Rorippa islandica (Oeder ex Murray) Borbás (Brassicaceae) in Wales

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ABSTRACT

Rorippa islandica (Oeder ex Murray) Borbás sensu stricto is reported from ten localities in Wales, a newly discovered stronghold for the species. An updated distribution map of the species in the British Isles is presented. The habitats of the species on the Afon Teifi are described, including depressions in the flood plain, a rock outcrop and waste ground. Possible dispersal mechanisms are discussed and the distribution of seeds both by water and by wildfowl is considered probable.

KEYWORDS: Distribution, habitat, dispersal, life cycle.

INTRODUCTION

On 17 July 1991, A. O. Chater found a *Rorippa* growing on rocks by the Afon Teifi at Cenarth, Cardiganshire (v.c. 46), which agreed with the description of *R. islandica*, Northern Yellowcress, in *Crucifers of Great Britain and Ireland* (Rich 1991). He returned to collect ripe fruits on 25 August 1991, and the material was determined as *R. islandica* by T. C. G. Rich, and later confirmed by B. Jonsell. The find was a surprise in two respects. First, this was the first confirmed record for Wales; old records for '*R. islandica*' have been treated as the generally commoner *R. palustris* (L.) Besser rather than *R. islandica* (Oeder ex Murray) Borbás sensu stricto (Rich 1991). The nearest known localities were in the Isle of Man 250 km to the north and western Ireland 250 km to the north west, so it was a considerable extension of range (subsequently in 1993, another locality was discovered in Kilkenny 200 km to the west north west). Second, the plant was growing on rocks beside a river rather than in its more usual habitat in north west Europe of muddy ponds, turloughs and lough margins.

In 1993, we re-surveyed known *Rorippa* localities along the Teifi and searched other sites in the area to determine the status of the plant. We have also examined the excellent regional collection held at the National Museum of Wales (**NMW**). In this paper we have documented the occurrence of *R. islandica* in Wales and presented an updated distribution map. As there is little ecological information available, we have also carried out studies on its habitats and vegetation on the Afon Teifi, and investigated possible dispersal mechanisms. Nomenclature follows Stace (1991).

DISTRIBUTION IN WALES

All Welsh records traced are listed below. As the widespread occurrence of *R. islandica* in south west Wales casts some doubt on unconfirmed records of *R. palustris* in Rich (1991), we have also included brief details of genuine *R. palustris* records seen in the field or verified from herbarium specimens. Fig. 1 shows the distribution of *R. islandica* in the British Isles as it is currently known, incorporating the Welsh records and many additional localities in Ireland (Goodwillie 1994).

