JUNCUS SUBULATUS FORSK. IN THE BRITISH ISLES

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In May, 1957, two colonies of a perennial rush were found in the salt marsh at Berrow on the North Somerset coast (v.c. 6), in circular patches about 10 m. in diameter that suggested vegetative spread from plants originally established perhaps some ten years before. The plant was identified as *Juncus subulatus* Forsk. after investigations had shown that it was not of hybrid origin, meiosis proving to be quite normal and the pollen good. This species occurs mainly in salt marshes along Mediterranean shores and has not been previously recorded in the British Isles. At Berrow the *Juncus* is surrounded mainly by *Scirpus maritimus*, which it has successfully displaced, but is itself sparsely interspersed with etiolated *Glaux maritima*, *Carex extensa*, *Atriplex hastata*, *Juncus gerardii*, *Triglochin maritima*, and *Aster tripolium*. The formation and the vegetational development of the Berrow salt marsh are recent and have been described by Thompson (1922, 1928, 1930), Kendall (1938), and Boley (1942).

An account is given here of the morphology and geographical distribution of the rush, together with some observations on its ecology in its British habitat and in the Mediterranean. Some of this information was given at the Society's Exhibition meeting in November 1958, when herbarium specimens of the Berrow plant were shown.

Morphology and Taxonomy

J. subulatus was described by Forskål (1775) in *Flora Aegyptiaco-Arabica*, and later Desfontaines (1798) described it under the name *J. multiflorus* (non *J. multiflorus* Retz., 1795). Buchenau (1890, 1906) classified *J. subulatus* as the only member of the subgenus *Junci subulati*; the subulate stem leaves, some of which are inserted high on the axis, are an important diagnostic character.

The British *J. subulatus* seems to be very similar to the Mediterranean plant. It has a strong, slightly branched rhizome which creeps c.6 cm. (4–8 cm.) below the mud surface and is about 6 mm. in diameter. The rhizome bears brown scale-leaves (see Fig. 1 A) and buds which give rise to rather fragile erect aerial shoots, 2–10 cm. apart. These are often a metre or more high and 3–4 mm. in diameter at the base where they bear several shiny brown sheaths. The stems, which are furrowed and in the autumn vinous red at their bases, bear two to four leaves which are somewhat channelled, non-articulate and hollow except for evanescent web-like partitions (Buchenau, 1906, p. 102), as in the stem. The leaves have sheathing bases (c. 10 cm.) and pronounced ligules (Fig. 1 B), and like the stems are glaucous grey-green during the growing season.

The inflorescence is many-flowered, interrupted, diffuse, and subtended by a short bract. The pale yellowish-green flowers are about 3·5 mm. long, cup-shaped at first (Fig. 1 C) and later spreading; each is surrounded by membranous, acute bracteoles with broad bases (Fig. 1 G). The outer perianth segments are lanceolate, acute, and rather longer than the inner, which are more obtuse and slightly involute with a fairly broad subterminal portion, having whitish membranous margins (Fig. 1, E & F). Inserted close to the perianth are the six stamens with short filaments and anthers c. 1 mm. long.

