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An ecological study of *Schoenus ferrugineus* L. in Scotland

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ABSTRACT

The vegetation and some habitat features of the two native sites of *Schoenus ferrugineus* in Perthshire are described. The plant is found in base-rich flushes with high levels of calcium and low levels of nitrogen and phosphorus. Both vegetation and habitat are very similar to that of comparable sites which do not support *S. ferrugineus*. Wider comparisons are made with European sites and communities containing *S. ferrugineus*. The Perthshire sites have greatest floristic similarity with *S. ferrugineus* stands in south-western Norway.

INTRODUCTION

In 1979 the Brown Bog Rush, *Schoenus ferrugineus* L., was re-found in Perthshire, in two separate places (Smith 1980). The varied history of this species in Scotland has been documented by Brookes (1981). It was first recorded by James Brebner in 1884 from the shore of Loch Tummel and persisted in various places around the loch (Campbell 1948) until the populations were destroyed in 1950 by a rise of water level. Plants were collected however, and some transplants were made, two of which survive.

Both of the new localities support large populations of the plant and this, together with the absence of documentation to the contrary, suggests very strongly that they are native localities and not transplant sites. The importance of the sites to the British flora is augmented by their phytogeographical and phytosociological interest, as in Perthshire *Schoenus ferrugineus* is well separated from its main area of European distribution and is growing at the western edge of its Eurasian range (Fig. 1).

SITES

Both of the *Schoenus ferrugineus* sites occupy grazed hillsides, on slopes ranging from about 2 to 15°. Site A, which faces south-west, is the smaller and supports several hundred plants of *S. ferrugineus*. Site B, with a northern to north-eastern aspect, has several thousand plants growing in five separate areas over a quite extensive hillside. At both sites *S. ferrugineus* is growing in base-rich flushes situated within calcareous grassland or adjoined by heath. The flushes show the typical conformation of scoured runnels of open mud and stones, usually adjoined by 'lawns' of waterlogged mire and separated by hummocks and more extensive patches of elevated ground. These patches are generally associated with stones (sometimes boulders) and deeper accumulations of organic material. In parts of site B there is an extensive, intricate mosaic of runnels and stony hummocks. *Schoenus ferrugineus* occupies a wide range within this mosaic, growing in some of the most open and wet runnels as well as on some of the hummocks. Its optimal development, however, is in the 'lawns', either bordering the runnels or in flushed hollows.

