Chromosome numbers and flower sizes of *Ulex minor* Roth. and *Ulex gallii* Planch. in Dorset

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ABSTRACT

This study was carried out to address the continuing uncertainty concerning the identification and chromosome numbers of the closely-related species *Ulex minor* Roth. and *U. gallii* Planch. (Fabaceae). The species co-occur in Dorset and chromosome counts from mixed and single-species populations gave results of n = 16 for all 52 *U. minor* plants sampled and of n = 32 for 52 *U. gallii* plants. The *U. minor* count is uncontroversial. The *U. gallii* count has been reported in other studies, but some studies in Great Britain, Ireland, France and Spain have reported n = 48. One plant, found in a mixed population of the two species and identified as *U. gallii*, had a count of n = 24. This number has never been reported before for a European *Ulex* and the plant may be a *U. gallii × U. minor* hybrid. It had an intermediate flower size.

Although the two species are best distinguished by flower size, a survey over Dorset showed appreciable overlap in flower standard and calyx lengths. However, use of a suite of characters (flower size, spine length and bush size) always gave correct identification when tested against chromosome number. A search for hybrids – based on the hypothesis that mixed populations will contain more intermediate plants (because of hybridization) than singlespecies populations – suggested that *U. gallii* × *U. minor* hybrids are rare.

KEYWORDS: Ulex gallii \times U. minor, U. gallii \times U. europaeus, gorse, morphometrics, ploidy levels.

INTRODUCTION

Ulex minor Roth. and *U. gallii* Planch. (Fabaceae) have caused problems to British and European botanists since *U. gallii* was first described by Planchon in 1849. Before its description, *U. gallii* was taken to be a large form of *U. minor*, and there are still problems in distinguishing the two species (Castroviejo & Valdés-Bermejo 1990; Gloaguen 1986; Proctor 1967). This is because the species show substantial overlap in many characters, e.g. bush height, spine length, flower colour and pod size (Proctor 1965). Although flower size (standard and calyx lengths) is the most reliable character for species identification, even this character is not completely distinct between the species; indeed, they do have different chromosome numbers (see below). However, cytological studies over the past decade have opened up a new area of controversy and debate.

Several studies of *U. minor* in France and Spain have all arrived at a count of 2n = 32 (e.g. Alvarez Martinez *et al.* 1988; Castroviejo & Valdés-Bermejo 1983, 1990; de Castro 1941; Fernandez Prieto *et al.* 1993; Misset 1990; Misset & Gourret 1996). The same results were obtained from a site in Dorset by Fernandez Prieto *et al.* (1993) and from a site in Surrey listed in the B.S.B.I. database. However, chromosome counts for *U. gallii* have been more varied. The first count, by de Castro (1943), suggested 2n = 80. This was probably wrong, and the debate over the last 15 years has revolved around the fact that studies of *U. gallii* in Europe have found both 2n = 96 and 2n = 64. Castroviejo & Valdés-Bermejo (1983, 1990) counted both 2n = 64 and 96 in Spain. Alvarez Martinez and co-workers (Alvarez Martinez *et al.* 1988; Fernandez Prieto *et al.* 1993) found 2n = 64 in Spain and France, 2n = 96 in spain and one plant with 2n = 32 in Spain. Misset (1990; Misset & Gourret 1996) found 2n = 96 in north-west France, although she had one example of 2n = 64. In the British Isles, Fernandez Prieto *et al.* (1993) studied eight *U. gallii* sites in Devon and Cornwall and found only plants with 2n = 64. However the B.S.B.I. database contains counts of 2n = 96 from three *U. gallii* sites, on Alderney, in Derbyshire and in County Dublin. Where methods have been given, all these studies distinguished species in the field using the differences of flower calyx and standard lengths, spine length and bush size reported by Proctor (1965).

