An important new diploid *Avena* species discovered on the Canary Islands[1]

B. R. BAUM
Agriculture Canada, Plant Research Institute, Ottawa K1A 0C6, Canada
AND
T. RAJHATHY AND D. R. SAMPSON
Agriculture Canada, Ottawa Research Station, Ottawa K1A 0C6, Canada
Received January 4, 1973

BAUM, B. R., T. RAJHATHY, and D. R. SAMPSON. 1973. An important new diploid *Avena* species discovered on the Canary Islands. Can. J. Bot. **51**: 759–762.

Avena canariensis sp. nov., $2n = 14$, is described from the Canary Islands. Its spikelets have non-disarticulating upper florets and bidentate lemmas, suggesting the evolutionary sequence: *A. canariensis* ($2x$) → *A. magna* ($4x$) → *A. sterilis* ($6x$). Hence it is a putative ancestor of the $6x$ cultivated oats. The karyotype consists of two pairs of satellited chromosomes, four pairs with median and one pair with submedian centromeres, suggesting affinity with the A genome diploid avenas. It was found on a diversity of natural and disturbed sites in the uplands of Fuerteventura, but not as a weed of field crops.

BAUM, B. R., T. RAJHATHY et D. R. SAMPSON. 1973. An important new diploid *Avena* species discovered on the Canary Islands. Can. J. Bot. **51**: 759–762.

Les auteurs décrivent ***Avena canariensis***, sp. nov., $2n = 14$, provenant des îles Canaries. Les fleurs supérieures de l'épillet ne se désarticulent pas et les glumelles inférieures sont bidentées, ce qui suggère la séquence évolutive suivante: *A. canariensis* ($2x$)→ *A. magna* ($4x$)→ *A. sterilis* ($6x$). *Avena canariensis* est donc présumément un ancêtre des avoines cultivées hexaploïdes. Le karyotype consiste en deux paires de chromosomes avec satellite, quatre paires à centromère médian et une paire à centromère submédian, ce qui indique des affinités avec les avoines diploïdes possédant le génome A. *Avena canariensis* a été trouvé dans divers sites naturels et perturbés des hautes-terres de Fuerteventura, mais non comme mauvaise herbe des champs cultivés. [Traduit par le journal]

Introduction

A new species of oat, which by its mode of dispersal and bidentate lemma tips resembles the hexaploid *A. sterilis* L. and the tetraploid *A. magna* Murphy et Terrell (Murphy *et al.* 1968), was detected by one of us (B.R.B.) while examining a 120-year-old collection from the Canary Islands obtained on loan from the Webb Herbarium of the Institute of Botany, Florence, Italy. Because of its smaller size and very hairy lemmas it suggested a miniature *A. magna*. On the basis of the configurations of the disarticulating scar, the lodicule, and epiblast, and these coupled with traditional characters, it became apparent that two herbarium sheets, one from the island of Fuerteventura and the other from Lanzarote (Fig. 7), were representatives of a new species. It so happened that one of us (D.R.S.) was at that time in England on a sabbatical leave, and arrangements were made for a short visit to the Canaries to find the new species and collect viable seeds for cytogenetic studies. On May 1 and 2, 1972, he found *A. canariensis* at 15 of the 24 localities examined on the island of Fuerteventura.

In this paper we describe the morphology, karyotype, and habitat of this new species, and also speculate briefly on its probable phylogenetic status within the genus *Avena*.

Description, Cytology, and Field Biology

Avena canariensis Baum, Rajhathy, et Sampson, sp. nov.

Spiculis Avenae sterilis similis sed minoribus: flore inferiore articulato, superiore non articulato, glumella inferiore apice bidentata. Articulationis cicatrix lineari-elliptica. Lodiculi et epiblasti *A. sativa* similes. Chromosomatum numerus $2n = 14$.