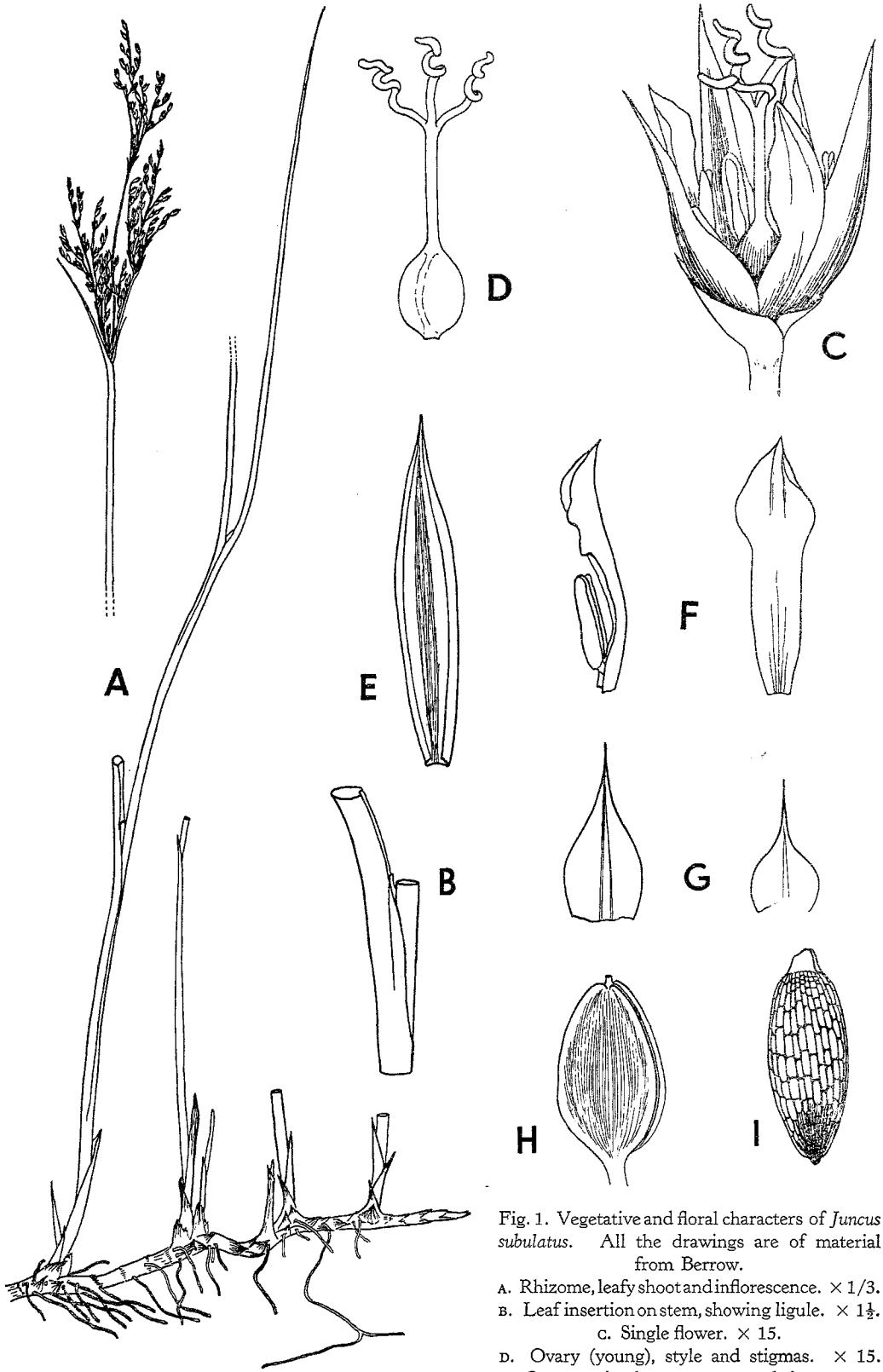

Fig. 1. Vegetative and floral characters of *Juncus subulatus*. All the drawings are of material from Berrow.

A. Rhizome, leafy shoot and inflorescence. × 1/3.
B. Leaf insertion on stem, showing ligule. × 1½.
C. Single flower. × 15.
D. Ovary (young), style and stigmas. × 15.
E. Outer perianth segment, ventral view. × 18.
F. Inner perianth segment, lateral view (with stamen) and ventral view. × 18. G. Bracteoles. × 18.
H. Capsule, fairly mature. × 15. I. Seed. × 40.

The unilocular ovary later becomes almost completely trilocular by the ingrowth of septa, and bears the style (c. 1 mm.) with three pink papillose stigmas which twist clockwise, as seen from above (Fig. 1 D). The mature capsule is trigonous (Fig. 1 H), usually a little shorter than the perianth, shiny reddish-brown, and often mucronate (cf. Fiori & Paoletti, 1921, p. 74). Only a few (2–5) of the numerous ovules mature and the longitudinally reticulate seeds are 0·6–1·0 mm. long and slightly appendaged (Fig. 1 I).

