ORIGIN OF CULTIVATED OATS

Difference in Ancestry has Vital Bearing on Adaptability of Varieties—Forms Derived from A. Sterilis Best Suited to Southern Countries—Possibilities of Hybridization—Indication that Environment is Factor in Causing Variation—Influence of Culture and Result of Mutations

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ALTHOUGH botanists have in the past usually considered that the many varieties of cultivated oat were descended from Avena fatua, *research has now proved that several species are to be found in the ancestry of these cultivated varieties, and particularly that those grown in the Mediterranean region mostly trace back to* Avena sterilis. *In future planting, therefore, and in attempting to extend the region where oats can be successfully grown, it is absolutely essential that regard be paid to the botanical affinities of the variety chosen, so that time and energy shall not be wasted by attempts to grow descendants of* Avena fatua *of temperate climates in subtropical regions where only* A. sterilis *will flourish, or in a dry region where* A. barbata *is best adapted to cultivation. The prevailing belief that oats can not be grown in the southern United States is probably based on the fact that all the experiments made there have been with cold-climate oats. A great deal of money has already been lost by such attempts, foredoomed to failure because of the unsuitableness of the material:—although suitable material might have been had, and the country's wealth thus enormously increased, had growers studied the genetic history of the cultivated oats earlier. From this point of view, the interesting studies of Dr. Trabut have such practical importance to plant breeders throughout the world that the council determined to republish them from the Proceedings of the Fourth Congress of Genetics, to which body they were communicated at the meeting in Paris in 1911. The translation is by S. C. Stuntz.*

In studying the section Euavena of the genus Avena with a little care, we are impressed with the great number of secondary forms which constitute the species, often living in the midst of cultivated crops in "outposts" established as a result of their wide dispersion outside of the region of their origin.

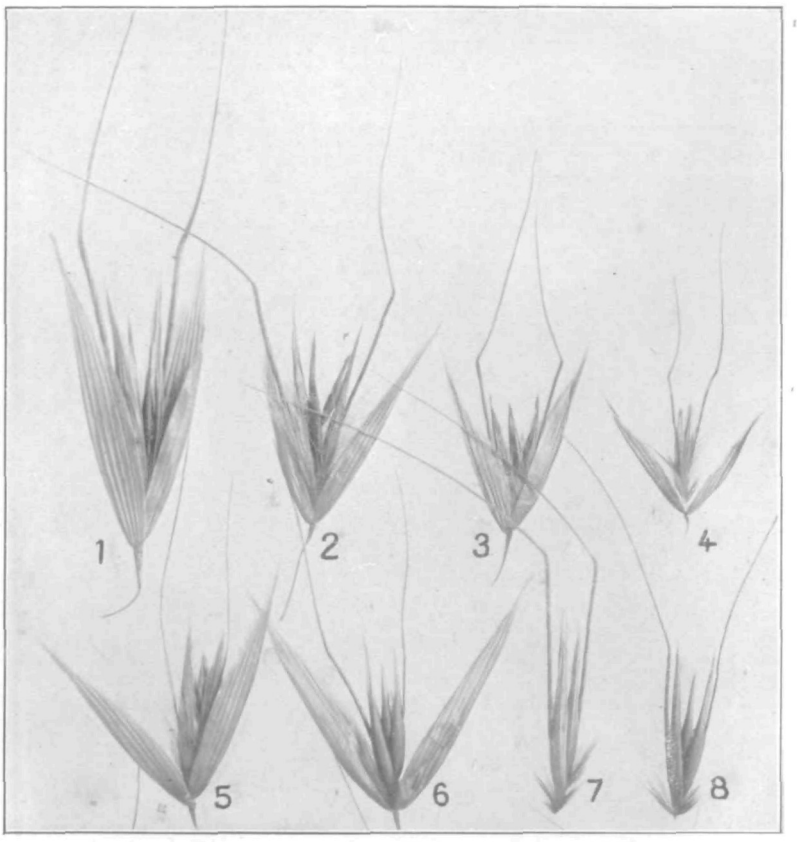
Without doubt these forms may be ascribed to the influence of cultivation, causing variations, or favoring forms which would not find place under the natural conditions of existence. I am even convinced that it is by this involuntary cultivation that man has caused the appearance of the useful races of the genus *Avena*.

