# The current status of *Rumex rupestris* Le Gall (Polygonaceae) in England and Wales, and threats to its survival and genetic diversity

R. E. DANIELS

*N.E.R.C. Institute of Terrestrial Ecology, Furzebrook Research Station, Wareham, Dorset, BH20 5AS*

E. J. McDONNELL

*Dungeon Cottage, Cocklake, Wedmore, Somerset, BS28 4HB*

and

A. F. RAYBOULD

*N.E.R.C. Institute of Terrestrial Ecology, Furzebrook Research Station, Wareham, Dorset, BH20 5AS*

ABSTRACT

All U.K. sites from which *Rumex rupestris* Le Gall, a dock endemic to N.W. Europe, had previously been recorded, and which could be identified from herbarium specimens and Flora records, were surveyed. The objectives were to obtain up-to-date information on the distribution of this apparently declining species, the size of its extant populations and the suitability of previously occupied sites for re-introduction under the Species Recovery Programme. The amount of genetic variation, and its distribution within and between populations was measured using isozyme electrophoresis. Although a relatively large amount of the total variation found is held within individual populations, there is evidence of some isolation of populations by distance. Results also support the expectation that larger populations hold more genetic diversity. Possible threats to the survival of populations and to variation within the species are discussed.

KEYWORDS: Shore Dock, distribution, isozymes, gene flow.

## INTRODUCTION

*Rumex rupestris* Le Gall (Shore Dock) (Polygonaceae) is a rare and threatened European endemic growing in scattered populations along the coasts of Galicia, western France, the Channel Isles, south-west England and south Wales, with an outlying (possibly introduced) population on Anglesey. It grows above high water mark where there is a supply of fresh water. Some populations occur in wet crevices in the lower parts of cliffs, where fresh water discharges on to the upper parts of beaches or slumped head material. Others are found in seepage zones at the base of cliffs or in small pools on wave cut platforms. Less frequently, plants also grow along the margins of streams or ponds in dune slacks. Population size is usually small, frequently with fewer than ten individuals, growing as scattered individuals or small clumps. Throughout its range it appears to be vulnerable to the same set of threats: habitat instability, human activity and small population size. The objective of the present study, sponsored by English Nature under the Species Recovery Programme, was to determine the current status of the species in Britain and the Channel Islands, assess the magnitude of the different risks and develop proposals for its reintroduction into some of its former sites. This paper reports the results of the first two of these activities.

## METHODS

Floras and herbaria were consulted in order to determine the locations of all past and present populations of *R. rupestris* in England and Wales, and the dates when last records were made. In late summer 1994 all known extant sites in Devon and Cornwall, based on data in King (1989) and information from local botanists, were visited and counts made of plants present (McDonnell 1995). Species associated with colonies of *R. rupestris* were also recorded. Similar counts were made of populations in the Isles of Scilly by R. Parslow (Parslow & Colston 1994). Q. Kay and A. Jones provided information on the present status of the species in Wales. In summer 1995 most of the mainland sites were revisited together with all sites in Cornwall, Devon and Dorset for which old records had been found in order to determine whether any plants were still present (Daniels, McDonnell & Moy 1996). Comparisons were also made with sites visited the previous summer, in order to assess suitability for re-introduction, bearing in mind the known or predicted ecological requirements of the species and practical considerations. Such information, together with site history, where this was known, was also used to suggest possible reasons for loss of individual populations and to select sites for re-introduction.