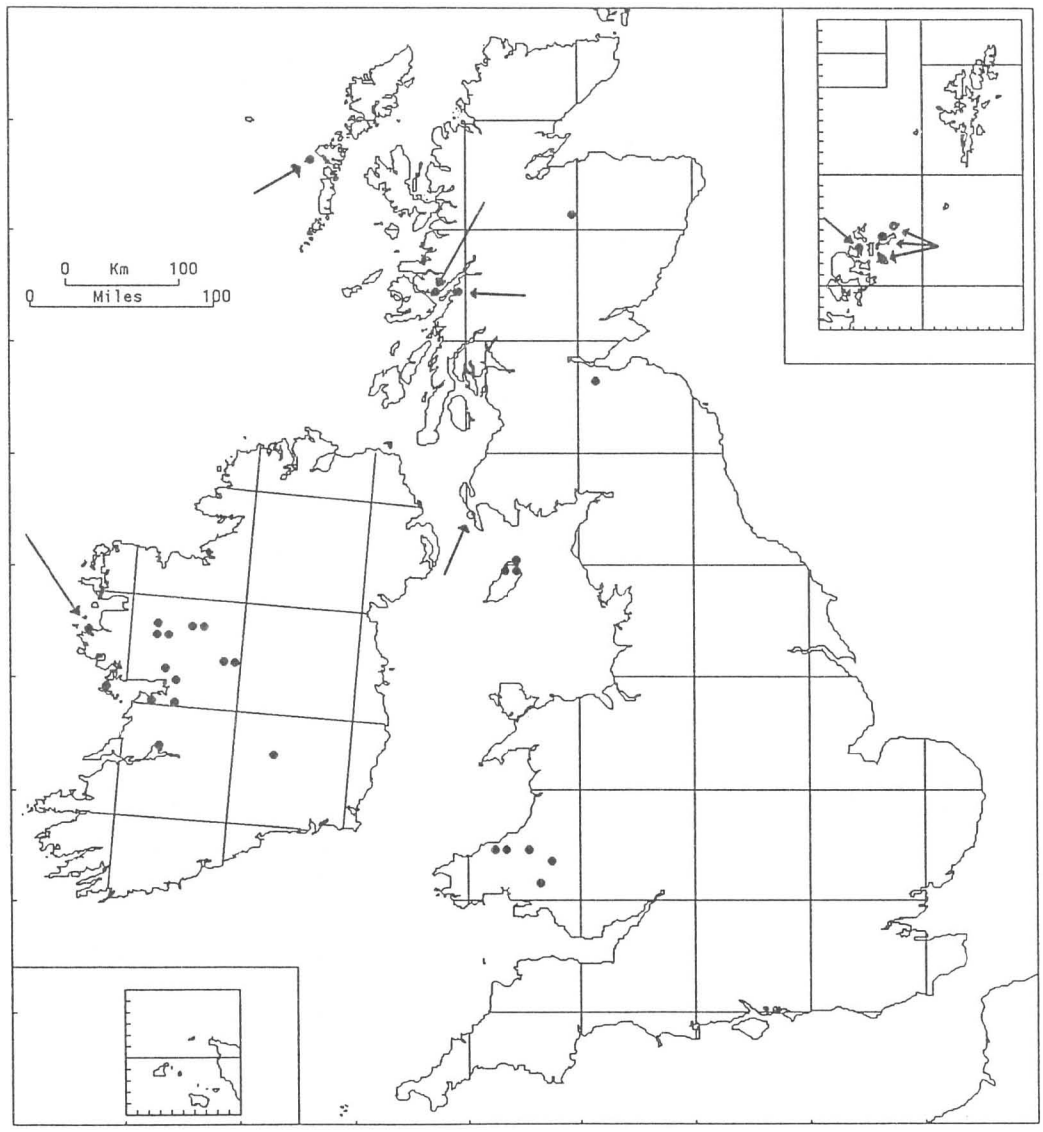

FIGURE 1. Distribution of *Rorippa islandica* in the British Isles, updated from Rich (1991). ● 1950–1993. ○ pre-1950.

Glamorgan, v.c. 41:

1. Garnswllt, near River Loughor (SN/62.10), 13 July 1981, *R. G. Ellis* (**NMW**). First v.c. record.

Carmarthen, v.c. 44:

2. 800 m E of Newcastle Emlyn castle (SN/319.408), muddy hollows in silage field south of river and N. of disused railway, 25 m a.s.l., c. 1000 plants, including many non-flowering rosettes, 23 August 1993, *A. O. Chater and T. C. G. Rich* (**NMW**).

3. Afon Bran, near bridge N. of Llandovery (SN/783.362), 11 September 1981, *R. D. Pryce* (**NMW**). Immature plants collected at Cwm Mynys Isaf, N.E. of Llanwrda (SN/726.340), August 1986, *H. J. Killick* (**NMW**), and on a rubbish tip at West Pwll (SN/4.0, tetrad Q), August 1982, *I. K.*

Morgan (**NMW**) may also be *R. islandica*. The former site was searched in 1993 by A. O. Chater but no suitable habitat for the plant was found.

Other material seen in **NMW**, including Pont Stephen, Felinfach (SN/5.4, tetrads T and Y) collected by A. O. Chater and R. D. Pryce in July 1982, is *R. palustris*.

Pembroke, v.c. 45:

4. 600 m E. of Llechryd Bridge, in silted-up bed of disused canal south of river and minor road (SN/223.434), 7 m a.s.l., c. 20 fruiting plants and many non-flowering rosettes (number uncertain because of presence of *Rorippa palustris* and consequent doubt about identity of vegetative rosettes), 23 August 1993, *A. O. Chater and T. C. G. Rich* (**NMW**). First v.c. record.