But, not to depart from the realm of fact, we know that on the Mediterreanean litoral we are able to bring together the following very important series of *Avena sterilis*, beginning with the most useless forms and ending with an oat largely cultivated in the Mediterranean region, and up to the present wrongly confounded by both scientific and practical writers with *Avena sativa*.

COMPLETE SERIES OF FORMS.

Avena sterilis maxima Perez Lara, Fl. Gad. (fig. 11, No. 1). Inflorescence few-flowered. Spikelets very large, the glumes attaining 50 mm.; lemmae covered with long hairs, and bearing a strongly developed, geniculate and twisted, often hairy, awn.

A. sterilis segetalis Bianca, Todaro



SERIES OF FORMS OF "ANIMATED" OR "FLY" OAT

All of the above are merely varieties of *Avena sterilis*, and a glance at them, when they are side by side, shows plainly the mistake made by writers who considered the two extremes as separate species, making the Algerian oat a form of *A. sativa*, when it is really a form of *A. sterilis*, in which the awns have been reduced and the articulation consolidated through a complete series of intermediate forms. The varieties are as follows: 1. *Avena sterilis maxima.* 2. *A. sterilis.* 3. *A. sterilis ludoviciana.* 4. *A. sterilis micrantha.* 5. *A. sterilis segetalis.* 6. *A. sterilis pseudovilis.* 7. *A. sterilis calvescens.* 8. *A. sterilis pseudovilis.* (Fig. 11).

Exsicc. Sic. 712 (fig. 11, No. 5). Spikelets a little less voluminous, remarkable because of the great reduction of the not geniculate and barely twisted awn. Sicily in cultivated fields. A form very close to this is quite common in Algeria in cultivated fields; the seed is large and the lemmae are black.

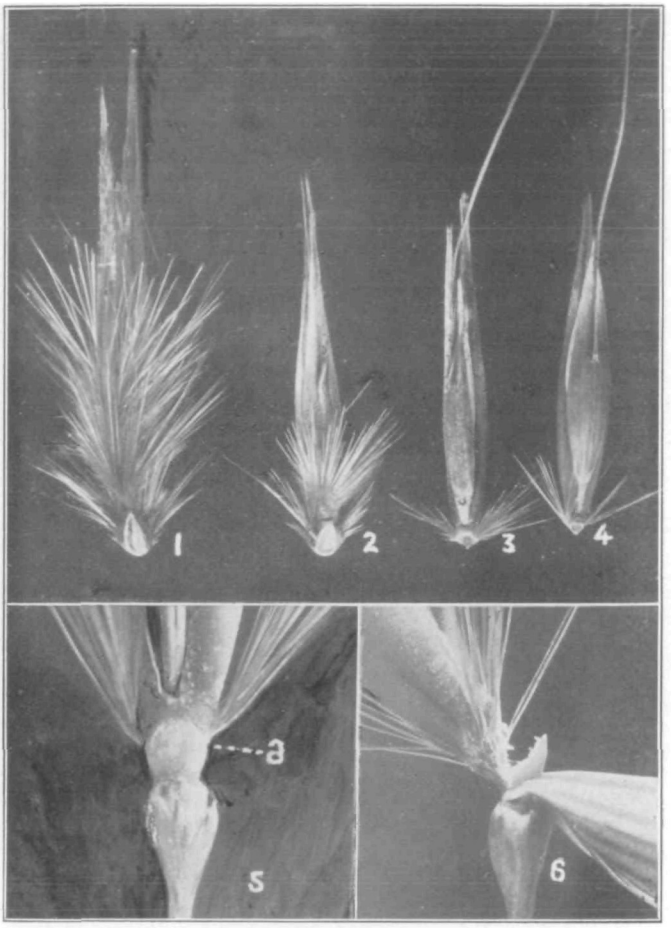
A. sterilis calvescens Trabut and Thellung, Vierteljahrssch. Naturf. Ges. Zurich, vol. 56, p. 315, 1911; *A. sterilis var. A.* Trabut (Compt. Rend. Acad. Sci., vol. 491 p,. 227-229, 1909). Lemmae coriaceous, glabrous, awn twisted, geniculate, but the callus still very hairy (fig. 11, No. 7).