In 1994, small seed samples were collected from all populations visited. A sub-sample of these seeds was used to grow plants for examination of electrophoretic variation in leaf material. Enzyme extracts were prepared in 0·1M Tris buffer containing 10% glycerol, 1% ascorbic acid and 0·1% mercaptoethanol. The natural acidity of the leaf tissue obviated the need for pH correction of the buffer to pH 7·0 using HCl. The resulting slurry was centrifuged at 1400 rpm for 3 minutes and the supernatant was stored at $-73°$ C until used for electrophoresis. Electrophoresis was performed in a BioRad Protean II chamber using 1 mm thick polyacrylamide gels. The 13% separating gel was prepared in a 0·4M Tris-HCl buffer (pH 8·8) and a 7% stacking gel in a 0·1 Tris-HCl buffer (pH 6·8). Gels were run for 7 hours at a constant 250V using a 0·072M glycine-0·005MTris electrode buffer (pH 8·5). Gels were stained for eight different enzyme systems using the protocols of Raybould *et al.* (1991).

## RESULTS

### STATUS AND DISTRIBUTION

The distribution of extant (in 1989–1995) and former sites in England and Wales is shown in Fig. 1. Subsequent to this survey, a new site was found in Glamorgan, south Wales (Kay 1996). Table 1 gives the number of plants present in each of the surveyed sites in Devon and Cornwall in 1989 (data from King 1989), 1994 and 1995, together with 1994 and 1996 data for the Isles of Scilly (Parslow & Colston 1994; Parslow 1996) and 1996 data from Glamorgan (Kay 1996). Some difficulty was experienced in assessing absolute numbers because of possible confusion of vegetative plants with non-fruiting specimens of *Rumex crispus*, especially in its coastal variant, subsp. *littoreus* (J. Hardy) Akeroyd. Because of this, reliable comparisons of population size can only be made using counts of fruiting plants.

Sites at which the plants had been recorded formerly but were not found in 1994 are listed in Table 2, together with the dates of last records. In some cases the actual locations are ill-defined because of lack of clarity in recording the precise location of a Flora entry or a herbarium specimen. In a few cases it has been assumed that two records with different names have referred to the same populations, especially where one of them has been as vague as "near Plymouth". Whilst some locations appear several times, with the species being noted by more than one recorder, others are represented by single records only.