Plants from Castlemartin Corse (SR/9.9) are *R. palustris* (**NMW**).

Cardigan, v.c. 46:

5. 300 m W.S.W. of Llwynduris Farm, in and on banks of overgrown ditch in pasture and alongside hedge on N. side of river (SN/235.433), 5 m a.s.l., c. 35 plants, mostly fruiting, 23 August 1993, *A. O. Chater and T. C. G. Rich*, and 22 September 1993, *A. O. Chater* (**NMW**).
6. 50 m W. of Cenarth Bridge, on slightly sloping rock platform on north bank of river (SN/246.416), 10 m a.s.l., four plants of *R. islandica* in crevices in an area of 4 m × 5 m, prostrate and level with the surface of the rocks, 17 July 1991, *A. O. Chater* (**NMW**). Three plants with inflorescences and six non-flowering rosettes, 23 August 1993, A. O. Chater and T. C. G. Rich. No plants were found on the south bank in v.c. 44 in 1993. First found "by the Teifi, Cenarth" in August 1958, *Miss D. E. de Vesian* (**NMW**).
7. 200 m S. of Newcastle Emlyn castle, along c. 100 m length of silted-up ox-bow and around ox-bow pool on north side of river (SN/312.405), 25 m a.s.l., several thousand plants, including many non-flowering rosettes, 23 August 1993, *A. O. Chater and T. C. G. Rich* (**NMW**).
8. The Moat, 1 km E.S.E. of Llandyfriog, muddy depressions and carr in pastures between disused railway and river (SN/341.408), 30 m a.s.l., c. 1000 plants, including many non-flowering rosettes (number uncertain because of presence of *R. palustris* and consequent doubt about identity of vegetative rosettes), 23 August 1993, *A. O. Chater and T. C. G. Rich* (**NMW**).
9. Aberbachnog, 1·7 km E. of Henllan, by pond south of disused railway and in hollows in the pasture between here and river (SN/374.402), 40 m a.s.l., c. 300 plants, 24 August 1993, A. O. Chater and T. C. G. Rich. There is a specimen from the pond collected on 1 September 1979, *A. O. Chater* in **NMW**.
10. Lampeter, 500 m N. of the college, marsh by pool in waste ground and on adjacent soil tips (SN/579.488), 125 m a.s.l., c. 80 plants in marsh and c. 1500 plants on tips including many non-flowering rosettes, 4 September 1993, *A. O. Chater* (**NMW**). Some plants on the tipped soil were over 1m in diameter, and the ground beneath the prostrate stems was orange with the shed seed.

A number of other sites where it was felt that *R. islandica* might occur on the Teifi were visited in 1993 without success, and these are listed as grid references in Table 1. Although negative records are of lesser value, this information may help in any future survey of the species to indicate whether there has been any change in the distribution on the river.

TABLE 1. AFON TEIFI SITES SEARCHED WHERE *RORIPPA ISLANDICA* WAS NOT FOUND. (SITES WHICH SEEMED PARTICULARLY SUITABLE ARE INDICATED BY AN ASTERISK)

SN/154.484*	SN/454.401*
SN/182.443	SN/518.435* – 516.439
SN/184.449	SN/552.462* – 581.476*, many suitable sites
SN/225.432*	SN/597.484
SN/227.434	SN/606.495 – 616.499*
SN/235.414	SN/617.501
SN/256.416	SN/666.580*
SN/256.422*	SN/673.589*
SN/296.418*	SN/672.612
SN/391.396*	SN/683.626
SN/407.403 – 420.411	SN/709.664
SN/429.419* – 425.418	

Rorippa palustris was also found at three additional sites without *R. islandica* (voucher specimens in **NMW**). These sites were Pont Ceri (SN/296.418), 700 m E. of Dolaugwyrddon-Isaf (SN/564.465) and 400 m S.S.E. of Dolaugwyrddon-Isaf (SN/559.463).