A. sterilis pseudovilis Hausskn. Kritische Bemerkungen über einige Avena Arten, 1894. *A. sterilis var. B.* Trabut, *loc. cit.* This variety differs but little from the cultivated form in which no hairs are found except on the callus of the lower flower, the awns are reduced, but at maturity the spikelet separates very easily from the glumes (fig. 11, No. 8.).

THE ALGERIAN OAT

Above is a head of *Avena algeriensis*, a single spikelet of which is shown below, at the left. Next to this is a photograph of the grains shown in more detail, at the right of which the second seed is shown alone. On the extreme right of the photograph (lower section) is shown the product of an improved variety of this type. (Figure 12.)

A. sterilis byzantina (Koch) Trabut. *A. byzantina* Koch (Linnaea, col. 21, p. 392. 1848). *A. sterilis var. Y.* Trabut, 1910. B. A. Alg. Tunis. This form was described by Koch in 1848. M. Thellung has established the synonymy of this interesting variety. Cosson (Bull. Soc. Bot. France, vol. 1, p. 15, 1854) and the contemporary authors have referred *A. byzantina* Koch to *A. fatua*, more especially to the glabrous forms: *A. hybrida*, *A. fatua glabrescens* Cosson. Haussknecht published it as *Avena sterilis parallela* in 1885. *Avena sterilis*



ARTICULATIONS OF A. STERILIS

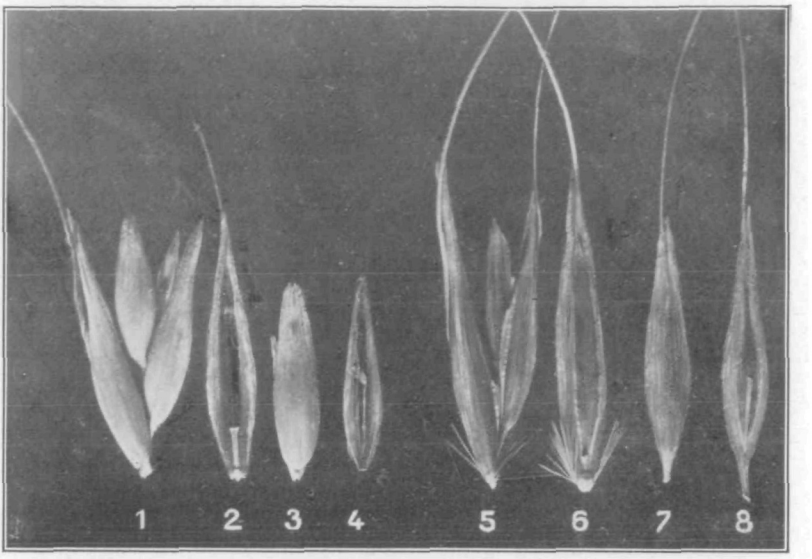
1. *A.sterilis maxima.*—2. *A.sterilis glabrescens.*—3. *A.sterilis byzantina.*—4. *A.sterilis culta.*—5. The same, viewed from the front.—6. The same, viewed in profile. The articulation is perhaps the most distinctive character of this species, and the progress of amelioration in the cultivated varieties simply leads toward a greater consolidation of the articulation. (Figure 13.)

byzantina, has largely lost the characters of the sterilis type, and constitutes the last stage before reaching the cultivated form; the awn is reduced, the hairs of the callus are reduced, the articulation is still well preserved and the flowers fall easily at maturity, and the lemmae are also more lengthened than in the cultivated races. In 1907 M. Hackel wrote me that he considered this form as intermediate between *A. sativa* and *A. sterilis* and named it provisionally *A. sativa biaristata* (fig. 13, No. 3.)