This confusion has prompted suggestions for changes in the taxonomy of the two species, involving splitting *U. gallii* Planch according to chromosome numbers. Castroviejo & Valdés-Bermejo (1983, 1990) suggested that plants with 2n = 64 should be named *U. minor* subsp. *breoganii* and those with 2n = 96 become *U. minor* subsp. *gallii* (with *U. minor* becoming *U. minor* subsp. *minor*). Conversely, Alvarez Martinez *et al.* (1988) suggested 2n = 64 plants should remain *U. gallii* while 2n = 96 plants become *U. cantabricus*. However, neither suggestion has been accepted generally. Clearly, more data are needed on the chromosome numbers of *U. gallii* and *U. minor*.

Another unresolved question concerns the occurrence of *U. gallii* \times *U. minor* hybrids. While *U. gallii* \times *U. europaeus* hybrids are commonly described (Benoit 1962; Gloaguen 1986; Misset & Fontenelle 1992; Stace 1975) (interestingly, no *U. minor* \times *U. europaeus* hybrids have been suggested), the evidence for *U. gallii* \times *U. minor* hybrids is weak (see Stace 1975). Millener (1952) failed to produce



FIGURE 1. The distributions of *Ulex minor* and *U. gallii* in Britain. *U. minor* occurs east of the line, and *U. gallii* occurs west of the line - - - - and in East Anglia in the region marked *.

| Ulex minor | Ulex gallii |
|---|--|
| Flowering season: July–September Flowers Standard: 6–12 mm (mode 9.5 mm) Calyx: 6–9 mm Wings: variable Pedicels: 3–5 mm, appressed hairs Flower colour – mostly aureolin and lemon yellow Bracteoles: 0.5–0.8 × 0.6–0.8 mm Pod: 6–11 mm Spines: 6–25 mm Bush height: 5–150 cm | Flowering season: as U. minor Flowers Standard: 10.5–18 mm (mode 15 mm) Calyx: 9.5–12.5 mm Wings: strongly curved, c. 1 mm longer than keel Pedicels: as U. minor Flower colour – mostly buttercup and Indian yellow Bracteoles: as U. minor Pod: 6–12 mm Spines: 8–34 mm Bush height: 10–200 cm Other: flower opens more widely than U. minor after pollination. Possible red veining of standard. |

| TABLE I. CHARACTERS OF TWO ULEX SPECIES IN BRITAIN, AS DESCRIBED BY PROCIO | R (196 | 96: | 55 | j) |
|--|--------|-----|----|----|
|--|--------|-----|----|----|

pods or seeds in an attempted cross between *U. minor* (\mathcal{J}) and *U. gallii* (\mathcal{Q}). All suggestions of *U. gallii* × *U. minor* hybrids in the field derive from notes by Corillion (1950) and Lambinon (1962) on plants with vegetative and floral characteristics intermediate between the two species. Given the overlap in characteristics of the described species (e.g. Proctor 1965), it is extremely tenuous to call intermediate plants hybrids. Chromosome counts would provide more solid evidence of hybrids, if plants of intermediate chromosome numbers were found in mixed populations of *U. gallii* and *U. minor*.

U. gallii occurs in the west of Britain and U. minor is in the south-east, and their distributions only overlap substantially in Dorset (Fig. 1). Within Dorset most heaths contain only one of the two Ulex species (single-species populations), although there are several heaths (mixed populations) with both species (unpublished data J. M. Bullock & R. J. Edwards); this suggests competitive separation of the two species. It is therefore likely that any British U. gallii $\times U.$ minor hybrids would be found in Dorset. In this study we carried out chromosome counts of a large sample of plants from a mixed population of U. gallii and U. minor and from single-species populations in Dorset in order to answer the following questions.

- 1. What are the chromosome numbers of U. gallii and U. minor in Dorset?
- 2. Is field identification of *U. gallii* and *U. minor* using Proctor's (1965) criteria reliable, as tested by chromosome counts?
- 3. Is there any chromosomal evidence for U. gallii × U. minor hybrids in mixed populations?