HOLOTYPUS: Fuerteventura, ad spiracula de Oliva, Febr. 1846, Bourgeau Pl. Canarienses No. 1038; PARATYPUS: Lancerotta, in campis prope oppidum Teguise, Febr. 1846, Bourgeau Pl. Canariensis No. 1039; conservantur in Webb Herbarium, Firenze, Italia.

[1]Contribution No. 934, Plant Research Institute and No. 334, Ottawa Research Station, Research Branch, Agriculture Canada.

The name *A. canariensis* was used only once, by Steudel (1840), but as a nomen nudem, probably for another plant altogether, and does not affect our choice of the name from the nomenclatural point of view.

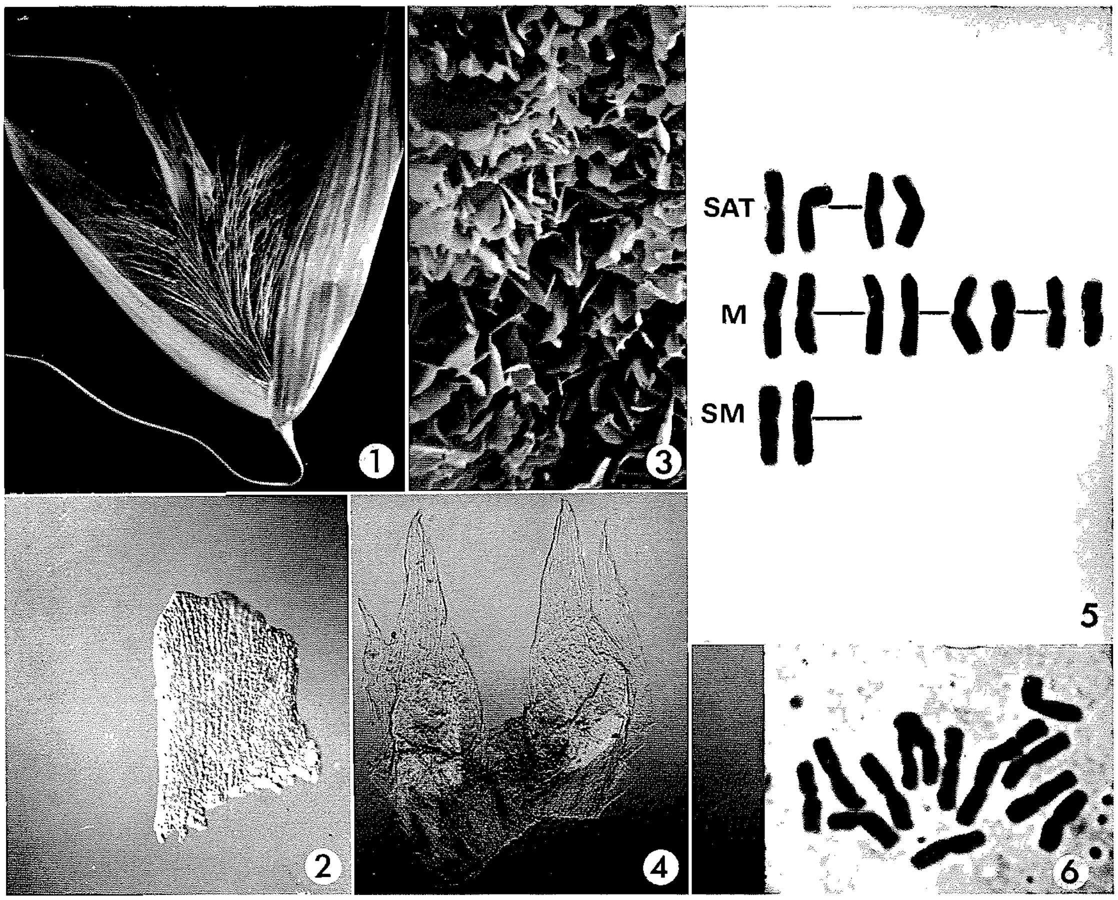
The spikelets of *A. canariensis* resemble those of *A. sterilis* and *A. magna* in that only the lowermost floret disarticulates and the upper always remains attached to the lower, thus forming a single diaspore. Furthermore, the lemmas are bidentate as in all of the hexaploids and in the tetraploids *A. magna* and *A. murphyi* Ladizinsky, a character previously unknown in diploid *Avenae*. The glumes are subequal to equal, 15 to 17 mm long. Our material has two or three florets per spikelet. The dispersal unit without the awns is 12 to 14 mm long. The disarticulation scar is convex in plane, narrowly elliptical in outline and resembles that of *A. barbata* Pott ex Link. The dark reddish-brown lemma is extremely tough and very tightly envelops the caryopsis. The palea is not beset with any kind of hairs and prickles on the back, a rare feature among oat species. The lodicules (Fig. 4) have a configuration similar to those of *A. sativa* L. (Baum 1969). The epiblast (Fig. 2) is similar to that of *A. sativa* (Baum 1969) and unlike any other diploid species of oats except for *A. prostrata* Ladizinsky (Baum, unpublished). The disposition and density of hairs on the back of the lemmas (Fig. 1) suggests a miniature *A. magna* (see Fig. 1 of Murphy *et al.* 1968). The fine pattern of the cuticle of the glumes, i.e. the wax crystals (Fig. 3), consists of dense dentate-fimbriate plates, and in this respect resembles *A. murphyi* but not *A. sterilis* nor *A. magna* (Baum and Hadland, unpublished).