A. sterilis algeriensis Trabut, 1 10. *A. sterilis culta.* The Algerian oat is the cultivated form of the sterile oat. It is characterized by the reduction of the awn and the consolidation of the articulation.

THE ALGERIAN OAT.

The Algerian oat (fig. 12) is very widely distributed in the whole Mediterranean basin where it has long been recognized by growers: MM. Denaiffe



THE TWO SPECIES CONTRASTED

Nos. 1, 2, 3, 4, are the ordinary cultivated oat of temperate regions, *Avena sativa*. 1. The spikelet. 2. The lower flower with the fragment of the axis which bore the second flower. 3. and 4. The second flower, disarticulated. Nos. 5, 6, 7, 8 are the Algerian oat, a cultivated form of *A. sterilis*, which can be most easily distinguished by its method of disarticulation, in which the second flower carries away its own axis, as shown in 7 and 8. No. 6 shows the third flower without the second axis (compare with No. 2, showing the same flower in *A. sativa*), while No. 5 shows the whole spikelet of this Algerian oat. (Figure 14.)

and Sirodot[1] in their monograph on oats, in connection with the Abruzzi oat, indicate good characters and even propose to separate the Abruzzi oat and the Algerian and Tunisian oat as sections of *A. sativa*. Haussknecht, who studied the forms of sterilis very conscientiously, expressed the wish to see a useful race arise some day from this group which is so well adapted to the Mediterranean region; in 1894 in the Mittheilungen des Thüringisches Botanisches Vereins (n. f. no. 6, p. 39), he expressed himself thus: "For the countries of Southern Europe, *Avena sterilis*, improved by cultivation, on account of its larger yield, would produce a very desirable forage plant, especially where our *A. sativa* will not thrive well." If Haussknecht had had occasion to study the southern oats in the field, he would certainly have declared that his wish had for a long time been realized, and that his *Avena sterilis parallela* was nothing more than an escape from cultivation. The existence of a whole series of forms uniting the most characteristic *A. sterilis* with the oat which is cultivated in southern countries, is a strong chain which cannot be neglected, while a study of the morphological and physiological characters of the Algerian oat reveals affinities which no longer leave any doubt.

The section of *Avena sativa* characterized by non-articulate flowers which are separated only by the breaking of the axis, is based on an artificial character. It is because of cultivation that the articulations have ceased to function.

The group of *A. sativa* is made up only of the hairless and ankylosed oats of the other sections *biformes* and *conformes*. *Avena sativa* has retained all the characters of its ancestor, *A. fatua*. The second flower still separates easily from

[1]L'Avoine, pp. 181, 301, 1901.

THREE TYPES OF CARYOPSES

Reading from left to right, the first two are of *Avena sterilis maxima*, the third and fourth of *A. sterilis culta* (the ordinary Algerian oat), while the last, at the extreme right, is *A. sativa*, the ordinary oat of temperate regions. It will be noted that the caryopsis of the Algerian variety is as voluminous as that of the best races of *A. sativa*, but a little more lengthened. (Fig. 15).

the axis which persists above the lower flower, the articulation of the lower flower is more completely obliterated and it is a true rupture which permits it to separate from the glumes.

DISTINCTIVE CHARACTERS.

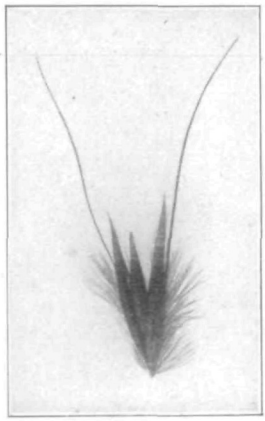
In the cultivated form of *A. sterilis* or Algerian oat, the basilar articulation is still very evident. The separation is not as easy in the cultivated race, as in the wild type, but the line of demarcation and the articular surfaces may easily be recognized. The second flower, which is not articulated in *A. sterilis*, as in *A. fatua*, remains adherent for a long time. It does not separate without carrying away at its base the axis itself, which constitutes one of its most characteristic points (fig. 14, no. 7). These two characters make it possible to recognize at sight the cultivated oats decended from *A. sterilis*, races which otherwise are very little different, and do not constitute so varied a series, as do the forms of *A. sativa* derived from *A. fatua*.

