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OBSERVATIONS OF FRUIT SHAPE AND OTHER CHARACTERS IN THE SPECIES OF THE SECTION *PATELLARES*, GENUS *BETA*

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SUMMARY

Doubt is cast on the classification of the species within the section. Although *Beta patellaris* is distinct, the complete interfertility and intergradation of morphological characters between *B. webbiana* and *B. procumbens* suggests them to be two extremes of a single ecospecies. This has significance in studies of hybridization between sugar beet (*B. vulgaris*) and the members of this section.

INTRODUCTION

Species within the section *Patellares* (*B. patellaris* MOQ., *B. webbiana* MOQ. and *B. procumbens* CHR. Sm., TRANSZCHEL 1927; COONS, 1954) possess many characters of great economic importance. Not only are they resistant to powdery mildew *Erysiphe polygoni*, the root eelworm *Heterodera schachtii*, *Cercospora* leaf spot and curly top virus (STEWART, 1950), but in particular, the monocarpous nature and globular shape of the fruit have attracted considerable attention. Both in Europe and in the United States many workers have been hybridizing these species with sugar beet with a view to transferring these desirable characters to the commercial crop plant.

The present observations cover eight years' experience in such hybridization, during which it has become clear that the characters used to distinguish the three wild species of this section are not satisfactory.

MATERIAL

All observations have been made on plants growing under glass at the University of Cambridge and at the Plant Breeding Institute, Cambridge. Sources of seed include major plant breeding establishments in Europe and in the United States of America, and also, via HIJNER (1954, personal communication) a special collection in the islands from which these species originate. (Fig. 1). It is assumed that we have examples of all three species described in the literature, although only the material studied by HIJNER was collected personally. Among the material exchanged between research institutes it is possible that original sources are from a narrow genetic base.

CHROMOSOME NUMBERS

Mitotic and meiotic chromosome contents have established that all our *B. patellaris*

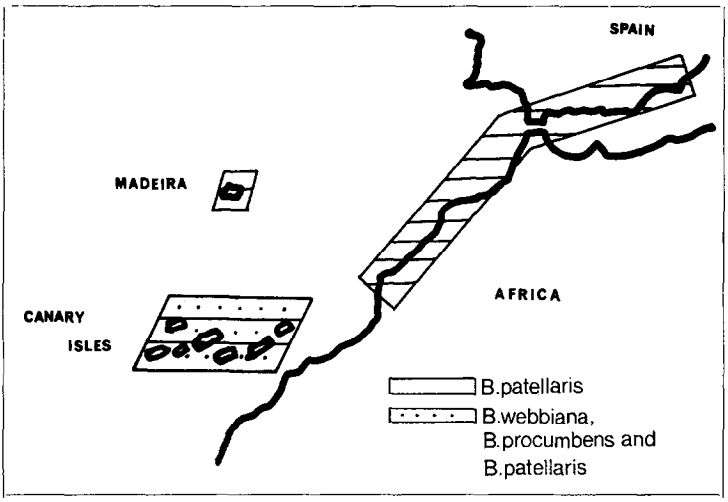

Fig. 1. Distribution of *B. patellaris*, *B. webbiana* and *B. procumbens*.

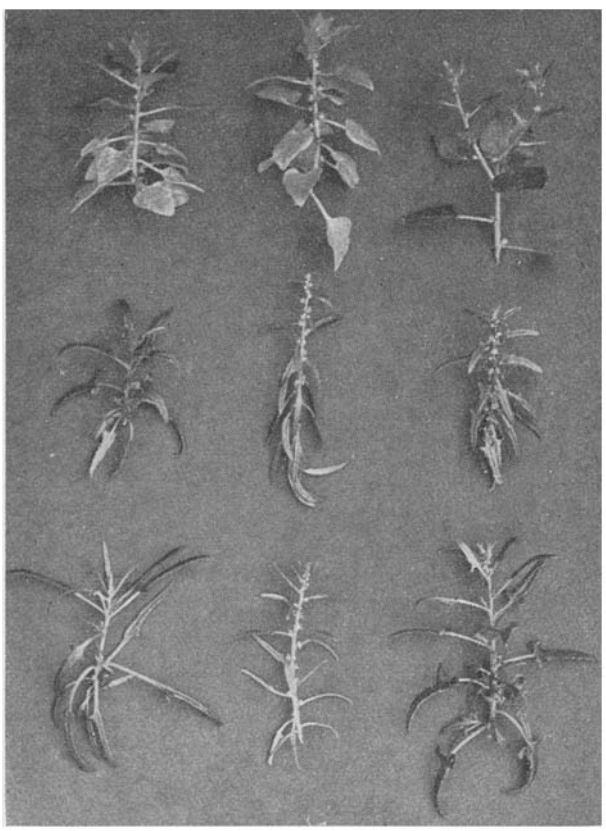

Fig. 2. Shoots of specimens of the section *Patellares*. Top row: *Beta patellaris;* middle row: from seed named *B. procumbens;* bottom row: from seed named *B. webbiana*.