### GENETIC VARIATION

Pot-grown plants at Furzebrook showed a wide range of variation in height, differences in leaf characters and divergence in inflorescence structure. In particular, nine robust plants with leaves standing out widely from the stems and wavy leaf margins (five from seed collected at Rame and four from seed collected at Westcombe) developed tall flowering shoots in which the branches formed acute angles with the main axes and the flowers were arranged in closely-set whorls. In addition, the fertile fruits produced had distinct wings. These plants so closely resembled *R. crispus*
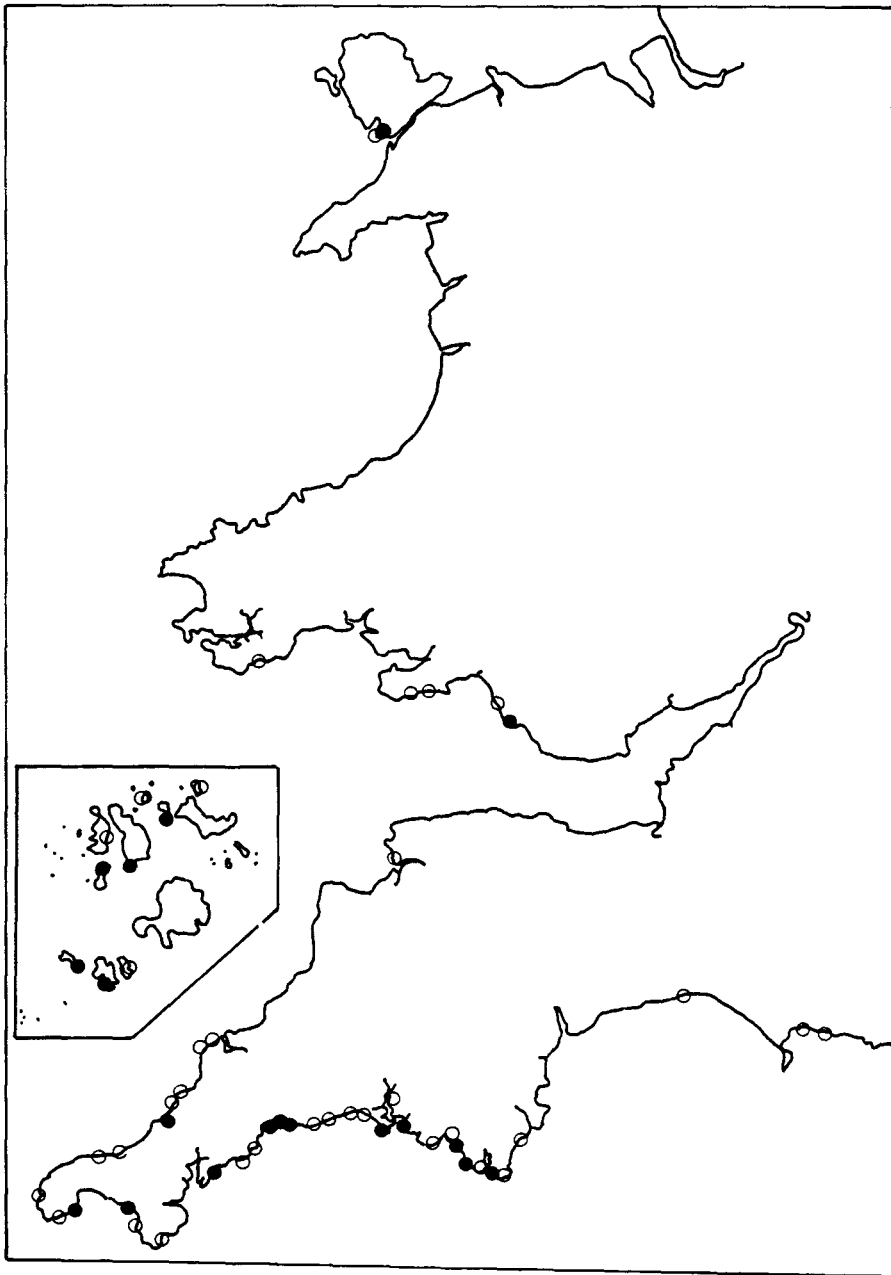
FIGURE 1. Distribution of extant (closed circles) and historical (open circles) populations of *Rumex rupestris* in mainland Britain, Anglesey and the Isles of Scilly.

TABLE 1. NUMBER OF PLANTS OF *RUMEX RUPESTRIS* (IN FRUIT AND IN TOTAL) AT
DIFFERENT LOCATIONS IN ENGLAND IN 1989, 1994, 1995 AND 1996
A zero indicates that no plants were observed: a dash indicates that no observations were made.

| Site | 1989 | | 1994 | | 1995 | | 1996 | |
|---|---|---|---|---|---|---|---|---|
| | + fruit | total | + fruit | total | + fruit | total | + fruit | total |
| Cornwall | | | | | | | | |
| Penhale | – | >50 | 33 | >33 | – | >50 | >70 | >70 |
| Lamorna | – | – | 2 | 3 | 2 | 3 | – | – |
| Gunwalloe | – | >50 | 7 | 7 | 0 | 2 | – | – |
| Pendower | – | 18 | 9 | 9 | 9 | 9 | – | – |
| Pencarrow | – | – | 3 | >3 | 7 | 7 | – | – |
| Llantivet Bay 1 | – | 2 | 2 | 4 | 1 | 4 | – | – |
| Llantivet Bay 2 | – | – | – | – | 7 | 7 | – | – |
| Rame | – | 69 | 24 | 36 | 31 | 35 | – | – |
| Devon | | | | | | | | |
| Wembury | – | – | – | – | 1 | 1 | 1 | 1 |
| Westcombe | 2 | 4 | 2 | 2 | – | – | – | – |
| Soar Mill | 5 | 6 | 13 | >13 | 3 | 8 | – | – |
| Rickham | – | 19 | 0 | 0 | 0 | 0 | – | – |
| Venericks | – | 9 | 5 | 13 | 10 | 12 | – | – |
| Isle of Scilly | | | | | | | | |
| Tean | – | – | 19 | 72 | – | – | 19 | 97 |
| Tresco | – | – | 33 | 33 | – | – | 52 | 60 |
| Samson | – | – | 40 | 40 | – | – | 90 | 124 |
| Annet | – | – | 6 | 6 | – | – | 51 | 51 |
| St Agnes | – | – | 14 | 14 | – | – | 18 | 18 |
| Wales | | | | | | | | |
| Newborough | – | – | – | c 25 | – | – | – | – |
| Glamorgan | – | – | – | – | – | – | 21 | >21 |