The caryopsis of the Algerian oat is as voluminous as that of the best races of *A. sativa*, but it is a little more lengthened (fig. 15, no. 2).

Avena sterilis culta has the panicles generally few flowered, of from twenty-five to fifty spikelets; it suckers more than *A. sativa*, and when cut green, the Algerian oat will even give a second crop with rather numerous full panicles.

The importance of this distinction, besides its interest as indicating the origin of one of our most widely cultivated plants, rests above all in the very peculiar aptitudes of the races derived from *A. sterilis*.

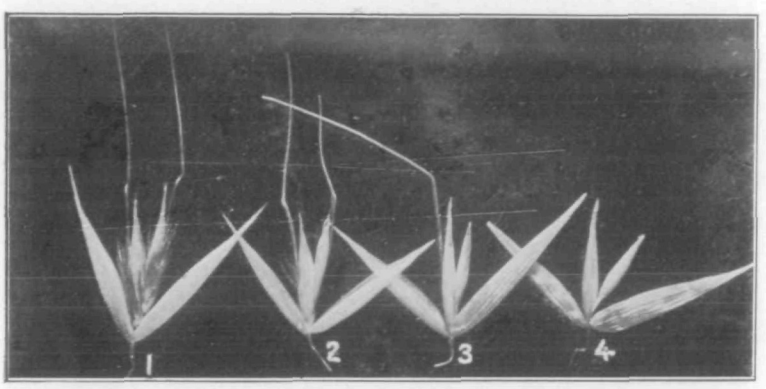
Since 1895, in the oat experiments undertaken at the Botanical Station[2],



A WILD BLACK OAT

This form of the Algerian species is sometimes found growing spontaneously. It has been named *A. sterilis segetalis f. nigra*, and a commercial variety has been produced from it, by selection to reduce the awns. It has been introduced to the United States. (Figure 16).

[2]Of Maison Carré, near Algiers.



TYPES OF THE WILD, TEMPERATE OAT

Four forms of *Avena fatua*. 1. *A. fatua* itself. 2. *A. fatua glabrescens*. 3. *A. fatua subuniflora*. 4. *A. fatua subuniflora inermis*. The second has sometimes been supposed, without any proof, to be a hybrid of *A. fatua* and *A. sativa*. The third is found at considerable altitudes in Algeria, and sometimes presents awnless individuals (no. 4), which could easily be fixed to produce an awnless variety of this subspecies. (Figure 17).

I have proven that very few varieties give satisfactory results in cultivation along the coast. The few varieties which have resisted drought and rust were received under names Abruzzi oats, Naples oats, Tunisian oats, Spanish oats, Greek oats. They all have the same appearance and are practically indistinguishable. They are all *Avena sterilis culta*.

This type derived from *A. sterilis* does not seem to have acquired any other characters than very secondary ones; color more or less bright, awn more or less reduced, hairs of the callus more or less abundant. By careful segregation, a form with shorter grain, more swollen and of greater density (fig. 1, 2, no. 4) is obtained, but the lemmae remain hard, which is a very serious defect. A form with three grains may also be fixed.

ALKALI RESISTANCE.

The Algerian oat not only resists heat and rust, but also to a certain degree alkali in the soil. In the plains of Oran, very extensive growths of *A. sterilis ludoviciana* are often seen in saline places.

It is evidently from this form that it will be possible to obtain a race suitable for saline soils; there already exist glabrescent variations with reduced awns.