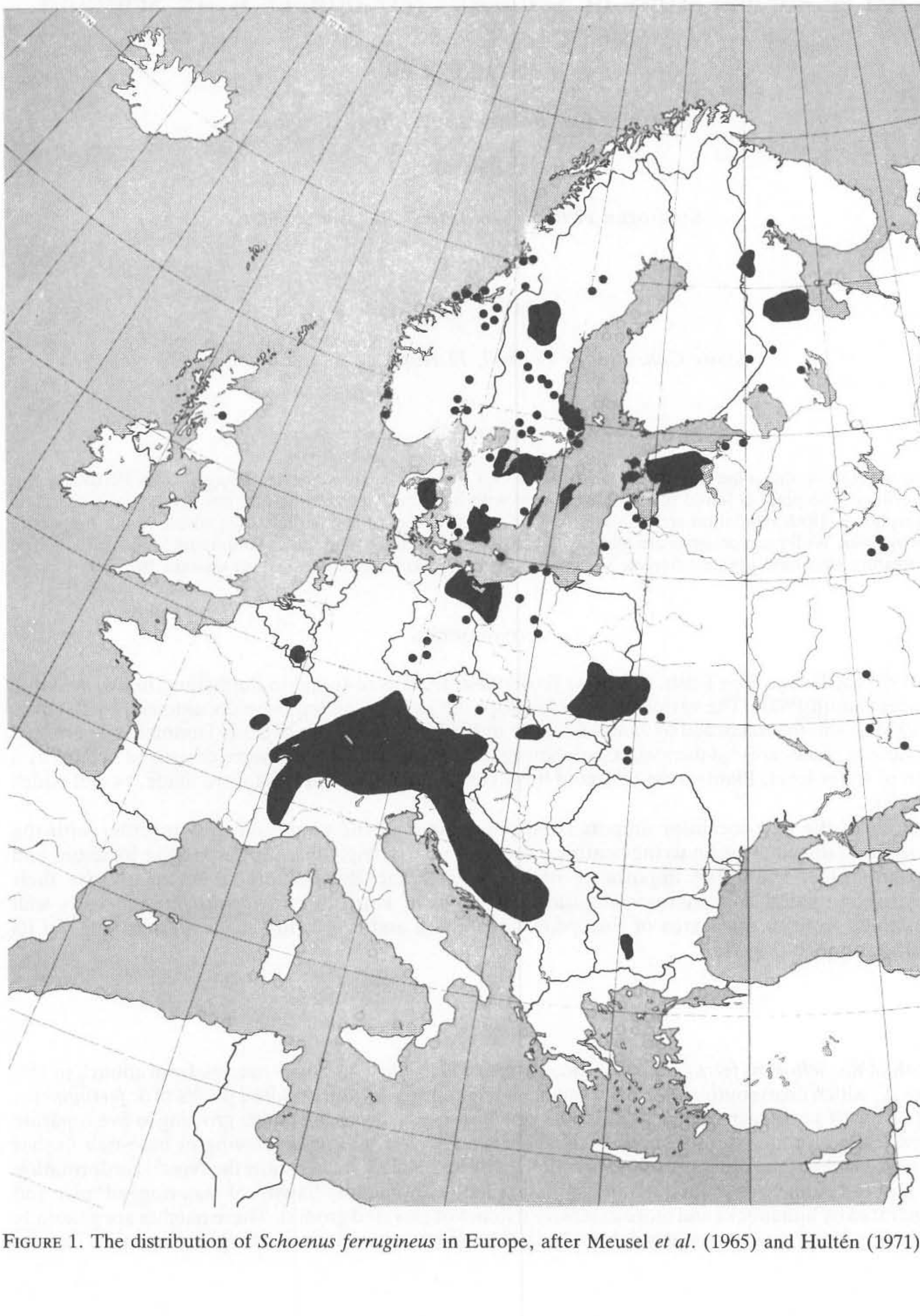

FIGURE 1. The distribution of *Schoenus ferrugineus* in Europe, after Meusel *et al.* (1965) and Hultén (1971)

VEGETATION COMPOSITION

Relevés were made of *Schoenus ferrugineus* stands to illustrate the range of vegetation types in which the plant occurs (Table 1). At site A, visually uniform stands were sampled (relevés 1–4) but at site B the intricate mosaic of vegetation-types demanded its sampling as a composite, single unit (relevés 5–7).

Three main types of vegetation can be distinguished. That of the scoured, muddy runnels (relevé 1) is open in character and comparatively species-poor. *Eleocharis quinqueflora* is especially prominent, often with much *Saxifraga aizoides*. Bryophytes are frequently conspicuous, particularly *Scorpidium scorpioides*.

Relevés 2–4 are more species-rich and represent short, more or less closed 'lawns' of vegetation composed mainly of small sedges and grasses. *Scirpus cespitosus* and (sometimes diminutive) *Erica tetralix* are constant species, but both occur at only low frequency and are largely confined to slight elevations. Relevé 3 represents a rather elevated turf and contains a number of species characteristic of calcareous grassland.

The third type of vegetation (relevés 5–7) is most typical of site B and is distinguished by the occurrence of several calcifuge species – *Calluna vulgaris*, *Drosera rotundifolia*, *Eriophorum angustifolium*, *Myrica gale*, *Narthecium ossifragum* and *Sphagnum* spp. (most frequently *S. subnitens*). Some of these species (e.g. *Calluna vulgaris*) show a tendency to grow on the more elevated hummocks of stones and peat but others (e.g. *Eriophorum angustifolium*, *Myrica gale*, *Narthecium ossifragum*, *Sphagnum subnitens*) can also be found growing in the runnels and 'lawns', irrigated by base-rich water. *Schoenus ferrugineus* grows close to all of these species.

The stands examined support a range of notable species in addition to *Schoenus ferrugineus*, although some are rather infrequent. They include *Carex capillaris*, *Equisetum hyemale*, *Juncus alpinus*, *Thalictrum alpinum* and *Tofieldia pusilla*. Bryophytes are well represented in the flushes and include *Blindia acuta*, *Gymnostomum recurvirostrum* (stony flushes) and *Preissia quadrata*. *Sphagnum imbricatum* occurs at site B: in one place *Schoenus ferrugineus* was noted growing through a loose hummock of it.