Questions 2 and 3 were explored further by taking measurements of floral standard and calyx lengths from *U. gallii* and *U. minor* plants in mixed and single-species populations throughout Dorset in order: 1. to assess the overlap in flower size (an extension of Proctor's 1965 work); and 2. to determine whether mixed populations have a greater proportion of plants with flower sizes intermediate between the two species; this would provide indirect evidence of hybrids, which (if they exist) should be more prevalent in mixed populations. Proctor (1965) showed that standard and calyx lengths were the best characters with which to separate the species (Table 1). Therefore, if hybrids have intermediate characters, then standard and calyx lengths should be the best characters with which to identify hybrids. It should be noted that this hypothesis does not assume that all intermediate plants are hybrids, but does assume that the presence of hybrids will change the frequency distribution of flower sizes. The third distinguishing character by Proctor (1965) was flower colour, but we did not use this because it is a discontinuous variable and would be difficult to use to identify intermediates.

METHODS

CHROMOSOME COUNTS

A survey of the occurrence of both species in each heath in Dorset had been carried out in 1995 (R. J. Edwards, unpublished data), and this was used to select three heaths from which to sample. Gore Heath

| Arne Heath | SY/964.878 |
|---------------------|---|
| Bovington Heath | SY/838.916 |
| Hurn Common | SZ/136.960 |
| Winfrith Heath | SY/380.876 |
| Canford Heath | SZ/021.962 |
| Cripplestyle Common | SU/092.118 |
| Puddletown Forest | SY/728.920 |
| Upton Heath | SY/974.956 |
| Ferndown Common | SZ/064.994 |
| Godlingston Heath | SZ/015.820 |
| Gore Heath | SY/924.900 |
| Ham Common | SY/976.908 |
| Holt Heath | SU/054.030 |
| Parley Common | SZ/084.986 |
| Stoborough Heath | SY/936.848 |
| Studland Heath | SZ/022.844 |
| | Arne Heath Bovington Heath Hurn Common Winfrith Heath Canford Heath Cripplestyle Common Puddletown Forest Upton Heath Ferndown Common Godlingston Heath Gore Heath Ham Common Holt Heath Parley Common Stoborough Heath Studland Heath |

TABLE 2. THE DORSET HEATHS (WITH GRID REFERENCE) FROM WHICH SAMPLES OF ULEX SPP. FLOWER SIZES WERE TAKEN

(SY/924.900) contained both species and the populations were intermingled. This was judged to be the best example of a mixed population in Dorset. Plants were sampled at random over the whole heath. Each plant was identified in the field as *U. minor* or *U. gallii* using Proctor's (1965) characters; the most useful characters were flower size (i.e. standard length), spine length and bush size. These characters were generally larger in *U. gallii* than in *U. minor* and we used field measurement of all three characters to distinguish the species (we did not make notes of these measurements). Every plant encountered was sampled, even those which were difficult to identify. Buds were taken from 50 *U. minor* bushes and the same number of *U. gallii* bushes. To provide baseline chromosome counts for both species, *Ulex* plants were sampled in heaths containing single-species populations. Ten *U. gallii* bushes were sampled from Canford Heath (SZ/021.962) and ten *U. minor* bushes were sampled from Winfrith Heath (SY/ 380.876). All sampling was done on 12–13 August 1996.

The methods used for counting chromosomes were the same as those given by Misset (1990) and Fernandez Prieto *et al.* (1993) (see also Gurr 1965). Flower buds of c. 2 mm length were fixed in the field in Carnoy's fixative (3:1 Glacial acetic acid-Ethanol) and then kept refrigerated for at least 48 hours. The anthers were then dissected out on a microscope slide in a drop of aceto-carmine and squashed under a coverslip. Counts were made of stained chromosomes in pollen cells at metaphase 1. Counts were made from at least two buds from each plant.