Anglesey, v.c. 52:
Jonsell (1968) suggested that "a constant occurrence (1813–1890s) at a small lake in Anglesey (Griffith 1895) may be this species" but this was a result of a misunderstanding of Griffith's text; Davies and Griffith recorded the plant at different sites. Davies (1813) noted "*Sisymbrium terrestre* . . . In the clay pits, at Beaumaris, Cors Ddygai, not rare", and Griffith (1895) gives "**Nasturtium palustre** *DC.* . . . Very rare . . . On the margin of Llyn Frogwy, Bodforth!" R. H. Roberts looked for *R. islandica* in the 1970s without success (pers. comm., 1993), and another survey in 1993 by him of all known sites for *R. palustris* (including Llyn Frogwy) was equally unsuccessful. *R. islandica* has not yet been confirmed for Anglesey.

IDENTIFICATION AND LIFE CYCLE

The field work provided an opportunity to review the identification characters given in Rich (1991). Plants of *R. islandica* were often decumbent to ascending at the base, whilst *R. palustris* was usually more or less erect, but plants of either species in trampled places could be ascending. Leaf shape was quite variable, and it was impossible to identify vegetative rosettes with confidence. There was considerable overlap in flower size between both species, and the floral characters are not very reliable. The presence of a short-petalled clone of *R. sylvestris* (L.) Besser on the Teifi also caused some confusion, though the regularly pinnate leaves, long creeping rhizomes and linear ovaries of this species are otherwise distinctive.

The fruit and seed characters, however, proved a reliable means of distinguishing the plants, which could be done from several metres' distance with some experience. The most striking morphological feature of the *R. islandica* plants on the Teifi was that the fruits were secund and swept downwards so that the whole inflorescence was one-sided, and also quite dense due to the relatively shorter pedicels. How reliable this character is across the range of the species is unknown, but it appears diagnostic in Wales. In contrast, the fruits of *R. palustris* were arranged evenly around the stem and were not so densely crowded.

With practice, the fruit shapes could be seen to be quite different, with *R. islandica* having more rectangular, square-ended fruits. When seeds of both species were examined side by side, those of *R. palustris* were darker in colour, slightly larger and the epidermal cells could just be made out with a ×20 lens (the epidermis of *R. islandica* appearing comparatively featureless). Identification should always be confirmed from microscopical examination of ripe seeds and comparison with voucher material. The size of the epidermal cells is diagnostic, although it is difficult to quantify this because of variation on different parts of the seed.

Rorippa islandica and *R. palustris* have previously only rarely been found growing together in the same place (e.g. in Ireland, Goodwillie 1994). One plant was found at The Moat (Site 8) which was partially sterile (**NMW**), but this is more likely to be due to environmental factors than hybridisation since both species are habitually in-breeding. Jonsell (1968) failed to obtain any progeny from experimental crosses.

Rorippa islandica is usually considered an annual in the wild (e.g. Rich 1991), although Jonsell (1968) was able to keep some plants in cultivation for up to five years. In August and September 1993 we noticed that many plants (more than half the population at some sites) had not commenced flowering, and we assumed that these would flower later in the autumn. On revisiting these sites in early November 1993, there was still no sign of inflorescences on most of these rosettes, and they were still in the same condition in March 1994. Furthermore, many plants which had fruited in 1993 bore well-developed central rosettes through to March 1994. Several plants were also seen in November 1993 which had axillary rosettes of leaves on decaying fruiting stems which were about to break off from the parent plant to act as vegetative propagules (this phenomenon occurs occasionally in other crucifers, cf. Rich (1984), and Grime *et al.* (1988) for its occurrence in *R. palustris*). In its Teifi sites *R. islandica* therefore often behaves as a biennial, and possibly at least sometimes as a perennial, although further field studies with marked plants are needed to confirm

the perennial habit. Goodwillie (1994) mentions phenological plasticity in *R. islandica* as probably fitting the plant for growth in turloughs where the unpredictability of the water level is the major environmental variable. The plasticity of life cycles in response to environmental conditions is well known in other crucifers (Rich 1991).