CHEMICAL ANALYSIS

Chemical analyses were made of filtered samples of surface waters from relevés 1, 2, 5 and 7, collected in late August 1981 (relevés 3, 4 and 6 did not have surface water). 5 replicate samples were taken from each relevé. 5 replicate substratum samples were also collected (0–20 cm depth); in the mosaics of relevés 5–7 they were from the 'lawn' areas. Extracts were made from these using 0·5M ammonium acetate (pH 7·0) for cations, 2M potassium chloride for nitrogen and 0·5M sodium bicarbonate (pH 8·5) for phosphorus. In each case 100ml of extractant (200ml of ammonium acetate) were shaken with 38ml of fresh (i.e. not dried) sample for 1 hour. Subsequent analyses were the same for water samples and extracts. Calcium, magnesium, iron and manganese were determined by atomic absorption spectrophotometry (Pye-Unicam SP 190), sodium and potassium by flame-emission spectrophotometry (EEL 227 integrating flame photometer), soluble reactive phosphorus (SRP) by colorimetry using an acid molybdate-antimony reagent, and inorganic nitrogen by semi-micro kjeldahl distillation.

The surface water samples had rather similar chemical characteristics in all relevés (Table 2). All were of high pH and were rich in dissolved calcium. Soluble reactive phosphorus was present at only very low levels and dissolved inorganic nitrogen was undetectable. Samples from relevés 5 and 7 (site B) had considerably less dissolved magnesium than those from site A, though the significance of this is not known.

The substratum samples showed rather more chemical variation than the surface waters (Table 3). pH values were generally high but (where comparisons are possible) were below those of the surface waters. Relevés 4 and 6 were distinctive in having a substratum with somewhat lower levels of pH, calcium and magnesium. However, the 'lawns' of relevés 5 and 7 (which supported some calcifuge species) were not more base-poor than other examples. Levels of extractable phosphorus were rather variable but were low in all samples. The substrata of relevés 1, 6 and 7 contained more extractable nitrogen than the others.

TABLE 1. SPECIES COMPOSITION OF STANDS WITH *SCHOENUS FERRUGINEUS*, AND FLORISTICALLY SIMILAR STANDS, IN PERTHSHIRE

Characters are cover values using the Braun-Blanquet scale; those in parentheses were recorded just outside of the relevé plot. Habitat types: R: open, muddy runnel; L: 'lawn' (closed turf); H: hummock (closed turf); M: mosaic of R, L and H. Nomenclature follows Tutin *et al.* (1964–1980) for vascular plants, Corley & Hill (1981) for bryophytes and Hawksworth *et al.* (1980) for lichens.

Relevé number	1	2	3	4	5	6	7	8	9
Plot size (m^2)	1	2·5	4	4	4	4	4	4	1·5
Habitat	R	L	H	L	M	M	M	M	R/L
Slope (approx.)	8°	8°	5°	12°	12°	3°	2°	8°	8°
Vegetation cover (%) (approx.)	60	95	100	100	80	95	95	95	70
Schoenus ferrugineus	1	5	3	5	1	2	+		
Erica tetralix		+	+	+	+	1	1	1	
Juncus bulbosus		+	+	+	(+)	+	+	+	
Potentilla erecta		+	+	+	+	+	+	+	
Selaginella selaginoides		+	+	+	+	+	+	+	+
Succisa pratensis		+	+	+	+	+	+	+	
Carex pulicaris		(+)	+	+	+		+	+	
Scirpus cespitosus		+	1	+		1	+	2	
Briza media		+	+	+	+	+		+	
Racomitrium lanuginosum		+	+		+	+		+	
Tofieldia pusilla		+	+		+	+		+	+
Linum catharticum		+	+	+	+			+	
Calluna vulgaris			+		+	+	+	+	
Drosera rotundifolia					+	+	+	+	
Sphagnum subnitens					+	+	+	+	
Eriophorum angustifolium						+	+	+	
Myrica gale						2	1		
Narthecium ossifragum						+	+	+	
Campylium stellatum	+	4	+	3	1	2	4	+	+
Carex hostiana	+	+	2	+	+	1	+	1	2
Carex panicea	+	(+)	+	+	+	1	+	+	+
Ctenidium molluscum	+	1	1	+	1	3	+	+	+
Drepanocladus revolvens	+	+	+	1	+	+	+	+	+
Eriophorum latifolium	1	1	+	1	+	1	+	2	+
Festuca ovina	+	+	+	(+)	+	+	+	+	
Molinia caerulea	(+)	+	1	1	+	1	1	1	+
Pinguicula vulgaris	+	+	+	+	+	+	+	+	+
Saxifraga aizoides	+	+	+	+	+	+	+	+	+
Juncus articulatus	(+)		+	+	+	+	+	+	+
Scorpidium scorpioides	2	+	+		+	+	+	1	+
Eleocharis quinqueflora	1	+			1	1	1	2	4
Carex flacca	(+)	1	1			1		1	2
Carex lepidocarpa	+			+		+	+	+	
Euphrasia scottica	+	+	+	+				+	+
Bryum pseudotriquetrum	+				(+)		+	+	
Cratoneuron commutatum	+				+		+		
Equisetum palustre		+		+			+		+
Fissidens adianthoides				+		+	+		
Nostoc commune	+	+				+			
Pedicularis palustris	+	+					(+)	+	+
Juncus alpinus	+	+			+			+	+