The results of my observations on the resistance of the Algerian oat, have, for a long time, attracted the attention of the experiment stations of Cape of Good Hope, Australia, and the United States, which have checked my statements and have made important distributions of seed of Algerian origin. The results obtained have been good.

From the point of view of genetics, it is interesting to show the great uniformity of *Avena sterilis culta*, while *Avena fatua sativa* has been almost overwhelmed by the multiplicity of its cultivated races.

I have tried hybridizing, after having shown that no cultivated form could be regarded as having the combined characters of the two species. It will be useful, by causing variations, to obtain the following modifications of the Algerian oat:

a) Reduction of the length of the lemmae. There already exist elementary forms showing this character, as well as the reduction of the awns.

b) Reduction of the hardness of the lemmae which make this oat less digestible. The weight of chaff in relation to kernel is nevertheless no higher in

TWO FORMS OF THE BARBED OAT

B The type (*Avena barbata*). It has given rise to a number of cultivated forms which seem especially adapted to dry regions. At the right (S) is one of these, *A.strigosa*, which has hitherto been grouped with *A.sativa*, but is merely a glabrous form of *A.barbata*, which has lost the fragility of articulations which characterize the latter. (Figure 18).

the Algerian oats. The proportion is, in harvests made under good conditions, 71% of kernels to 29% of chaff. But the experiments of Captain Bosnot, at the Horse Breeding Station at Tiaret, have shown that the Algerian oat has a coefficient of digestibility a little lower: thus with Houdan oats, 62 grams per kilo escaped digestion and with Algerian oats, 70 grams,—although the White Canada oat, in the same trials, has 75 grams not digested. Histological examination of the lemmae does not reveal any difference in thickness or consistency from those which are observed in *A. sativa.*

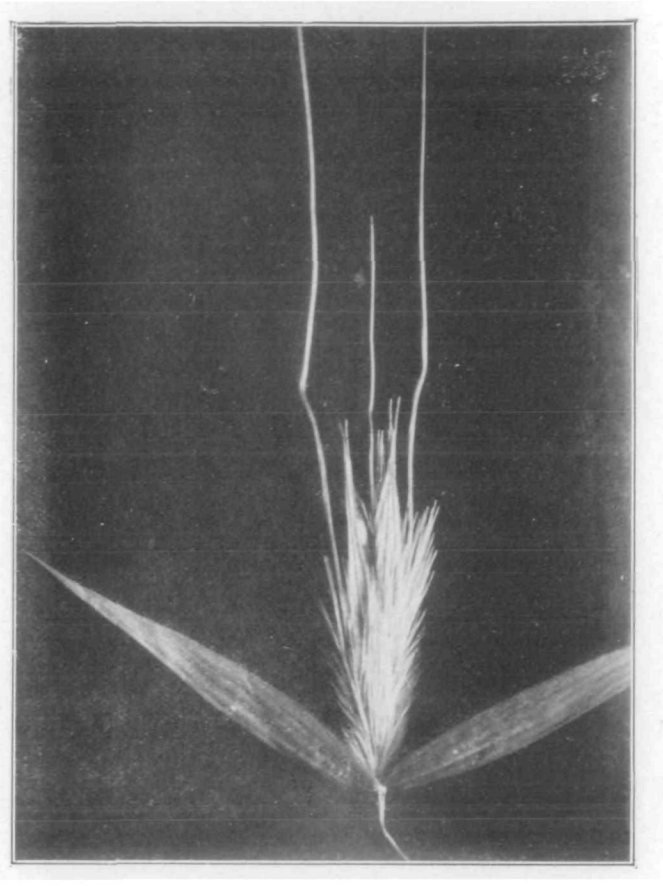
c) Selection by density quickly gives a practical result, perhaps still more evident in this species than in the ordinary oat.

d) The Algerian oat is of bright color, but there are also black races, derived from the black forms of calvescens and segetalis which are easily found at harvest time. *Avena sterilis segetalis f. nigra* (fig. 16) is such a race.

e) I have succeeded in fixing by selection a race of this oat having only a single awn, on the first flower, the awn on the second flower not developing.