Herbarium material indicates that *J. subulatus* varies little over its range. Cosson and Durieu, however, described a more slender plant under *J. multiflorus* Desf. subvar. *salinus* from Algeria (Bory de St. Vincent *et al.*, 1854–67). The name for this plant is now *J. subulatus* f. *salinus* (Dur.) Maire & Weiller (Maire & Weiller, 1957); it is smaller than the Berrow rush, has narrower leaves, and a less-branched inflorescence.

Geographical Distribution

The chief area of distribution of *J. subulatus* is the Mediterranean (Fig. 2), but the plant also occurs in the region of the Caspian Sea (Täckholm & Drar, 1950; Maire & Weiller, 1957). Information about the latter area is, however, so limited that here attention will be confined to the former. The data on Fig. 2 were compiled from the herbaria of the British Museum, the Royal Botanic Gardens, Kew, the University of Bristol, and various Floras (see references).

J. subulatus is usually a maritime species. It occurs locally around the Mediterranean and on many of the islands, mostly in salt marshes not far from the sea. Records are most abundant from North Africa, and the centre of its distribution is almost certainly in the Nile Delta region of Egypt, where it is especially abundant between Port Said and Alexandria; it extends southwards up the Nile as far as Asyut (Täckholm & Drar, 1950). *J. subulatus* is also found at a number of oases inland, especially in the Kharga and Bahariya regions west of the Nile. The plant is recorded for the fresh water canal at Port Said, and appears able to survive in non-saline habitats (see also Maire & Weiller, 1957). From Egypt the rush extends westwards along the coast of North Africa, occurring locally as far as Morocco, inland in the Ahaggar region of the Sahara, and at high altitudes in the shotts of the Algerian plateaux (Braun-Blanquet, 1932, p. 197). *J. subulatus* also occurs locally all along the northern Mediterranean shores from Syria and Turkey to Spain. Of special interest is its occurrence at two places on the Atlantic coast of Spain (at Bilbao, and near Oviedo) suggesting a similar distribution to that of certain 'Lusitanian' and south-western rarities of our British flora, which also appear to reach their northern limit in south-west England or Ireland. Examples are *Scirpus holoschoenus*, *Helianthemum apenninum*, *Juncus pygmaeus*, and *Asplenium adiantum-nigrum* subsp. *onopteris*; the first is in some respects ecologically similar to *J. subulatus* but its distribution is more continental and extends into Siberia, while the last three show a closely similar geographical pattern in spite of their very varied ecology.

Ecology

(a) *The British Isles*

The Berrow salt marsh is of recent origin and has developed between the channel of the river Parrett and the sand dune system inland. Colonisation of the marsh began in 1910 and may have been made possible by the formation of a new tributary channel draining from the muddy Berrow flats into the Parrett. Vegetation was sparse until 1920, when the commonest plants were *Salicornia* spp. and *Puccinellia maritima* (Thompson, 1922). *Spartina townsendii*, which was first noticed in 1920, now dominates much of the

area, and *Salicornia* spp. have much declined. The marsh has doubtless risen gradually by mud and sand accretion and is now separated from the open shore by a broken ridge of low embryo dunes, formed in the last twenty years (Kendall, 1938). It is partially flooded by sea water only at very high tides; some fresh water drains into it by seepage from the dunes which form the landward boundary.

The vegetation of the marsh clearly falls into three zones. A belt transect of the marsh was surveyed in August 1958, the vegetation being scored by the technique of