TABLE 1 CONTINUED

Additional species (cover values are + unless otherwise indicated (in parentheses)):

1: *Parnassia palustris*; 2: *Cladonia arbuscula*, *Dactylorhiza incarnata*, *Gymnadenia conopsea*, *Preissia quadrata*, *Taraxacum* sp., *Thalictrum alpinum*, *Tussilago farfara*; 3: *Anthoxanthum odoratum*, *Campanula rotundifolia*, *Carex capillaris*, *Cladonia arbuscula*, *C. portentosa* (1), *C. fimbriata*, *Frullania tamarisci*, *Hypnum cupressiforme*, *Lophocolea bidentata*, *Pellia endiviifolia*; 4: *Carex dioica*, *C. echinata*, *Prunella vulgaris*, *Taraxacum* sp.; 5: *Agrostis stolonifera*, *Blindia acuta*, *Deschampsia cespitosa*, *Equisetum hyemale*, *Gymnostomum recurvirostrum*, *Preissia quadrata*; 6: *Aneura pinguis*, *Breutelia chrysocoma*, *Leucobryum glaucum*, *Sphagnum palustre*; 7: *Carex dioica*, *Dactylorhiza maculata*, *Deschampsia cespitosa*, *Gymnadenia conopsea*, *Potamogeton polygonifolius*, *Sphagnum imbricatum* (2), *Triglochin palustris*, *Utricularia minor*; 8: *Sphagnum imbricatum*.

DISCUSSION

One of the notable features of the *Schoenus ferrugineus* stands is that, apart from the occurrence of the Brown Bog Rush, they are not at all exceptional. Although local, very similar vegetation (without *S. ferrugineus*) is widely distributed in Perthshire, particularly in association with the Daldradian limestones extending from Beinn Laoigh in the south-west to near the Cairnwell in the north-east. This is illustrated by relevés 8 and 9 (Table 1) which were made in comparable vegetation at a site where *S. ferrugineus* does not grow. Apart from the absence of *S. ferrugineus* these have almost identical species compositions to relevés 5 and 1 respectively. Even local species, such as *Sphagnum imbricatum*, are known from several such sites (including relevé 8; cf. McVean & Ratcliffe (1962)). In terms of the types of Scottish mire vegetation recognised by McVean & Ratcliffe, the very open, flushed communities may be ascribed to the *Cariceto-Saxifragetum aizoides* nodum and the more closed stands to the *Carex panicea-Campylium stellatum* nodum. Both community-types are largely confined to calcareous substrata but are widespread in Scotland (McVean & Ratcliffe 1962). Comparable communities also occur on the limestones of northern England (Pigott 1956, Bradshaw & Jones 1976, Wheeler 1980), so it is of interest that *Schoenus ferrugineus* is so localised.

As there are so few chemical data published from Scottish flushes, it is difficult to evaluate the measurements from the *Schoenus ferrugineus* stands. Further, in this study, substratum extracts have been made from a known volume of fresh soil, so that it is not possible to make direct comparisons with the soil analyses given by McVean & Ratcliffe (who made extracts from a known weight of air-dried samples), except for substratum pH, the levels of which are generally slightly higher than values reported by these workers. The levels of pH and dissolved calcium measured in the surface waters were also somewhat higher than those reported from comparable vegetation types by McVean & Ratcliffe (1962) and Birks (1973), but this may be due in part to the time of sampling, viz. late August 1981, near the end of an unusually dry period.

All available evidence indicates that the chemical conditions of the *Schoenus ferrugineus* flushes are very similar to those of comparable base-rich mires in northern Britain (B. D. Wheeler, unpublished data). They have a near neutral pH, fairly high levels of calcium and, as seems to be characteristic of calcareous mires supporting a low-productivity, species-rich vegetation (Wheeler 1980), they have generally low levels of nitrogen and phosphorus. The somewhat higher level of extractable nitrogen determined from relevé 1 may reflect the influence of a local nitrogenous source. Relevés 6 and 7, which both support much *Myrica gale* (which has nitrogen-fixing symbionts), also have a substratum with relatively high levels of inorganic nitrogen, though it is not known if this is related to the presence of *Myrica*. The levels are within the range measured in base-rich flushes elsewhere in northern Britain (B. D. Wheeler, unpublished data).