FLOWER SIZES

The 1995 survey was used to select four heaths which contained only *U. minor*, another four heaths which contained only *U. gallii*, and eight heaths with mixed populations (Table 2). In each heath 20 bushes of each of the gorse species present (identified using Proctor's characters) were chosen at random over the entire extent of the heath. As with the chromosome counts, difficult bushes were not avoided. Five fully opened flowers were picked from each bush and stored in an ice-box. Within 24 hours of collection the floral standard and calyx lengths of each flower was measured to the nearest 0.5 mm. The five measures for each bush were used to calculate mean standard and calyx lengths for each of the 320 bushes sampled. Sampling was carried out over August 1995.

RESULTS

CHROMOSOME COUNTS

The ten *U. minor* plants from Winfrith Heath all gave chromosome counts of n = 16 and the ten *U. gallii* plants from Canford Heath had counts of n = 32. Of the plants from the mixed population on Gore Heath,

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all those identified in the field as *U. minor* gave counts of n = 16 (counts were taken from 42 plants; we were unable to obtain adequate preparations from the remaining eight plants), but of those identified as *U. gallii* 42 gave counts of n = 32 and one gave a count of n = 24 (Fig. 2). To assess the consistency of this last unusual chromosome number, counts were made from ten buds on the plant and all gave n = 24. Several preparations were made of pollen grains, and the pollen for the n = 24 plant appeared normal and similar to that of the n = 16 and n = 32 plants. A single flower preserved with the buds of the n = 24 plant had a standard and a calyx length of 11.5 mm and 8.5 mm respectively. This plant had been identified in the field as *U. gallii* on the basis of its standard and spine lengths and bush size. However, we were not able to relocate this plant in the field in order to make detailed measurements of its floral and vegetative characters.

FLOWER SIZES

T-tests showed that the average floral standard and calyx lengths of the *U. minor* and *U. gallii* were significantly different (single-species populations, standard length, t = 19.4, p < 0.001, calyx length, t = 16.3, p < 0.001; mixed populations, standard length, t = 28.6, p < 0.001, calyx length, t = 25.8, p < 0.001), and most of the *U. gallii* plants had longer standards and calyces than any *U. minor* plant (Figs 3 & 4). However there was an overlap in flower sizes, with both species having bushes with mean standard lengths of 11-12.5 mm and mean calyx lengths of 8-10 mm. The distribution of flower sizes of each species did not differ between the single-species populations and the mixed populations (standard length, *U. minor* $\chi^2 = 12.3$, df = 7, nsd; *U. gallii* $\chi^2 = 6.6$, df = 8, nsd; calyx length, *U. minor* $\chi^2 = 10.7$, df = 6, nsd; *U. gallii* $\chi^2 = 11.5$, df = 8, nsd).

The hypothesis that mixed populations would have a greater proportion of bushes with intermediate flower sizes (suggesting the presence of *U. gallii* × *U. minor* hybrids) was tested by comparing the proportions of three categories of bushes between the single-species and mixed populations. These categories were: bushes with intermediate flower sizes, bushes with smaller than intermediate flower sizes and bushes with larger than intermediate flower sizes. Two definitions of intermediate standard size were tested: a. $11\cdot5-12$ mm, b. $11-12\cdot5$ mm. Definition a gave no significant differences between the population types ($\chi^2 = 4\cdot3$, df = 2, nsd). Definition b resulted in a significant difference ($\chi = 6\cdot5$, df = 2, p < 0.05), but this was because there was a smaller rather than greater proportion of intermediate plants in the mixed (16%) than in the single-species population (25%).

Similarly, two definitions of intermediate calyx size were tested: a. $8 \cdot 5 - 9 \cdot 5$ mm, b. 8 - 10 mm. Neither definition gave a significant difference between the population types (a, $\chi^2 = 3 \cdot 1$, df = 2, nsd; b, $\chi^2 = 3 \cdot 8$, df = 2, nsd).

DISCUSSION

CHROMOSOME NUMBERS OF U. GALLII AND U. MINOR

Despite the overlap in flower sizes of the two *Ulex* species (Figs 3 & 4), the suite of character differences (we found the most useful to be flower size, bush height and spine length) between the two species allow accurate field identification of the species. There was complete agreement between the field identification of the plants and the chromosome counts obtained, n = 32 for *U. gallii* and n = 16 for *U. minor* (the single unusual count of n = 24 is discussed below), even for plants in an extensively mixed population.