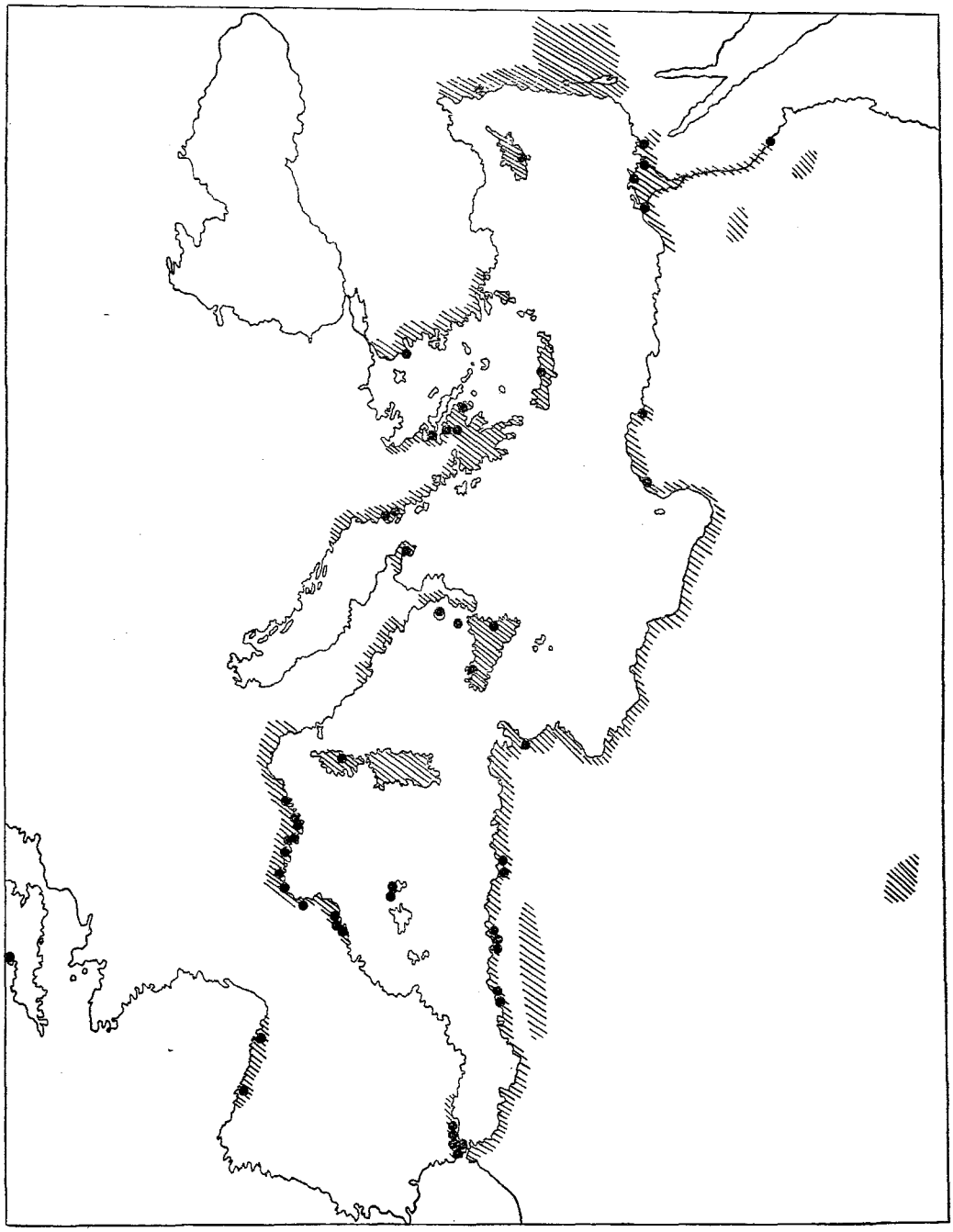

Fig. 2. The geographical distribution of *J. subulatus*; the occurrence of the plant in the Caspian Sea region is not included. Records based on herbarium specimens are shown by ● ; information on distribution derived from Floras is indicated by hatching.