HABITATS OF *RORIPPA ISLANDICA* ON THE TEIFI

The Afon Teifi is about 115 km long and rises at 550 m a.s.l. in acidic moorland. When it has fallen to 160 m a.s.l., it meanders slowly for about 8 km through the extensive raised mire complex of Cors Caron, through beds of silts and clays. For much of the rest of its length, and especially in its lower half, the river is relatively fast-flowing and rocky. This is a reverse of the usual pattern, in which rivers have their faster, rocky section above the slower, meandering ones. The Teifi is also unusual in having no large tributaries. The Cors Caron stretch thus has an unexpectedly dominating effect on the rest of the river (Holmes 1983; Chater 1994). The underlying rocks of the whole river system are Ordovician and Silurian shales and mudstones and are largely acidic. Sites 4–9 are situated in the lower third of the river, and site 10 is three-fifths of the way up the river.

Six of the eight sites on the Teifi, nos. 2, 4, 5, 7, 8 and 9, are depressions in the floodplain, within 300 m of the river but separated from it. Four of these depressions originated as meanders or ox-bows which have become silted up and two still contain areas of more or less permanent open water adjacent to the *Rorippa* populations. Site 4 is a long-disused and largely silted-up canal, and site 8 is a meander anciently modified into a moat, half of which is now silted up. All six sites are regularly flooded, usually at least once a year and often for some days at a time, when the whole of the floodplain is inundated. These floods can occur at any time of the year, though rarely in summer. All six sites are on fine, silty, gley soils, probably mostly of the Conway series (Bradley 1980; Rudeforth *et al.* 1984) in situations where they form part of the Teme Association.

Soil pH was measured for each site from one fresh soil sample collected from the top 5 cm of the soil profile (i.e. the root zone). The samples were mixed with a similar volume of de-ionised water to form a paste and allowed to stand for about five minutes. pH was measured using a Piccolo ATC pH-meter (Hanna Instruments Inc.) with a HI 1280 amplified electrode. The soil pHs measured ranged from 5·2 to 6·6 (Table 2).

Site 6 seems to be unique for *R. islandica* in that it is a gently sloping platform of rock c. 1 m above normal water level in a rocky section of the river. The plants grow in crevices in the rock and are very dwarfed, and some are adjacent to patches of concrete placed to smooth the platform. It is frequently flooded, and the pH of the soil in the crevices is 6·9, possibly influenced by the concrete. The site used to be used for sheep-dipping and is now much used by fishermen and picnickers. Our initial impression that this habitat was unusual has thus been confirmed by further survey.

Site 10 is just west of a tributary, the Afon Dulas, 1·1 km above its confluence with the Teifi. Until about ten years ago it was a wood yard but is now marshy ground around a shallow pond. The ground is patchy and partly open and parts of it, including the area with *R. islandica*, are usually flooded for much of the winter. Flooding is due to poor drainage and the site, unlike the other seven, is not part of the Teifi floodplain although it is within the catchment. The pH here averaged 7·6, the substrate including timber, tarmac, stones and other imported material. Along the south side of the

TABLE 2. SOIL pH VALUES FROM *RORIPPA ISLANDICA* SITES IN THE TEIFI VALLEY, WALES

Site 2	pH 6·0
Site 4	pH 6·6
Site 5	pH 6·5
Site 6	pH 6·9
Site 7	pH 5·2
Site 8	pH 5·6
Site 9	pH 5·3
Site 10, marsh	pH 7·6
Site 10, tip	pH 8·2

marsh is a large area of soil and rubble of unknown origin, illegally tipped here in early 1992. The pH of this by the main colony of *R. islandica* here is 8·2. 100 m to the south-east is another equally recent soil tip, the material having come from excavation on the site; *R. islandica* is by far the most abundant plant on this tip. *R. islandica* must be a recent arrival at this site, as there was no vegetation on it until a decade or so ago. It is impossible to guess whether it arrived first in the marsh, where it could have been brought by birds (Mute Swans nest on the pond), or whether it arrived with the illegally dumped soil and spread from this to the adjacent tip and to the marsh. *R. islandica* has also been reported from rubbish tips in the Isle of Man (L. S. Garrad, pers. comm., 1989).

VEGETATION

Species associated with *R. islandica* at the eight Teifi sites are listed in Table 3 (at site 10 only the marsh part of the site is included). It should be understood that the species lists in Table 3 are not to be interpreted as floristic tables for the communities present, but are simply lists of species growing within 1 m of *R. islandica* plants. The most constant associates were *Persicaria hydropiper*, *Gnaphalium uliginosum* and *Callitriche brutia*, all also annuals of disturbed open, damp ground.