The Scottish habitat of *Schoenus ferrugineus* is very similar to that in which its close relative *S. nigricans* is often found (McVean & Ratcliffe 1962, Birks 1973, Birse & Robertson 1976, Wheeler 1980). Although it is uncommon in central Scotland and has very few Perthshire sites, *S. nigricans* is, of course, a much more widespread species in Britain (Perring & Walters 1962).

On the European mainland the distribution of *Schoenus ferrugineus* is also less widespread and more discontinuous than that of *S. nigricans* (Meusel *et al.* 1965), although the two species occupy similar habitats and sometimes grow together. It has two main centres (Fig. 1). One is in the alpine foothills of central Europe where the plant is widespread and, where, in appropriate plant communities, it tends to replace *S. nigricans* at higher altitudes (Koch 1926, Oberdorfer 1957). The

TABLE 2. CHEMICAL COMPOSITION OF SURFACE WATERS (mg l^{-1}) FROM STANDS OF *SCHOENUS FERRUGINEUS* IN PERTHSHIRE, AUGUST 1981

Values are means (±S.E.) of 5 replicates. n.d. not detectable. (Relevés 3, 4 and 6 did not have surface water). SRP: soluble reactive phosphorus.

Relevé	pH	Ca	Mg	Na	K	Fe	Mn	SRP	^{N}inorganic
1	7·3±0·09	51·5±2·5	10·4±0·9	9·6±0·3	3·3±0·2	0·06±0·001	0·02±0·004	0·03±0·0004	n.d.
2	7·2±0·03	61·3±2·6	11·3±0·6	9·5±0·2	3·5±0·2	0·04±0·003	0·05±0·01	0·03±0·0006	n.d.
5	7·5±0·08	44·2±2·2	3·9±0·08	13·6±0·3	3·0±0·2	0·13±0·009	0·04±0·009	0·05±0·001	n.d.
7	7·4±0·09	48·3±1·3	4·5±0·1	14·7±0·3	2·8±0·2	0·16±0·01	0·16±0·02	0·03±0·0006	n.d.

TABLE 3. CHEMICAL COMPOSITION OF SUBSTRATUM EXTRACTS (mg (l FRESH 'SOIL')$^{-1}$) FROM STANDS OF *SCHOENUS FERRUGINEUS* IN PERTHSHIRE, AUGUST 1981

Values are means (±S.E.) of 5 replicates.

Relevé	pH	Ca	Mg	Na	Extractable K	Fe	Mn	P	^{N}inorganic	NH_4–N
1	7·3±0·1	544±21	42·4+4·2	13·4±20·5	14·7±1·0	0·39±0·1	0·34±0·05	0·22±0·01	4·41±0·5	2·00±0·08
2	6·6±0·1	608±25	73·2±8·1	16·8±0·5	20·6±1·1	0·44±0·05	0·18±0·009	0·04±0·001	1·47±0·1	0·56±0·07
3	6·8±0·09	875±29	71·3±9·0	14·4±0·5	24·8±0·9	0·21±0·03	0·12±0·009	0·16±0·02	1·08±0·1	0·73±0·05
4	6·4±0·1	558±25	16·1±0·7	14·8±0·5	10·3±0·6	0·21±0·04	0·11±0·01	0·06±0·004	1·34±0·2	0·87±0·05
5	6·8±0·07	1114±37	41·7±3·8	19·6±0·8	13·6±0·5	0·24±0·01	0·18±0·02	0·12±0·02	0·91±0·09	0·73±0·08
6	6·2±0·05	562±20	19·9±1·1	16·3±0·5	14·4±0·9	0·32±0·03	0·14±0·008	0·08±0·001	2·11±0·5	0·86±0·07
7	6·6±0·1	950±35	39·6±3·9	20·2±0·8	13·0±0·6	0·16±0·03	0·16±0·01	0·20±0·002	2·40±0·5	2·40±0·12

species is absent from the lowlands of western Europe but has a second main centre of distribution around the Baltic Sea, occurring quite widely in north-eastern Germany, Estonia, Finland and southern Sweden, and replacing *S. nigricans* at the higher latitudes. It also occurs in Norway, particulary along the west coast (Hultén 1971). This boreal-alpine distribution is shared by various other mire plants (e.g. *Primula farinosa*) and may indicate a glacial relict status.