plants have 36 somatic chromosomes and that all the *B. procumbens* and *B. webbiana* plants had initially 18 chromosomes, although tetraploid examples of these latter have been induced by colchinine treatment. Sugar beet normally has 18 chromosomes but many tetraploid lines have been produced artificially.

CROSS-FERTILITY

Our *B. patellaris* is normally self-fertile and no difficulty has been encountered in producing selfed seed by enclosing individual plants in paper bags. The other species, however, have been reluctant to set fruit under those conditions. Seed was produced by plants bagged in pairs and it was at this time that doubts were first cast on the validity of the specific distinctions between our specimens of *B. webbiana* and *B. procumbens*. In material tested so far from all accessions, these two species are not only morphologically similar but also completely interfertile, producing fertile offspring. This is in direct contrast to COONS who found no hybridization between these two species. Hybridization between *B. patellaris* and these two species has not been succesful.

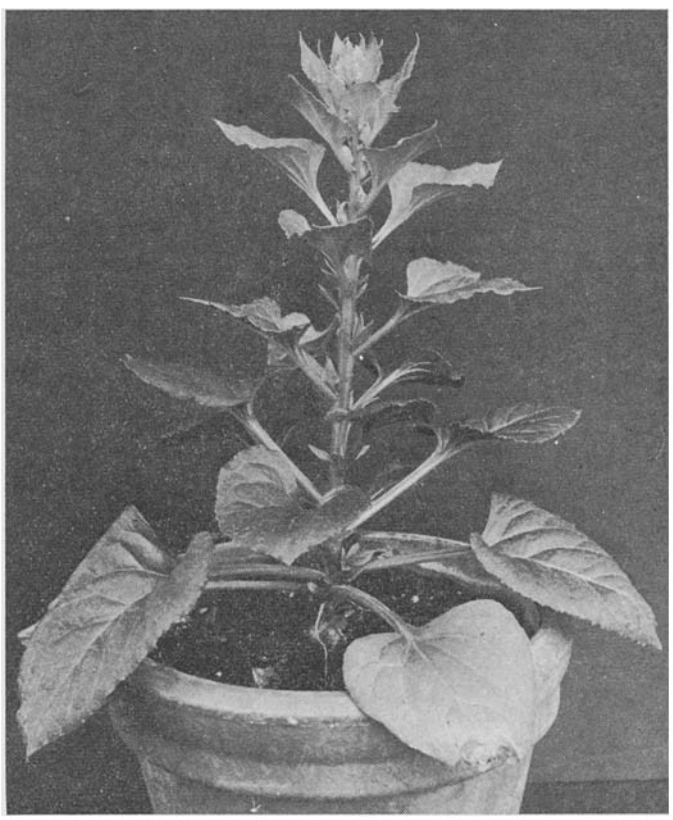

Fig. 3. Hybrid of *Beta vulgaris* (chromosome number 36) and *B. patellaris* (chromosome number 36). Plants of this cross are remarkably uniform.