The vegetation of these sites falls into two main types which can be described in terms of *British plant communities* (Rodwell 1991, *et seq.*). The drier sites support *Agrostis stolonifera – Alopecurus geniculatus* grassland (MG13), which is characterised by constant *Agrostis stolonifera* and *Alopecurus geniculatus*, with *Ranunculus repens*, *Holcus lanatus*, *Poa trivialis*, *Juncus effusus* and *Glyceria fluitans*. It occurs in seasonally inundated places, on poorly drained, clayey soils, often in grazed and trampled conditions, and the sward is usually short and fairly open. It is not uncommon throughout most of lowland Britain. This was the most characteristic vegetation type for *R. islandica* which was very abundant in it at sites 2, 7, 8, and 9.

The *British plant communities* frequency table for *Agrostis stolonifera – Alopecurus geniculatus* grassland appears to underestimate the frequency of the annuals characteristic of these muddy, trampled sites (e.g. *Persicaria hydropiper, Gnaphalium uliginosum*), both in western Wales and elsewhere. An additional sub-community of the *Agrostis stolonifera – Alopecurus geniculatus* grassland, characterised by *Persicaria hydropiper*, might be justified.

The wetter sites support *Glyceria fluitans* swamp, *Alopecurus geniculatus* sub-community (S22c), which occurs in shallow, seasonally-inundated water on nutrient-rich soils, usually with a fine mineral substrate. It is often grazed and is frequent in ditches in fields, dry ditches and along the margins of small streams. It is dominated by *Glyceria fluitans* and *Alopecurus geniculatus*, with a few other frequent species such as *Rumex crispus* and *Poa trivialis*. It is widespread and common in the agricultural lowlands of Britain. *R. islandica* occurred in this vegetation type at sites 4, 5 and 8, and in the first two is at a much lower frequency than in the MG13 grasslands.

The Cenarth site (Site 6) supports sparse vegetation which is best treated as MG7 *Lolio-Plantaginion*, but can scarcely be considered a typical example of the vegetation.

The vegetation at site 10, disturbed and of recent origin, is probably best considered as M23 *Juncus effusus/acutiflorus – Galium palustre* rush-pasture, but the *R. islandica* grows in sparsely vegetated ground uncharacteristic of the community as a whole.

DISPERSAL

Rorippa islandica is easily overlooked, both because of its inconspicuous nature and because of the difficulties of identification, and, more than for many other species, absence of records should not be taken to indicate absence of the species. The earliest record from the Teifi is from Cenarth in 1958 (Site 6 or nearby), and the next is from Aberbachnog in 1979 (Site 9); it is still present at both of these sites. It was first found at the others in 1993. The only certain comment that can be made about the history of the populations is that the one at site 8 must be less than about a decade old. Sites 2 and 4–9, all in the lower half of the river, are on the floodplain where seeds could easily have been transported by regular flooding.

Unlike many other crucifers, the epidermal cells of the seeds of *R. palustris* and *R. islandica* do

TABLE 3. SPECIES GROWING IN THE SAME COMMUNITIES AS AND WITHIN 1 M OF *RORIPPA ISLANDICA* AT EIGHT SITES IN THE TEIFI VALLEY, WALES