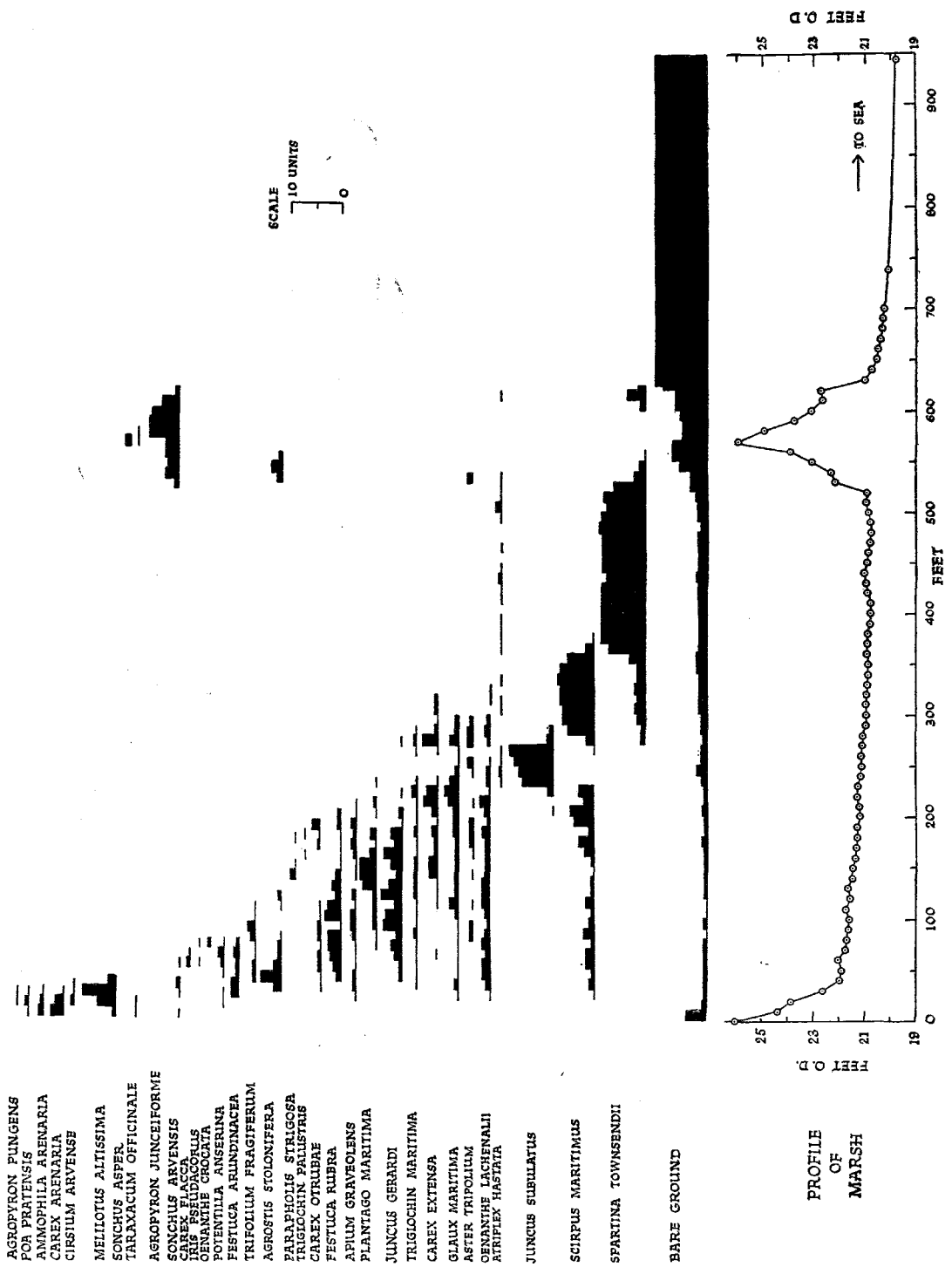

Fig. 3. The profile and vegetation of a transect across the marsh at Berrow, mid-August 1958. The vegetation was scored (out of 10 units) according to the relative bulk (volume) of the component species, an allowance for bare ground being made; successive areas, 10 feet long and 3 feet wide, along the transect were recorded. The distribution of most of the plants is shown in histogram form, but not included in the figure are the following : distance 0–10ft., 0·5 unit of *Bromus mollis, Calystegia soldanella,* 0·1 unit of *Cerastium holosteoides, Crepis capillaris, Holcus lanatus, Hypochaeris radicata, Senecio jacobaea, Trifolium arvense, T. campestre;* 10–20ft., 0·5 unit of *Bromus mollis, Trifolium repens,* 0·1 unit of *Crepis capillaris, Holcus lanatus, Plantago major, Poa annua, Ranunculus acris, Trifolium arvense, T. campestre, Vicia angustifolia;* 20–30ft., 0·1 unit of *Bryum pseudotriquetrum, Lycopus europaeus.*