Root tip squashes were made on 14 of the 15 collections of *A. canariensis* and each showed $2n = 14$ chromosomes. The karyotype of *A. canariensis* consists of two dissimilar pairs of satellite (SAT) chromosomes, four pairs of chromosomes with median centromeres, and one pair with submedian centromeres (Figs. 5, 6). Of the SAT pairs, one has a subterminal centromere and a small satellite attached to the short arm, the satellite being slightly larger than in similar chromosomes (SAT 1) in other species (Rajhathy 1971). The other SAT pair has submedian centromeres and large satellites attached to the short arms. The short arm : satellite ratio is about 2:1 as in similar chromosomes (SAT 2) in the hexaploids and it appears as a median chromosome when the secondary constriction is not apparent. The four pairs of median chromosomes are of decreasing size, resembling those in *A. longiglumis* Durieu (2*x*), *A. damascena* Rajhathy et Baum (2*x*), *A. magna* (4*x*), and those in the hexaploids. The single pair of submedians is about the size of the longest pair of medians and in relative size and centromere position it resembles the SM 11 chromosomes in the standard karyotype of the hexaploids (Rajhathy 1963).

Twenty-four localities on the volcanic island Fuerteventura were searched for *Avena* species and one or more of *A. canariensis*, *A. barbata*, *A. occidentalis* Durieu, and *A. sterilis* were found at 23. The main vegetation of Fuerteventura is xeric grassland with a winter growing season. An annual precipitation of 11.2 cm is recorded at Tefia (elevation 150 m) with 82% falling in the 4 months of November to February. Higher elevations probably receive more precipitation than this. *Avena canariensis* is common in the interior (Fig. 7), usually above 200 m elevation, and up to 550 m, the highest locality visited. It was always accompanied by one or more of the other *Avena* species. Unlike the other species, it was not found in the lowlands, neither at Puerto del Rosario in the east, nor Lajares, La Carhris, and Roque in the north. Lanzarote was not visited. Its climate and vegetation are similar to those of Fuerteventura.

Two additional collections of *A. canariensis* were identified by B.R.B. when he examined the herbarium specimens labeled *A. fatua* L. from the Canary Islands collection of Johannes Lid (on loan from the Botanical Garden, University of Oslo, Norway). One is from Lanzarote, west slope of Montana Los Helechos, elevation 520 m, collected on April 11, 1954. More interesting is a specimen (mixed with *A. occidentalis*) from the west side of Tenerife, over 250 km west of the other known sites of *A. canariensis*: El Molledo, south of Santiago del Teide, elevation 900 m, collected on May 6, 1957.