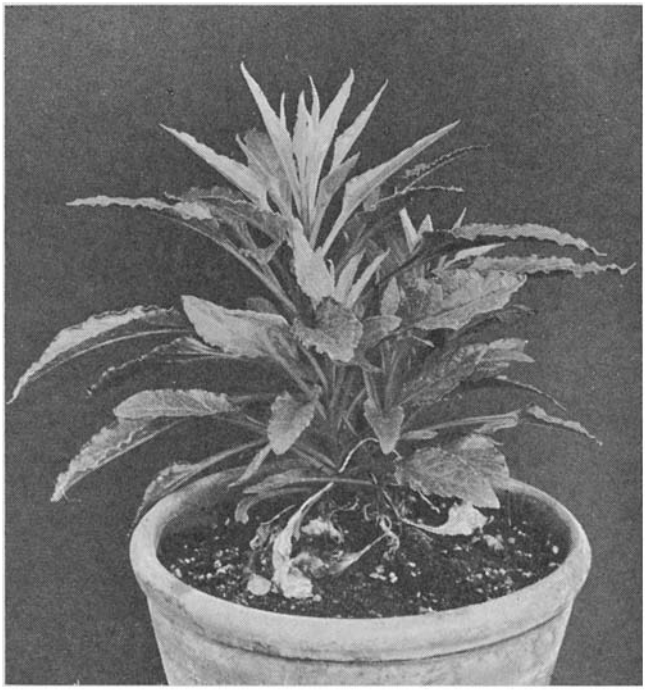

Fig. 4. Hybrid of *Beta vulgaris* (18) and *B. procumbens* (18). The range of morphology of this cross is very similar to that of *B. vulgaris* (18) × *webbiana* (18) although each is clearly distinguishable from crosses between *B. vulgaris* and *B. patellaris*.

MORPHOLOGY

Plants agreeing with the classical descriptions of the two species are obtainable from the extremes of morphological range of both alleged species and from the hybrids between them. Leaf form varies with position on the stem, age of plant and cultural treatment (Fig. 5). Examples of fruit taken from our species do not exhibit the classical distinctions claimed by TRANSZCHEL: in fact the range of our material between these species is no greater than that observed within *B. vulgaris*, particularly in the occasional "monogerm" varieties where extreme reduction of the normal syncarpous to the monocarpous condition occurs (Fig. 6).

B. patellaris is readily distinguishable in our material by chromosome number. The leaf shape is also less variable and clearly diagnostic and in hybrids with sugar beet (both diploid and tetraploid) many morphological characters are unique. The leaf shape and stem branching system as well as the distinctive surface texture of the plants, are characteristic. The hybrids of *B. webbiana* and *B. procumbens* with sugar beet however, cannot be distinguished by external morphology and cytological examination.