Willis *et al.* (1959); the results are given in Fig. 3, which shows that the slope of the marsh is fairly uniform. The lowest area, to seaward, is dominated by *Spartina townsendii*, and few other plants are able to survive its competition. In the next zone *Scirpus maritimus* is very abundant; it is here that *J. subulatus* occurs and is clearly dominant in the two patches where it grows. Both patches are at closely similar levels (21·1 and 21·4ft. O.D.). In the third zone, at still higher levels, a number of species dominate locally; *Juncus gerardii, Oenanthe lachenalii, Festuca rubra, Carex extensa, Plantago maritima* and *Glaux maritima* are plentiful. The presence of *Iris pseudacorus, Phragmites communis* and *Typha latifolia* on the landward margin of the zone suggest the influence of fresh water here.

J. subulatus is clearly subject to considerable changes of salinity at Berrow, since the sites are reached by only the highest tides. The rush is known to tolerate high concentrations of salt (Braun-Blanquet, 1932, p. 193) and at Berrow must at times be growing under conditions of low salinity. Measurements of the sodium chloride content of the soil water (using a flame photometer) after a period of fairly high tides in December, 1958, gave a value of 1·0% at the seaward margin of the colony shown in Fig. 3. At the inland limit of this colony the sodium chloride content was 0·9%, and of the second, which is further inland, 0·7%. The calcium content of the soil water was low (0·01–0·02%) and the pH between 7·2 and 7·5.

(b) *The Mediterranean*

J. subulatus often grows bordering brackish lagoons in southern France and its main association is Salicornietum fruticosae (Braun-Blanquet, 1952); frequently occurring with the rush are *Salicornia fruticosa, S. radicans, Arthrocnemum glaucum, Puccinellia convoluta, Triglochin bulbosa, Halimione portulacoides, Limonium vulgare, Suaeda maritima, Aeluropus littoralis*, and *Polypogon maritimus*. With the last two grasses *J. subulatus* forms a subassociation succeeding Salicornietum after burning, which destroys *Salicornia*, whereas the *Juncus* rhizomes survive. Near the mouths of the Rhône, the rush, sometimes accompanied by *Juncus maritimus*, dominates areas less saline than those occupied by *Salicornia* spp., but the Juncetum may be progressively invaded by *Phragmites communis* as the salt content of the soil diminishes (Molinier, 1948).

In Spain the rush often occurs with *Salicornia* spp. in littoral calcareous marshes (A. & O. Bolós, 1950); the commonest associates are *Scirpus maritimus, Eleocharis palustris* and *Juncus maritimus*. Another somewhat similar community is described by Holmboe (1914, p. 211–2) from Cyprus; here, in a brackish lagoon, its associates included *J. acutus, Scirpus maritimus, Carex divisa* and *Triglochin bulbosa*.

Occurrence and climatic limitation in Britain

J. subulatus must be regarded as a recent arrival, since its only known locality in Britain has not long been vegetated. It seems likely that the rush was brought in by shipping or birds from the Mediterranean, and was carried by tidal action to the site where it is now flourishing.

At Berrow *J. subulatus* is at its northern limit of distribution (see Fig. 2), and its flowering season is much later than in the Mediterranean. In North Africa and Syria it flowers between April and July, and fruits from July onwards, whereas at Berrow and in the Bristol University gardens it flowers from July or August to September and fruits correspondingly later, if at all. The fruiting at Berrow seems to depend on a warm dry summer; in the wet autumn of 1958 only little seed was set, although plants grown in a greenhouse produced some good fruits and seeds in late September. Possibly the northern

extension of the plant is controlled more by the length and temperature of the growing season than by the low temperature of winter, the rush in this respect perhaps showing a parallel to *Scirpus holoschoenus* (Willis, unpublished). The amount of rainfall in summer may well have an important effect on the fruiting of *J. subulatus*.

Although the plant may not often produce viable seed at Berrow, it is spreading sufficiently vigorously by the growth of the rhizome to replace *Scirpus maritimus*, and gives every appearance of becoming an important member of the salt marsh community.

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* Used in compilation of Fig. 2.

[*Note added in proof.* The two colonies have now been recognised on aerial photographs in April, 1954.]