Avena canariensis grows on diverse substrates ranging from rock piles (basalt) to cinders, to fine textured volcanic soils and in diverse habitats ranging from the terrace banks of irrigated fields, to roadsides, to broad, open steppes, to high, exposed mountain sides. Thus it occupies natural sites as well as areas disturbed by man. It does not appear to be a weed of field crops, for al-



FIGS. 1–6. External morphology and chromosomes of *Avena canariensis*. (1) Spikelet, one awn missing, × 5.3. (2) Epiblast, × 150. (3) Cuticular wax crystal on glumes, × 600. (4) A pair of lodicules, × 100. (5) Karyotype. (6) Somatic plate from which Fig. 5 was obtained.

though found along field margins, it was not seen in the fields of wheat, barley, and lentils where *A. occidentalis* and *A. sterilis* were common. At maturity *A. canariensis* may be distinguished in the field from other *Avena* species by its shorter stature but more readily by the tendency for the plump, hairy spikelets to remain on the panicles long after they have ripened. The islanders gather plants of *A. canariensis* along with other wild grasses to use as livestock feed. Plants *in situ* are grazed by goats.

FIG. 7. Locations of 1846 holotype and paratype collections (Bourgeau) of *Avena canariensis* and 1972 itinerary and collections (D.R.S.) on the Canary Islands of Fuerteventura and Lanzarote.

Seedlings of *A. canariensis* grown in growth cabinets (20°C days, 15°C nights, 16-h photoperiod) from seed collected on Fuerteventura showed extensive variability in vegetative characters. Some collections gave prostrate, narrow-leaved seedlings, some gave erect, wider-leaved plants that flowered about 1 month earlier than the prostrate kind, and other collections were mixed. Within both kinds were plants with glabrous leaves and others with pubescent leaves. Variation in the intensity of stem anthocyanin also was present. This is in contrast to the phenotypic uniformity that we have observed in numerous collections of *A. magna* and it indicates genetic diversity within *A. canariensis*.

Discussion and Conclusions

The discovery of a new diploid *Avena* species, of which only six were known previously, is in itself an event of significance. But in this economically important genus, the species of which form a polyploid series, the evolutionary importance of a diploid is determined primarily by its contribution to the polyploids. Although a full assessment of *A. canariensis* must await further studies, the limited evidence presented in this paper suggests that it may have played an important role in the evolution of polyploid oats.

Previous karyotype and chromosome pairing studies pointed to the A genome diploids as donors of one of the genomes of the polyploids (Marshall and Myers 1961; Rajhathy 1971) but none of the known A genome diploids has the spikelet morphology and adaptation of *A. sterilis* and its tetraploid relative *A. magna*. As Ladizinsky and Zohary (1971) summed it up: "...we still lack in *Avena* a *sterilis*-like diploid..." The spikelet morphology of *A. canariensis* and particularly its bidentate lemma fulfils this demand. *Avena canariensis* is clearly the diploid which most resembles the *A. sterilis* and the *A. magna–murphyi* complex. It must be remembered, however, that other traits of *A. canariensis*, such as the scars, lodicules, and pattern of cuticular wax crystals, point in other directions.

Geographically and ecologically *A. canariensis* and *A. magna* are similar in having restricted distributions and narrower adaptability than *A. sterilis*, although both coexist with *A. sterilis* and form mixed colonies with it (Baum *et al.* 1972).

Avena magna is known only from the triangle formed by Tiflet, Teddes, and Rommani in western Morocco. Because of the geographical proximity of the Canary Islands to this area and similarity of habitats, it is possible that at one time all three species coexisted on the West African mainland.