that it appears most likely that in the field specimens of *R. crispus* subsp. *littoreus* were sampled rather than *R. crispus*, despite conviction at the time that all seed came from shore dock plants. A second group of plants grown from seed collected at Church Cove had spreading, leafy, inflorescences and comparatively long petioles and were, undoubtedly, *R. conglomeratus* Murray. Field survey in 1995 confirmed that all plants at this site were *R. conglomeratus*. Several individuals showed characteristics which were intermediate between *R. conglomeratus* plants and more typical *R. rupestris* in the cultivation trial. This suggests that either the range of variation is continuous between the two species or that some of the plants were of hybrid origin.

Of the eight enzyme systems tested, five produced only monomorphic banding patterns and only three (esterase, malate dehydrogenase and phosphogluco-isomerase) showed polymorphism. Even in these cases, band interpretation in terms of alleles at different loci was difficult and different band combinations were recognised only as different phenotypes. Because of this, variation at the species and population levels was calculated using the Shannon Diversity Index (King & Schaal 1989) rather than F-statistics.

Each of the phenotypes for each of the systems where polymorphism was found were combined to give a set of overall phenotypes (e.g. AAA represents a phenotype showing banding patterns recognised as phenotype A for each of the systems whilst AAB represents a combined phenotype with a different PGI banding pattern). The proportions of each of these combined phenotypes were used to calculate dissimilarity indices. Calculations of overall diversity ($H_{sp}$), the mean diversity within populations (mean of $H_{pop}$) and the contributions of within-population and among-population to overall diversity were made at three different scales. Taking all populations as distinct, independent, units, 55% of the total variation was contained within populations and 45% was attributable to differences among populations. This implies that, although there are differences among the isolated populations of *R. rupestris* in south-west England, each still retains much of the total variability found within the species in England. The maintenance of diversity may result from gene flow between populations (either through pollen transfer or seed dispersal) and if this is the

TABLE 2. FORMER SITES OF *RUMEX RUPESTRIS* IN ENGLAND AND WALES

English sites with asterisk are those where there is only a single record.

| Site | Grid square | Last record |
| --- | --- | --- |
| Cornwall | | |
| Harlyn Bay | SW/8.7 | 1900* |
| (Trevose Head & | SW/8.7 | 1963) |
| (Constantine Bay | | 1951) |
| East Pentire | SW/7.6 | |
| Fistral | SW/7.6 | 1912 |
| Newquay | SW/8.6 | |
| Gravel Hill mine, Cubert | SW/7.5 | 1903* |
| Godrevy Point | SW/5.4 | 1951* |
| Lelant | SW/5.3 | 1909* |
| Sennen Green | SW/3.2 | 1870's* |
| Boscawen Cliff | SW/4.2 | 1900* |
| Poltesco | SW/7.1 | 1870's |
| Hemmick Beach | SW/9.4 | 1905* |
| Vault Beach | SX/0.4 | 1900* |
| Looe | SX/2.5 | 1917* |
| Downderry | SX/3.5 | 1875* |
| Portwrinkle | SX/3.5 | 1875* |
| Tregantle | SX/3.5 | 1875* |
| Devon | | |
| Wadham | SX/5.4 | 1875* |
| Pamflete | SX/4.5 | 1876* |
| Little Seacombe | SX/7.3 | 1989 |
| Gammon Head | SX/7.3 | before 1939 |
| Slapton Ley | SX/8.4 | 1977* |
| Braunton Burrows | SS/4.3 | 1955 |
| Dorset | | |
| Lyme Regis | SY/3.9 | 1923* |
| West Bay | SY/4.9 | 1949* |
| Ringstead Bay | SY/7.8 | 1985 |
| Durdle Door | SY/8.8 | 1985 |
| Poole | SZ/0.9 | 1900* |
| Glamorgan | | |
| Three-cliffs Bay | SS/5.8 | 1985 |
| Pennard Burrows | SS/5.8 | 1910 |
| Kenfig Burrows | SS/7.8 | 1948 |
| Dunraven Bay | SS/8.7 | 1934 |
| Methyr Mawr | SS/8.7 | 1954 |
| Pembrokeshire | | |
| Lydstep Haven | SS/0.9 | 1957 |

