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The Distribution and Ecology of the Arctic Plant Iceland Purslane (*Koenigia islandica*) in Scotland

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Abstract: *Koenigia islandica* has a disjunct Arctic-sub Arctic circumpolar distribution extending southwards to several isolated mountain ranges of northern Europe, Asia and North America. The population of this plant on the Isle of Skye (at altitude 461-726 m) and Isle of Mull at (385-523 m) was the most Southerly in Europe and therefore the most vulnerable likely to exhibit the impact of climatic fluctuations on numbers and survivorship. *Koenigia* was also an annual, which made it particularly vulnerable to adverse conditions and exhibited large fluctuations in number and survivorship between years. Mapping the precise position of colonies of *Koenigia* on island of Mull and Skye was done by geographical positioning systems (GPS).

Key words: *Koenigia islandica,* Isles of Mull and Isles of Skye,GPS, North America, Iceland purslane

Introduction

Koenigia islandica or Iceland purslane is a diminutive plant, usually less than 2 cm tall, and is the only annual found throughout the Arctic. The sites in Scotland are at the southern edge of its range in Europe. Although this plant is not given special protection under wildlife and countryside act of 1981, it is restricted to two small areas in Scotland and is listed in the British Red Data Book (Perring and Farrelm, 1983). These are the Ardeanach Peninsula on the island of Mull and Trotternish Hills on the Isles of Skye. As this plant at the southern edge of its range in Europe it may provide the earliest indication of significant effects of climatic change on the vegetation of British Isles.

Koenigia is typically associated with bare very mobile substrates that are too unstable for perennial plants to establish and outcompete this very small plant. The plant must however be capable of growing to maturity, flowering and setting sufficient seed in the short cool growing period found in the Arctic and Scottish hills. Due to increased concentrations of carbon dioxide in the atmosphere it is predicted from Global Circulation Models that winter temperature will rise more than summer (Houghton *et al*., 1990). This means that frequency of freeze-thaw cycles in winter will be much reduced and consequently mean that soils in the uplands will become more stable. If winter frost heave activities prevent the establishment of seedlings of perennial species of plant in the areas where *Koenigia* occurs in Scotland it will therefore mean that *Koenigia* will be out competed. This plant therefore has the potential to give the earliest indication of climate change in the British Isles. The objective of this work was to know the ecology of this plant and also to know which environmental factors account for any inter annual variation in it.

Materials and Methods

The approximate location of colonies of *Koenigia* was established using a Magellan GPS. The experiment was carried out on 30 June to September 1996 at the Ardmeanach Peninsula, Mull and 10 July to September 1996 at the Trotternish Hills of the Isles of Skye. The reconnaissance visits allowed us to choose sites for more detailed investigation of substrate characteristics and mobility to be located. These are located at Benin na h-lolaire on Mull and the western flanks of the storr on Skye. At both these sites 0.5×0.5 m^2 permanent quadrets were set up with small wooden pegs and the number of plants in each square was recorded. Two permanent transects were also established at the Mull site and the number of plants in 0.5×0.5 m^2 quadrets at 1 m interval were also recorded. The mean depth of the soil at each quadrat was calculated from the five maximum depths to which a 2.5 mm diameter metal skewer could be inserted vertically into the substratum.

Soil samples were taken from each quadrat along both transects. These soil samples were weighed, dried and re-weighed so that the moisture content could be calculated. The pH and particle size distribution of the soil samples were also determined.

Results and Discussion

Site characteristics: The bare areas of weathered basalt occur on the hilltops and exposed ridges of the

Ardmeanch Peninsula and Trotternish Hills. The pH of the substrate where *Koenigia* occurs varied between 4.4 and 5.7 (Table 1). Very few other species of plant occurred in areas where *Koenigia* grews, but most commonly it included a yellow sedge (*Carex demissa*), three-flowered rush (*Juncus triglumis*), sheep's fescue (*Festuca ovina*) and a species of moss (*Oligotrichum hercynium*). The vegetation surrounding the sites on Mull was an upland grassland, typically an *Agrostis-festuca* grassland that approximates closely to the National Vegetation Classification Community U4 (Rodwell *et al*., 1992). The assemblage of plants, which grew with *Koenigia* in the bare open flushes on Skye, had given their own community description (M 34) under National Vegetation Classification (Rodwell *et al*., 1991). However *Koenigia* was the only species present on Mull and Skye and the plant often covered less than 1% of the weathered basalt.