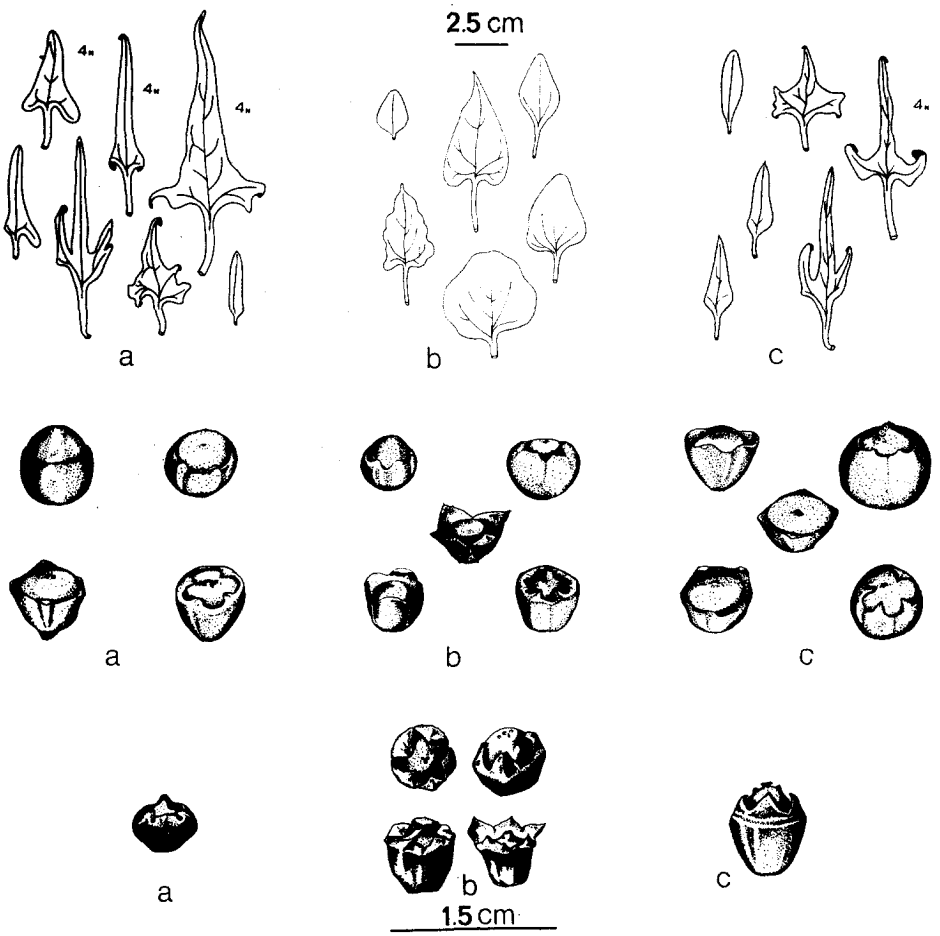

Fig. 5. Morphology of leaf and fruit in plants of the section *Patellares*, genus *Beta*. Drawings from glasshouse grown plants except where indicated.
a: *B. webbiana* b: *B. patellaris* c: *B. procumbens*
Top row: leaf shape; middle: fruit shape; bottom: fruit shape, redrawn after TRANSZCHEL (1927)

EELWORM RESISTANCE

Finally it is well established that, for instance, the resistance of *B. patellaris* to *Heterodera schachtii* SCHM. (an eelworm pest of sugar beet) is not complete and that males readily, and females less often, mature on the root system (SHEPHERD, 1959; STEELE and SAVITSKY, 1962). Identical tests on *B. procumbens* and *B. webbiana*, however, show that although the eelworm may invade the roots (as it may many non-hosts) it never develops to maturity. This, while not of course proving them to be the same species, lends support to such a conclusion and, it is important, particularly in the context of plant breeding, to distinguish between these two reactions within the section *Patellares*.

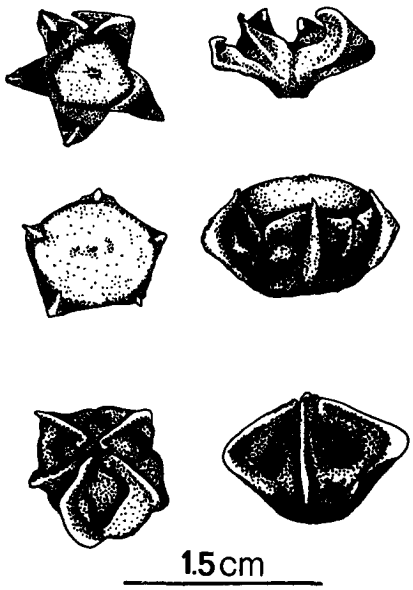

Fig. 6. Fruit shape in "monogerm" sugar beet. Variation among fruit from different plants.

DISCUSSION

DU RIETZ (1930) defined *species* in terms acceptable to most systematists as "the smallest natural populations permanently separated from each other by a distinct discontinuity in the series of biotypes". By 'biotypes' he meant a collection of individuals which are genotypically essentially the same. DAVIS and HEYWOOD (1963) expressed *species* similarly as "morphologically definable units made up of groups of individuals (populations) which it is assumed are usually interbreeding, the containers and expression of one or more gene pools".

In studies of interspecific hybridisation this concept of *species* depends upon acceptance of the essentially artificial situation obtaining in the production of the hybrids. In the present observations, however, doubt is expressed in the validity of the criteria used to distinguish *B. procumbens* from *B. webbiana* just because they cannot be identified distinctly from recognised descriptions.

Regarding *B. patellaris* there is little problem, since it may be distinguished by leaf shape alone although not necessarily by fruit shape.

It has been stressed that examples of each of the the other species as described in the literature can be identified in the material so it is unlikely that we are testing with only one or other of the species *B. webbiana* or *B. procumbens*. If so, then we may conclude that it is unwise to rely upon the criteria of fruit shape for the classification of the section *Patellares*. Such physiological distinctions as annual or perennial habit used by KRASOTSCHKIN (1960) following TRANSZCHEL have not been found to apply in the material we have observed here. Individual plants live from one to many years in the glasshouse, independent of the specific origin. In fact, the two species *B. webbiana* and *B. procumbens* probably represent the two extremes of a single ecospecies, perhaps in the evolutionary process of geographical isolation.

The incorporation of such desirable characters as fruit shape and disease and pest resistance (particularly to *H. schachtii*) may just as well proceed by crossing cultivated beet with hybrids between *B. procumbens* and *B. webbiana*, since the genetic basis of these characteristics is probably identical. Hybrids of sugar beet and *B. patellaris*, however, may involve genetically distinct, and therefore physiologically dissimilar characters.

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