case we would expect the highest rates of gene flow to be between neighbouring populations and the lowest between the most distant populations (isolation by distance). Gene flow could not be implied directly from our results because of our inability to define alleles and our resulting reliance on calculation of dissimilarity from phenotypic data only. Pairwise calculations were made to determine the relative amount of variation found within pooled pairs and between them. The results were then compared with geographical distance (log transformed to allow for the wide range of distances used) between the population pairs. A significant positive relationship was found between geographical distance and the amount of dissimilarity shown by the population pairs ($b = -2\cdot98 \times 10^{-2}$; $p$ ($b>0$) $= 0\cdot035$). The further apart the populations were, the more dissimilar they were. Separating Scilly Isles populations from those on the mainland and performing partial regressions on the results to allow for the fact that populations within each of the two regions are closer to each other than populations in different regions showed highly significant distance and region effects. In other words, the effect of distance between populations (after removing effects due to their

presence in different regions) on their dissimilarity was highly significant (b = $5 \cdot 77 \times 10^{-2}$; p (b>0) = $0 \cdot 0014$). Dissimilarity between regions (Scilly Isles and mainland), once distance effects had been removed, was also significant (b = $4 \cdot 41 \times 10^{-2}$; p (b>0) = $0 \cdot 0056$).

Although individual populations do hold much of the variation, we might expect that the amount would be reduced as population size decreases so that dispersed, small, populations would be susceptible to gradual loss of genetic variation. A regression of diversity on population size did show a positive relationship ($r^2 = 34 \cdot 3\%$) so confirming this expectation.

## DISCUSSION

The fact that the list of extant sites is shorter than that for former sites suggests a sharp decline in distribution of the species. In some cases the reasons for loss of *Rumex rupestris* from particular sites are quite clear. Drastic habitat modification caused by sea wall construction and cliff consolidation are known to have been instrumental in the decline of *R. rupestris* from sites such as Gunwalloe and may have been major factors in eliminating the plants from sites such as Lelant, Hemmick Beach and Slapton. Elsewhere, erosion, especially under the influence of severe storms, may have been responsible for colony destruction, as appears to have been the case at Ringstead Bay. Plant community development (especially the growth of a closed sward of coarse grasses and herbs) may also have been a contributory factor to the loss of *R. rupestris* from sites such as that at Constantine Bay.

The occasional occurrence of a single plant, or a few, isolated, individuals in sites from which they subsequently disappear may indicate that many populations are inherently ephemeral. Conditions for successful germination and seedling establishment may occur only occasionally, with those plants which do become established surviving for one or several years depending on site stability. At the same time, the appearance of plants in new locations from time-to-time does suggest that either seed banking and subsequent exposure, or seed dispersal, is effective and that seeds do occasionally arrive at suitable germination sites. Such a dynamic situation is not uncommon among species (including *Rumex* spp.) which do bank seed and require re-exposure before they can germinate successfully (Kendrick & Heeringa 1986; Voesenek *et al.* 1992). However, the unstable coastal habitats in which *R. rupestris* grows do not appear conducive to the retention of a persistent seed bank and so the potential for recolonisation will depend on a supply of seed from neighbouring populations reaching suitable germination and establishment sites. Given suitable sites we know from practical experience that seedling establishment is possible. However, as individual populations are extirpated or as conditions lead to the progressive loss of suitable germination or establishment sites, the capacity for replenishment is decreased.