Table 1: Some soil characteristics at *Koenigia islandica* sites on Skye and Mull

Parameters	n	Range	Mean	SE
pH	33	4.4-5.7	5.2	0.06
Water content (% fresh weight)	37	16-41	25.7	1.1
Soil depth (cm)	24	5.4->34	15.4	1.8
% sand	11	73-90.6	80.9	1.8
% silt	11	9.3-26.5	18.6	1.8
% clay	11	0.13-0.092	0.53	0.07
Plant density (m^{-2})	141	4-2480	403.0	42

There were indications that the bare areas on the Ardeanach Peninsula are increasing in extent and order ascertain whether this is the case, marker posts were placed at the edges of bare areas and their position was

Table 2: A list of sites where *Koenigia islandica* was found on the Trotternish Hills and the Ardmeanach peninsula, Mull

Site name	Grid reference	Plant density (m^{-2})	Approx. area of colony (m^2)	Features
Trotternish Hills Skye				
The Storr	49425399	14.8	4.2	Terracettes
The Storr	49405406	15.2	57.6	Bare flush
The Storr	495540	42.7	33.1	Bare hollow
The Storr	49305424	36.0	82.6	Flush
The Storr	4925432	149.0	120.0	Flush with strips
The Storr	49365442			
Bealach a'churin	48815464	79.0	30.5	Flat gravel terrace
Bealach a'churin	48755470			Stripes
Bealach Harteval	47505595	146.0		
Sgurr a' Mhalaidh	47125621	620.0		
Sgurr a' Mhalaidh	47105802	420.0		
Creag a' lain	46855860	16.0		No surface water
Bealach Chaiplin	45615999	388.0		
Groba nan Each	45466046	220.0		
Bealach Amadal	45566129	20.0		Active patterned ground
Bealach Mhoramhain	45476204	290.0		
Beinn Edra	45616298	352.0		
Beinn Edra	45606291	108.0		
Beinn Edra	45496304	24.0		
Mull				
Beinn na h-lolaire	45703136	77.0		
Beinn na h-lolaire	45383131	190.0		
Beinn na h-lolaire	45543107			
Fionna Mham	43933001			
Creach Bheinn	42462916	194.0		
Creach Bheinn	42312899			

taken with GPS. This erosion might be initiated by rabbits burrowing into peat that overlies the weathered basalt regolith. This allowed wind erosion to accelerate the removal of the peat and thus exposing the underlying mineral layers which might be further eroded by wind and overland flow.

Mapping colonies: The location of colonies of *Koenigia* were noted and in some cases t eir approximate size was estimated. The exact locations of the colonies are given in Table 2. At least 16 new colonies were found, but it was likely to be estimated that many more could be found not only within the Ardeanach Peninsula and Trotternish Hills, but also on the hills, which have the appropriate physical characteristics. Bare weathered basalts seemed to be a primary pre-requisite for *Koenigia* in Scotland and that there needed to be a reasonable degree of water seepage or moisture (Table 1) present to prevent the drying out and consequent death in late summer. The high water content would also increase the degree of vertical movement of the substrate during freeze-thaw cycles.

Population size: The density of colonies was typically less than 50 m^{-2} within squares covering 0.25×0.25 m^2, but the maximum density recorded was over 2000 individuals/m^{-2}. The median density of *Koenigia* plant was 192 m^{-2}.

Colonies were typically small, normally in the order of hundreds of individuals. The overall population size of *Koenigia* on Mull and Skye was very high and in order of thousands to tens of thousands of individuals.

As there was such a rapid flux in the number and size of colonies within and between years it was more valuable to ascertain which environmental variables account for any inter-annual variation in population size. Substrate mobility, erosion and water availability were thought to be the main determinants. The permanent quadrats and transects on Mull were revisited in September and survival of *Koenigia* was recorded to be 10.4% overall, but in many areas it was less than 1%. The dead seedlings were brown, dry crispy and it would therefore appear that summer drought, even in reasonably moist areas, might be a limiting factor for this plant in Scotland.

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