DIFFERENCE IN DISTRIBUTION.

Avena fatua has a very different distribution from that of *A. sterilis;* this species is found on our high plains, the steppes or on the slightly humid Oranian and Tunisian littoral. Like *A. sterilis*, *A. fatua* presents numerous transition forms toward the cultivated type,—*A. sativa.*



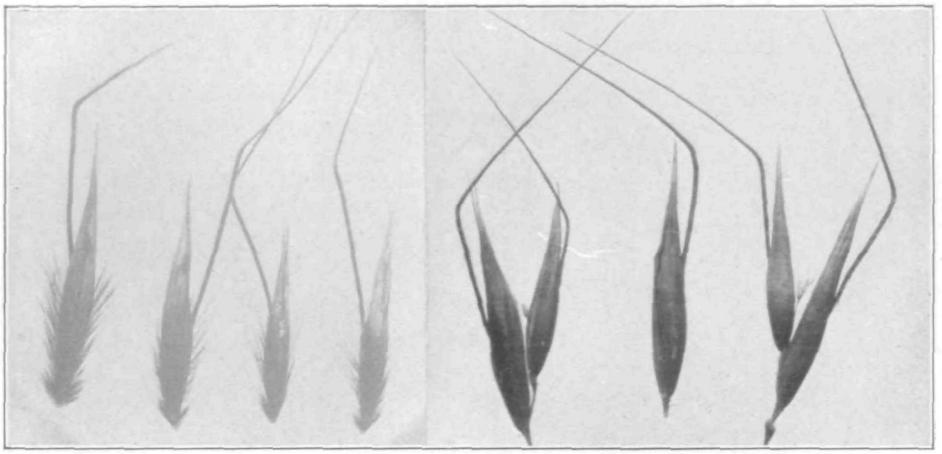
AVENA BARBATA TRIFLORA

A well-marked form of *A.barbata*. This species is found throughout much of northern Africa, the Abyssinian varieties being closely allied to it, if not identical. (Figure 19).

In 1854, Cosson (Bulletin de la Société Botanique de France, vol. 1, p. 15) distinguished an *A. fatua glabrescens* which merges with *A. hybrida* Peterm. (Flora Saxonica, p. 17, 1842). These forms have been regarded as hybrids of *A. fatua* and *sativa*, but without any proof. In the Sersou (altitude 1000 metres) I have found a link uniting *A. hybrida* with *A. sativa*.

This form (*A. subuniflora*) presents the general characters of *A. fatua;* but it is glabrous, the well indicated articulation functions badly, the second flower is most often abortive and the lower flower has a long twisted and geniculate awn (fig. 17, nos. 3–4) like the wild forms. In culture it maintains itself and presents at the same time some awnless individuals which it will be easy to fix. These transition forms are sometimes regarded as returns of a cultivated race to a wild state; this is possible, but it is certain that the supposed reversions of *A. sativa* lead toward *A. fatua*.

It is quite evident today that *A. fatua* has supplied the great majority of the cultivated oats brought together under the name *A. sativa*, and that it is still possible to bring together the whole series of intermediate forms between the wild type and the forms adapted to cultivation.



THE ABYSSINIAN OATS

1, 2, 3, 4, *Avena wiestii*, a hairy form growing wild in Abyssinia, and seemingly adapted to desert regions. 5, 6, 7, *A. abyssinica*, a cultivated form grown by the Abyssinians, not for grain, but for forage. In cultivation, all the transition stages between these two have been found. They offer a rich field to plant breeders, in the production of varieties of oat adapted to severe desert conditions. (Fig. 20).

OTHER SPECIES EXAMINED.

A. barbata. The creation by Linnaeus of an artificial species (*A. sativa*), comprising all the forms of Avena not disarticulating themselves, has for a long time misled searchers wishing to clear up the origin of *A. sativa.*

If we are able to admit as demonstrated that *A. sterilis* and *A. fatua* have transformed themselves into two cultivated oats, it remains for us to examine the other species to see if they have not undergone the same modifications by cultivation and if they have not become usable after having been weeds.