	Site no.							
Associated species	2	4	5	6	7	8	9	10 (marsh)
Agrostis capillaris					+	+	+	
A. stolonifera					+	+	+	+
Alisma plantago-aquatica	+	+	+					
Alnus glutinosa						+		
Alopecurus geniculatus	+	+	+		+		+	
Apium nodiflorum			+					
Bidens cernua	+				+			
B. tripartita	+	+	+			+		
Callitriche brutia		+	+		+	+	+	
C. stagnalis			+		+			
Cardamine flexuosa			+			+		
C. pratensis			+				+	
Carex remota			+					
C. vesicaria						+		
Chenopodium rubrum	+							
Eleocharis palustris								+
Equisetum arvense			+					
E. palustre								+
Festuca rubra				+				
Filipendula ulmaria			+					
Galium palustre								+
Glyceria declinata		+						+
G. fluitans	+	+	+					
Gnaphalium uliginosum	+	+	+		+	+	+	
Juncus articulatus			+			+		+
J. bufonius		+			+		+	+
J. effusus	+		+		+	+		
J. kochii								+
Lemna minor			+				+	
Lysimachia nummularia			+			+		
Lythrum portula					+	+	+	+
L. salicaria	+	+	+		+			
Matricaria discoidea				+		+		
Myosotis laxa								+
M. scorpioides		+						
Oenanthe crocata			+	+				
Persicaria amphibia	+		+			+		
P. hydropiper	+	+	+		+	+	+	+
P. maculosa								+
Phalaris arundinacea	+	+	+	+				
Plantago major				+	+			
Poa annua				+			+	
Potentilla anserina			+				+	+
Ranunculus flammula			+					+
R. repens		+		+	+		+	+
R. sceleratus	+							
Rorippa islandica	+	+	+	+	+	+	+	+
R. palustris		+				+		
Rumex obtusifolius		+					+	
Sagina procumbens				+				
Salix cinerea				+		+		+
Sparganium erectum						+		
Stellaria media				+	+			
Taraxacum sp.				+				
Trifolium repens				+				
Typha latifolia	+							
Urtica dioica			+					
Veronica beccabunga						+		

not produce mucilage, but are hollow (Jonsell 1968). This may have the advantage of making the seeds buoyant, facilitating dispersal in water, and enabling the seeds to be drawn up in water films as, for instance, by birds as they leave the water. Ridley (1930) reported the presence of *R. palustris* in many places by the River Thames at Kew, where its seeds can only have been carried by water, and he also found that seeds put in water floated for 24 days. The possibility of dispersal of *R. islandica* in water was tested by a simple experiment.

FLOTATION EXPERIMENT

Seeds of *R. islandica* and *R. palustris* were collected from ripe fruits of plants in cultivation on 7 September 1993. Batches of 20 seeds were floated on 200 ml of tap water in glasses, and the numbers of seeds floating were counted at intervals for two months. The water was agitated once each day by shaking the glass enough to cause the seeds to dip below the surface. The influence of surface tension was tested by adding two drops of household detergent (Fairy Liquid). Seeds in water floated in a group in the middle of the glass, whilst those in detergent lined up around the margin of the glass, as would be expected from the shape of the water meniscus. Seeds in detergent initially sank after agitation, but rose to the surface again after a minute or so. The results are shown in Table 4, and indicate that seeds of both species are buoyant in water for substantial periods of time. In water with detergent, it is possible that the larger epidermal cells of *R. palustris* are more easily infiltrated with water thus reducing their buoyancy.

Transport of seeds of *R. islandica* down the river by floods (which often occur in autumn when the seeds are ripe) would thus seem a strong possibility, although ending up in an appropriate habitat is purely a matter of chance. The dispersal of plants such as *Impatiens glandulifera* along river corridors is well known, and *Claytonia sibirica* and *Rorippa austriaca* are currently spreading on the Afon Tywi and Afon Loughor respectively in v.c. 44 (G. Hutchinson, pers. comm., 1993).

Seeds floating on the surface of the water are easily drawn up in a film of water when an object (e.g. a finger) is immersed and lifted out. It is possible to imagine the same type of mechanism being involved with birds' feet or plumage as they leave water.

BIRD DISPERSAL

Jonsell (1968) suggests that dispersal of seeds by geese is possible for *R. islandica* and points out the connections between its distribution and the migration routes of geese. Similar ideas have been put forward for other species (e.g. Heslop-Harrison 1953; Gornall 1987), and evidence for long-distance dispersal of seeds in the digestive systems of geese to Britain is given by Welch (1993). He collected droppings from where skeins of Pink-footed Geese migrating from Iceland first landed, and placed them in a moderately heated greenhouse on sterile compost, some immediately and some after a few months storage in a deep freeze. Seedlings which germinated immediately often died, perhaps due to the toxic conditions of the droppings, but in subsequent years some seedlings were successfully raised. Seeds may also be dispersed by mud on birds, and Kerner (1903; see also Ridley 1930) reports finding seeds of *R. palustris* and many other species, in mud from the feet, beaks and feathers of Swallows, Snipe, Wagtails and Jackdaws.