While there is no controversy about the chromosome numbers of *U. minor* (2n = 32), this paper contributes to the debate in France and Spain on the chromosome numbers of *U. gallii* (2n = 64 in this paper). Misset (1990; Misset & Gourret 1996) contended that *U. gallii* has 2n = 96 and called her single example of *U. gallii* with 2n = 64 a "ploidy accident" (Misset & Gourret 1996). Castroviejo & Valdés-Bermejo (1990) also asserted that 2n = 96 for *U. gallii* and suggested that the counts by Alvarez Martinez *et al.* (1988) of 2n = 64 were mistakes. Alvarez Martinez and co-workers (Alvarez Martinez *et al.* 1988; Fernandez Prieto *et al.* 1993) however suggested that the two ploidy levels for *U. gallii* are common (even suggesting that *U. gallii* with 2n = 32 may occur).

These workers have all identified their specimens using standard and calyx lengths (and sometimes other characters such as spine lengths), although most are not clear about the criteria used to distinguish the species. We assume that they have used the size range of flower sizes for each species reported by



FIGURE 2. Cells at metaphase 1 with stained chromosomes. a. Ulex minor, n = 16; b. U. gallii, n = 32; and c. plant identified as U. gallii, n = 24.



FIGURE 3. Histograms of the frequency distributions of flower standard length (using plant means) for the two *Ulex* species in single species populations (80 plants sampled for each species) and in mixed populations (160 plants sampled for each species).

Proctor (1965) (*U. minor* standard = 6-12.5 mm, calyx = 5.5-10.5 mm; *U. gallii* standard = 10.5-18 mm, calyx = 8.5-14.5 mm), which are similar to those found in this study (*U. minor* standard = 7.5-12.5 mm, calyx = 6-10 mm; *U. gallii* standard = 11-17 mm, calyx = 8-13.5 mm).

However, where measurements have been reported, they do not help to clarify the taxonomic problems concerning *U. gallii* ploidy levels. Alvarez Martinez *et al.* (1988) reported standard and calyx lengths of 8.7-15.8 mm and 6.8-14.5 mm respectively for plants with 2n = 64 identified as *U. gallii* and of 10.3-14.3 mm and 8.7-12.4 mm for plants with 2n = 96 named as *U. cantabricus*. These are curious results because the minimum lengths for *U. gallii* are very low in comparison to those in this



FIGURE 4. Histograms of the frequency distributions of flower calyx length (using plant means) for the two *Ulex* species in single species populations (80 plants sampled for each species) and in mixed populations (160 plants sampled for each species).

and Proctor's studies, and the *U. cantabricus* measurements fall within the range of the putative *U. gallii* plants in these other studies. Castroviejo & Valdés-Bermejo (1990) gave calyx lengths of 7-9.5 mm for plants identified as *U. minor* with 2n = 32, 9.5-14 mm for plants identified as *U. gallii* with 2n = 96, and 8.5-11 mm for plants named as *U. minor* subsp. *breoganii* with 2n = 64. Therefore, the plants named as *U. minor* subsp. *breoganii* with 2n = 64. Therefore, the plants named as *U. minor* subsp. *breoganii* have calyx lengths intermediate between those given for *U. minor* and *U. gallii* and Castroviejo & Valdés-Bermejo (1990) describe this putative subspecies as having a generally intermediate morphology.

It seems likely that U. gallii has two ploidy levels on the European mainland and - given the three

examples with 2n = 96 on the B.S.B.I. database and the populations with 2n = 64 found by Fernandez Prieto *et al.* (1993) and in this study – possibly in the British Isles. However, taxonomic and morphological confusion means that it is unclear whether it is possible to distinguish these ploidy levels morphologically or what their taxonomic standing should be. Clearly, there is a need to address these issues by extensive morphological and cytological studies in Britain and Europe. It would seem premature to adopt the names *U. cantabricus* or *U. minor* subsp. *breoganii* for one or other of the ploidy levels.