In a species which, with a few exceptions, appears to occur predominantly as small, isolated, populations, there are clearly risks associated with that small population size. Individuals become relatively more important as significant components of the population and the risks of loss of genetic diversity are increased. Isolation will also limit gene flow between individuals in different populations, unless there are effective mechanisms for pollen or seed dispersal, and so reduce the capacity to replace lost variation.

The existence of a high level of genetic diversity within populations and within groups of populations suggests that isolation may not be complete and that each population is a random selection of genes present in a wider gene pool. As the distance between populations, or groups of populations, increases, the possibilities for gene exchange are decreased and local patterns of variation become established. This is shown in particular when the Scilly Isles populations are compared with those on the mainland. When introducing or reintroducing the species to locations it may be more effective to use seed from more than one population in the region of the new site in order to obtain a more complete sample of the variation present in that region. Seed collected from a single (especially a small, single) population may represent only a small part of the variation available in the vicinity of the establishment site.

These results are only preliminary and more work is required: firstly, to develop systems for measuring genetic variation which can be interpreted more accurately in terms of allelic variation; secondly, to determine differences between plants in south-west England and other parts of the species' range; and thirdly, to ascertain whether the high levels of variation found at a local scale are

related to gene flow between individual populations at a local scale or to introgression of genes, for example, from the closely related *R. conglomeratus*.

REFERENCES

DANIELS, R. E., McDONNELL, E. J. & MOY, I. L. (1996). *Species Recovery Programme: shore dock (*Rumex rupestris *Le Gall)*. Second report. Report to English Nature, Species Recovery Programme.

KAY, Q. O. N. (1996). *The conservation of* Rumex rupestris *(Shore Dock) in Wales. Past, present and possible future sites and habitats of* Rumex rupestris *in South and West Wales*. Report to Countryside Council of Wales.

KENDRICK, R. E. & HEERINGA, G. H. (1986). Photosensitivity of *Rumex obtusifolius* seeds for stimulation of germination: influence of light and temperature. *Physiologia plantarum* **67**: 275–278.

KING, L. M. & SCHAAL, B. A. (1989). Ribosomal-DNA variation and distribution in *Rudbeckia missouriensis*. *Evolution* **43**: 1117–1119.

KING, M. P. (1989). *An investigation into the current status and ecology of the shore dock* Rumex rupestris *in Devon and Cornwall*. M.Sc. thesis, University College. London.

McDONNELL, E. J. (1995). *The status of shore dock (*Rumex rupestris *Le Gall) in Britain in 1994*. Report to English Nature, Species Recovery Programme.

PARSLOW, R. (1996). *Species Recovery Programme: Shore dock* Rumex rupestris *Le Gall in the Isles of Scilly*. Report to English Nature.

PARSLOW, R.& COLSTON, A. (1994). *The current status of* Rumex rupestris *in the Isles of Scilly*. Report to English Nature, Species Recovery Programme.

RAYBOULD, A. F., GRAY, A. J., LAWRENCE, M. J. & MARSHALL, D. F. (1991). The evolution of *Spartina anglica* C. E. Hubbard (Gramineae): origin and genetic variability. *Biological journal of the Linnean Society* **43**: 111–126.

VOESENEK, L. A. C. J., DE GRAAF, M. C. C. & BLOM, W. P. M. (1992). Germination and emergence of *Rumex* in river flood-plains. II. The role of perianth, temperature, light and hypoxia. *Acta botanica Neerlandica* **41**: 331–343.