Throughout its European range, *S. ferrugineus* is largely restricted to calcareous districts (Tyler 1981) and is most typically regarded as a calcicole – indeed Nordhagen (1937) used the name *Schoenion ferruginei* to encompass the range of plant communities that occupy low productivity, base-rich mires at lower altitudes. *S. ferrugineus* typically grows in soligenous mires (spring fens) (Koch 1926) and in topogenous fens, sometimes forming hydroseral communities around lakes and pools (Koch 1926, Zobrist 1935). However, it may also be found in open stony flushes and even in crevices amongst wet rocks (Faegri 1944). Although showing a clear affinity to calcareous conditions, *S. ferrugineus* is not exclusively associated with calcicolous species and can grow in less base-rich environments. This is particularly evident in some of the Baltic fens where associates may include *Andromeda polifolia*, *Carex lasiocarpa*, *C. limosa*, *Myrica gale*, *Rhynchospora alba*, *Salix rosmarinifolia*, *Scirpus cespitosus* and *Vaccinium oxycoccos* (Kloss 1965; Tyler 1979a, 1981). In Sweden, such acidophilous communities are often found in topogenous fens with a relatively high water table, deep peat and comparatively low levels of carbonate (Tyler 1979b).

The Scottish habitat of *Schoenus ferrugineus* is thus closely comparable with that of localities on the European mainland, although the known sites in Scotland are all soligenous mires. Even its association with some calcifuge species is compatible with its behaviour elsewhere, though it should be noted that, in the Scottish sites, the calcifuge species are themselves often growing in comparatively base-rich conditions. The apparent quite wide tolerance of *S. ferrugineus* makes its localisation the more curious.

The floristic variation of European mires containing *Schoenus ferrugineus* has been reviewed by Görs (1964), Kloss (1965) and Tyler (1981). As might perhaps be expected, the Perthshire sites show strong floristic affinities to Scandinavian *Schoenus* communities, particularly to examples in south-western Norway (cf. Skogen 1965, Jørgensen 1969). There are, of course, some important differences: the Scottish examples do not contain *Andromeda polifolia* or *Scirpus hudsonianus*, both widespread species in Fennoscandian fens, nor more typically northern species such as *Betula nana* or *Drepanocladus badius*. Instead, they have their own particular character with oceanic taxa such as *Erica tetralix*, *Narthecium ossifragum*, *Breutelia chrysocoma* and *Racomitrium lanuginosum*. Some of the most closely-related stands occur in highly oceanic localities in south-western Norway, where *Schoenus ferrugineus* is associated with these same species (Faegri 1944), forming a distinctive vegetation-type that was designated 'unclassified' by Tyler (1981). Thus, although clearly related to other European stands of *S. ferrugineus*, the Perthshire samples are quite distinctive and, perhaps along with some Norwegian examples, may be regarded as an expression of *Schoenus ferrugineus* vegetation developed in highly oceanic conditions. It would not, however, be appropriate to designate them as some new syntaxon based around *Schoenus ferrugineus* (e.g. as an '*Erica tetralix-Schoenus ferrugineus* association') as they are virtually identical to stands of some other Scottish mire communities except for the occurrence of *S. ferrugineus*. They are thus best regarded as *S. ferrugineus* forms of the *Cariceto-Saxifragetum aizoides* and *Carex panicea-Campylium stellatum* noda (following McVean & Ratcliffe (1962)) or, if the syntaxonomic proposals of Bradshaw & Jones (1976) and Wheeler (1980) are followed, as comparable versions of the *Pinguiculo-Caricetum dioicae*.

The unexceptional character of both the vegetation and habitat in which *Schoenus ferrugineus* grows in Scotland suggests that the localisation of the plant may perhaps be explicable in historical terms of relict status and isolation rather than present-day environmental conditions. Little is known about the reproductive biology of the species in Scotland. It appears to set viable seed: at one of the transplant sites, fully-formed seed has been found in approximately 10–20% of the flowers and the plant has produced 6 seedlings since 1945. However there has been no evidence of vegetative spread (Brookes, unpublished data). Although further observations are clearly required, this apparent reproductive potential may pose questions against a relict interpretation of the plant's localisation, especially in view of its absence from almost identical flushes closely adjoining those in which it grows. The possibility that the plant may be a relatively recent immigrant into its present Scottish sites cannot be completely discounted.

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