U. GALLII \times U. MINOR HYBRIDS

The mechanism that produced the single *Ulex* bush with a count of n = 24 (2n = 48) can only be guessed at. One possible explanation is that it was a *U. gallii* × *U. minor* hybrid, and indeed it did have an exactly intermediate chromosome number. Other supporting evidence (although tenuous) is that the single flower retrieved from the specimen was of intermediate size. It is usually stated or implied that the base chromosome number (x) for the genus *Ulex* is 16, and that *U. minor* is diploid, *U. gallii* is tetraploid (2n = 64) or hexaploid (2n = 96) and that *U. europaeus* is hexaploid (Castroviejo & Valdés-Bermejo 1990; Fernandez Prieto *et al.* 1993; Misset & Gourret 1996). If x = 16 then a plant (whether hybrid or not) with 2n = 48 would be a triploid, and would usually be infertile (Felber & Bever 1997). However, microscopic examination of pollen grains from this plant suggested that they were fertile. If the base number of *Ulex* was x = 8 (as suggested by de Castro 1941, 1943) then the putative hybrid would be hexaploid (*U. minor*) and octoploid (*U. gallii*) parents.

If the n = 24 plant was a *U. gallii* × *U. minor* hybrid, then such hybrids are extremely uncommon. This chromosome count has never before been reported for *U. minor*, *U. gallii* or *U. europaeus*, or any other European *Ulex*. Only one such plant was found in a sample of 85 bushes from Gore Heath; a heath where the intimate mixing of the two species should provide ideal conditions for hybridisation.

The fact that mixed heaths did not have a greater proportion of bushes with intermediate flower sizes (standard and calyx lengths) than single-species heaths also provides indirect evidence against there being any great abundance of hybrids. While not all intermediate plants are necessarily hybrids (given the morphological overlap between the species), the presence of hybrids should increase the proportion of plants with intermediate characters. However, such a conclusion assumes that hybrids will have intermediate characters. This assumption has been shown to be only partly true for plant hybrids; certain characters may be indistinguishable from those of one parent or the other (Stace 1975; Riesberg & Ellstrand 1993). However, without better information, this assumption is acceptable and these data will be of use until there are more detailed studies which link morphological characters with allozyme or DNA markers in populations over a wide geographical area.

The possibility that there are few U. gallii $\times U$. minor hybrids may be useful for British botanists, as it suggests that separation of the two species will not be complicated by the presence of hybrids. However, it raises the question of why such similar species with identical flowering seasons do not hybridise. Investigations of cross-compatibility and pollinator behaviour may suggest solutions.

U. GALLII × U. EUROPAEUS HYBRIDS

Although they were not looked for explicitly, our study of summer-flowering *Ulex* plants did not provide any evidence of *U. gallii* × *U. europaeus* hybrids. Such hybrids are commonly described, but evidence is usually based on intermediate vegetative and floral characters (Gloaguen 1986; Millener 1952; Stace 1975). Only Misset & Fontenelle (1992) give reliable evidence which is based on differing isoenzyme systems of *U. gallii* and *U. europaeus*, and shows that putative hybrids have elements of both isoenzyme systems. *U. europaeus* is usually described as 2n = 96 (de Castro 1941, 1943; Castroviejo & Valdés-Bermejo 1983; Misset 1990), and counts from four bushes sampled on Gore Heath on 14 January 1997 gave the same number (V. Herrera, unpublished data). The only chromosome counts for *U. gallii* × *U. europaeus* hybrids have given 2n = 96, and these are in papers which give the count for *U. gallii* of 2n = 96 (Misset 1990; Misset & Gourret 1996). Where the count for *U. gallii* is 2n = 64, the count for hybrids should be 2n = 80 (interestingly, the count originally given by de Castro (1943) for *U. gallii*). The flowering season of *U. gallii* × *U. europaeus* hybrids is described as extending over the seasons for both the parent species (Gloaguen 1986; Millener 1952; Stace 1975), so samples spread over a longer period than covered in this study may provide more solid evidence of hybridization.