Jonsell's suggestion is especially worth considering in the case of the *R. islandica* populations on

TABLE 4. NUMBERS OF *RORIPPA* SEEDS (OUT OF 20) REMAINING AFLOAT DURING A FLOTATION EXPERIMENT

Days from start of experiment	*R. islandica*		*R. palustris*	
	Water	Water + Detergent	Water	Water + Detergent
0	20	20	20	20
1	20	20	20	17
13	20	20	20	15
15	20	20	20	14
23	20	20	20	0
61	20	20	20	0

the Afon Teifi. The Greenland White-fronted Goose (*Anser albifrons flavirostris*) breeds in west Greenland, and winters exclusively in Ireland, west Scotland and Wales (Fox & Stroud 1985). A flock wintered on Cors Caron, the raised mire complex on the upper reaches of the Teifi, from at least the 1890s (when it probably consisted of c. 30 birds) until the 1960s. Numbers had risen to 250–300 by 1940, to 400 by 1957, and to 550–600 by 1962. A catastrophic decline followed, and the geese ceased to winter regularly there after 1967/8 (Fox & Stroud 1985). *R. islandica* does occur in west Greenland but is rare there, but of much greater significance is the fact that many of these geese break their autumn migration to the British Isles on the west and south coasts of Iceland (Cramp 1977). One of the two main areas for *R. islandica* in Iceland is in Arness Syslá in the south west (Jonsell 1968) and dispersal from here by migrating geese at a time when seed was ripe could explain how the seed came to be present in the Teifi river system. *R. islandica* has not yet, however, been found anywhere on the Teifi above site 10 at Lampeter, which is some 15 km below the former main wintering grounds of the geese.

Greenland White-fronted Geese also wintered further north in Cardiganshire throughout the first half of the present century, including Cors Fochno on the south side of the Dyfi estuary, and since the 1950s flocks of about 80–250 birds have been wintering regularly on this estuary. Neither *R. islandica* or *R. palustris* have been recorded from this area. Elsewhere in Wales the only regular wintering flocks that might have been expected to be involved in seed-dispersal direct from Iceland or Greenland have been in Montgomeryshire and perhaps Anglesey. Small flocks and casual records have been made in many places, including the lower Teifi, and on the Tywi in Carmarthenshire (Fox & Stroud 1985).

If Gornall's (1987) hypothesis that *Ranunculus reptans* is dispersed to the British Isles mainly by Pink-footed Geese, Mallard or Wigeon is correct, then one might predict that *R. islandica*, which grows in similar habitats and places to *Ranunculus reptans* at least in Iceland, might be expected to show some similarities in distribution in Britain. However, the distributions of *Rorippa islandica* and *Ranunculus reptans* in Britain do not overlap, and only *Rorippa palustris* (which is absent from Iceland) has been recorded from Loch Leven, the classic site for *Ranunculus reptans*.

DISCUSSION

The recent discoveries in Ireland (Goodwillie 1994) and the Welsh data presented here indicate that *R. islandica* has been widely overlooked, and it should be looked for elsewhere. It would be surprising if the species was not as widespread on the catchments of the Loughor and Bran/Tywi as it is along the Teifi. We would welcome further records supported by voucher specimens composed of a few ripe fruits.

The Afon Teifi and the Irish turloughs appear to be the major stronghold for the species in north west Europe. The Scottish localities are all scattered and isolated and support small populations. It is somewhat erratic in appearance in the Isle of Man. Whilst there is no definitive evidence, it is likely that *R. islandica* is not a new arrival in Wales. Its local abundance would seem to be associated with dispersal by water, and it is possible that the wider distribution is related to dispersal by geese.

The occurrence along a river system is also unusual. In Ireland it occurs in turloughs and ditches near the sea. In Scotland it occurs in small ponds, damp ground and loch margins. In Iceland it occurs around lakes and small bodies of water, moist soil and also around hot springs. In Greenland it occurs around small lakes and temporary ponds, as well as on or beside paths. In Norway it occurs in small coastal pools, ditches and potato fields. In central Europe it occurs on the shores of alpine lakes (Jonsell 1968).

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