silt during the growing season. The most typical associates are therefore likely to be annuals such as *Juncus bufonius* and *Gnaphalium uliginosum*, the latter having a striking similarity in habit. At Setley some colonies in shallow hollows have similar rings of plants resulting presumably from seeds stranded as water recedes, as described for St. Fergus; the perennial species *Mentha pulegium* also shows this. This plant is native in the New Forest, but occurs at Setley in a slightly different form, and has undoubtedly arrived from America where it is a serious weed. Similar introductions have occurred elsewhere in Britain, e.g. Kay (1996), far from native localities. Similarly, the Lee-on-the-Solent plant grew with *Parapholis incurva*, most probably another introduction even though native in S. Hants. Significantly, *P. incurva* did not reappear here during the next two years.

Dune slacks are an unusual habitat in having a major regular change in conditions between winter submergence and summer dryness. As dune slacks have quite small total extent in Britain and are not often affected by development and accompanying practices such as grass sowing, the number of colonisations by alien species like *Plagiobothrys scouleri* seems to have been small. But now with the colonies at St. Fergus and Setley well established, it is likely that secondary natural spread will proceed, brought about by wildfowl dispersing the seed *via* their muddy webbed feet to other water bodies at which there is summer drying-out. Fortunately, no rare native species seems likely to suffer as a consequence.

Finally, a reflection on the unexpected consequences of modern changes in life-style. The specific name of our plant commemorates John Scouler (1804–1871), a Scottish botanist who collected extensively in western North America: we are sure that he never dreamt that this plant would one day make a home for itself in his native Scotland.

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