The karyotype analysis permits one definite conclusion. *Avena canariensis*, because of the lack of subterminal chromosomes in its complement, is clearly not a member of the C genome diploids: *A. pilosa*,[2] *A. clauda* Durieu, and *A. ventricosa* Balansa (Rajhathy 1966). It may be a new member of the A genome diploids or the carrier of a new genome. Based on this scanty evidence, and because of the morphological and adaptive similarities, we are tempted to compare the karyotypes of *A. canariensis* to those of *A. sterilis* and *A. magna*.

The standard karyotype of the hexaploids (AACCDD) including *A. sterilis*, consists of three pairs of SAT, four pairs of median, seven pairs of submedian, and seven pairs of subterminal chromosomes (Rajhathy 1963). Of these, the chromosomes of *A. canariensis* match two of the satellited pairs, the four pairs of medians, and one pair of the large submedians. If the third SAT and six pairs of the subterminals originated from the C genome diploids as has been proposed (Rajhathy 1966; Ladizinsky and Zohary 1967), then the remaining seven pairs, forming the DD genomes, would consist of six pairs of submedians and a pair of subterminals. The chromosomes of neither of these karyotypes (CCDD) would match those of *A. canariensis*. This, combined with the *sterilis*-like morphology, suggests that *A. canariensis* may well be the diploid donor of the AA genomes of the hexaploids. The chromosomes of *A. canariensis* also match two pairs of the SAT's, all four pairs of the median, and one of the two pairs of the submedian chromosomes of *A. magna* (Murphy *et al.* 1968). Thus, an evolutionary pathway of *A. canariensis* → *A. magna* → *A. sterilis* can be envisaged, although the evidence is far from conclusive. This pathway also leads to the cultivated hexaploids so that *A. canariensis* may be regarded as a putative ancestor of important crop species. Experiments to identify the genome of *A. canariensis* and its relationship to those of the other *Avena* species are now in progress.

[2]We refrain from using the correct but little known name *A. eriantha* Durieu because the name *A. pilosa* (Roem. et Schult.) M.B. is in general use by oat workers. A monograph by B.R.B. is now in progress and all necessary nomenclatural changes will be published in it.

Acknowledgments

We thank Per Sunding, Botanical Garden, University of Oslo, for supplying maps of the Canary Islands and providing information on the Canary Island *Avena* collections of Johannes Lid. We also acknowledge the competent technical assistance of V. E. Hadland and B. Cummings in the preparation of microscope specimens.

BAUM, B. R. 1969. The role of the lodicule and epiblast in determining natural hybrids of *Avena sativa* × *fatua* in cultivated oats. Can. J. Bot. **47**: 85–91.

BAUM, B. R., G. FLEISCHMANN, J. W. MARTENS, T. RAJHATHY, and H. THOMAS. 1972. Notes on the habitat and distribution of *Avena* species in the Mediterranean and Middle East. Can. J. Bot. **50**: 1385–1397.

LADIZINSKY, G., and D. ZOHARY. 1967. *Avena ventricosa*: possible diploid contributor to hexaploid oats. Science (Washington), **155**: 1553–1554.

——— 1971. Notes on species delimination, species relationships and polyploidy in *Avena* L. Euphytica, **20**: 380–395.

MARSHALL, H. G., and W. M. MYERS. 1961. A cytogenetic study of certain interspecific *Avena* hybrids and the inheritance of resistance in diploid and tetraploid varieties to races of crown rust. Crop Sci. **1**: 29–34.

MURPHY, H. C., K. SADANAGA, F. J. ZILLINSKY, E. E. TERRELL, and R. T. SMITH. 1968. *Avena magna*: an important new tetraploid species of oats. Science (Washington), **159**: 103–104.

RAJHATHY, T. 1963. A standard karyotype for *Avena sativa*. Can. J. Genet. Cytol. **5**: 127–132.

——— 1966. Evidence and an hypothesis for the origin of the C genome of hexaploid *Avena*. Can. J. Genet. Cytol. **8**: 774–779.

——— 1971. The alloploid model in *Avena*. Stadler Symp. **3**: 71–87.

STEUDEL, E. G. 1840. Nomenclator Botanicus. Vol. 1. p. 171.