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REFERENCES

ALVAREZ MARTINEZ, M. J., FERNANDEZ CASADO, M. A., FERNANDEZ PRIETO, H., NAVA FERNANDEZ, S. & VERA DE LA PUENTE, M. L. (1988). El género Ulex en la Cornisa Cantabrica. I. Ulex gr. gallii-minor. Candollea 43: 483–497.

BENOIT, P. M. (1962). Ulex europaeus × gallii. Proceedings of the Botanical Society of the British Isles 4: 414–415.

CASTROVIEJO, S. & VALDÉS-BERMEJO, E. (1983). Notas sobre los tojos Gallegos. Anales Jardín Botánico Madrid 40: 73-81.

CASTROVIEJO, S. F. L. S. & VALDÉS-BERMEJO, E. (1990). On the identity of *Ulex gallii* Planchon (Leguminosae). Botanical journal of the Linnean Society **104**: 303–308.

CORILLION, R. (1950). Phanérogames intéressantes pour la Bretagne. Bulletin de la Société Scientifique de Bretagne 25: 131-140.

DE CASTRO, D. (1941). Algumas contagens de cromosomas no género Ulex L. (sensu lato). Agronomia lusitanica 3: 103-113.

DE CASTRO, D. (1943). Contribuïçao para o conhecimento cariológica dos géneros Ulex L. Stauracanthus Link e Nepa Webb. Agronomia lusitanica 5: 243–249.

- FELBER, F. & BEVER, J. D. (1997). Effect of triploid fitness on the coexistence of diploids and tetraploids. Biological journal of the Linnean Society 60: 95-106.
- FERNANDEZ PRIETO, J. A., NAVA FERNANDEZ, S., VERA DE LA PUENTE, M. L., ALVAREZ MARTINEZ, M. J., DIAZ, T. E., CASADO, M. A. F., FERNANDEZ-CARVAJAL, M. C. & VILLARIAS, M. I. G. (1993). Chromosome numbers and geographical distribution of *Ulex gallii* and *U. minor* (Leguminosae). *Botanical journal of the Linnean Society* 112: 43–49.
- GLOAGUEN, J. C. (1986). Les ajoncs de Bretagne. Bulletin de la Societe Botanique de France lettres botanique 133: 363–385.

GURR, E. (1965). The rational use of dyes in biology. Leonard Hill, London.

LAMBINON, J. (1962). Note sur les Ulex du Massif Armoricain. Lejeunia 9: 64-66.

MILLENER, L. H. (1952). Experimental studies on the growth forms of the British species of Ulex L. Ph.D. thesis, Pembroke College, Cambridge and the University of New Zealand.

MISSET, M. T. (1990). Données caryologiques chez le genre Ulex L. (Papilionidae) dans le Massif Armoricain. Taxon 39: 630-635.

MISSET, M. T. & FONTENELLE, C. (1992). Protein relationships between natural populations of *Ulex europaeus* and *U. gallii* (Faboideae, Genisteae) and their hybrids. *Plant systematics and evolution* **179**: 19–25.

- MISSET, M. T. & GOURRET, J. P. (1996). Flow cytometric analysis of the different ploidy levels observed in the genus Ulex L. Faboideae-Genisteae in Brittany (France). Botanica acta 109: 72–79.
- PROCTOR, M. C. F. (1965). The distinguishing characteristics and geographical distributions of Ulex minor and Ulex gallii. Watsonia 6: 177–187.
- PROCTOR, M. C. F. (1967). The British species of Ulex. Proceedings of the Botanical Society of the British Isles 6: 379–380.

STACE, C. A. ed. (1975). Hybridization and the flora of the British Isles. Academic Press, London.

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