In examining *A. strigosa* Schreber, which has also been included with *A. sativa*, there is little delay in finding all the characters of *A. barbata*, not taking into account the functioning of the articulations and the pilosity, two fluctuating characters without value, as we have seen in *A. sterilis* and *A. fatua. A. strigosa* is indeed the glabrous form which has lost the fragility of the articulations of *A. barbata.*

Haussknecht (l. c. 1894, p. 20) has observed the intermediate form, var. *solida*, but it appears very rare. In examining a great number of plants of *A. barbata*, I have never found anything other than a three-flowered, robust form with large spikelets, different from *barbata triflora* Wilk, and from the two-flowered forms with lagre spikelets growing in grain fields.

In cultivating *A. strigosa*, I have obtained transition forms towards *A. barbata*, with the spikelets of the lemmae almost as pilose as in the wild type, but with more solid articulations.

A. brevis Rotl which has been described as a form of *A. sativa* is connected with *A. strigosa*, derived of course from *A. barbata.*

THE ABYSSINIAN OAT.

Avena abyssinica. My study of *A. barbata* for the Flore de l'Algerie led me to separate the southern forms and those from the Sahara under the names of varieties *fuscescens* and *minor*. Haussknecht has since (1894) identified these desert forms with *Avena wiestii* Steudel.

A. Wiestii differs little morphologically from *A. barbata*, but it is nevertheless a form interesting because of its habitat. In northern Africa, it appears very widely distributed in sub-saharan localities. In Cyrenaica, Taubert collected at Derna a form *solida* (exsicc. no. 507) which is the transition stage toward cultivable forms. I have received from Abyssinia, from Dr. Bald-

rati, director of the Office Agraire Experimental, two lots of Abyssinian oats; one, Dr. Baldrati writes me, is made up of an abundant spontaneous form, the other of the form cultivated not for grain, but for forage. The wild oat was hairy with very fragile articulations. The other was glabrous or pretty near it, and with articulations retaining the grain better.

In cultivation at the Botanical Station, I have found all the transition stages between *A. wiestii* and *A. abyssinica*, which is the cultivable form of it.

A. abyssinica has therefore been wrongly connected with *A. sativa*. It is a form still half-wild. It appears, also, to be produced by the transformation of a native Avena, developed and modified in cultivation.

Although the differences between *A. barbata* and *A. wiestii* may be of little importance, it seems that these two plants are unequally xerophilous in dry places, *A. barbata* being simply the oat of the arid places of the Tell (the coastal region of Algeria), while *A. wiestii* is purely a desert plant.

The domestication of *A. wiestii* is as yet no more than outlined; it will be necessary to perform a vigorous segregation of the forms in the mixture and by appropriate treatment, either quickly or gradually by using patience, to obtain cultivable races superior to the *A. abyssinica* in use by the Abyssinians.

ORIGIN OF AWNLESS OATS.

In this study of the materials within my reach I do not pretend to have elucidated completely the question of the origin of all our oats. The awnless oats are also connectable with primitive species. If all transitions between the wild and the improved forms (intermediate forms which one may regard as the stages of a gradual improvement by culture), are found in the series of cultivated oats, it appears admissible for the awnless oats, that sudden mutations might have intervened. These oats are characterized by teratological anomalies; they are monstrosities such as produced *Triticum polonicum*.

The large Chinese awnless oat has the closest analogy with *A. sterilis*. I have been able to hybridize it with *A. sterilis culta*.

The study of the domestication of Avena presents, from the genetic point of view, some rather substantial arguments in favor of an ambient medium, a modifying agent causing fluctuations which end in the formation of varieties well characterized and fixed by selection.

Avena fatua in cultivation loses the fragility of its articulations, its hairs, its awns. It becomes a domesticated plant, but all the stages of its changes are easily retraced. Cultivated in very diverse surroundings, *A. sativa* has today a very numerous and extremely varied lot of domesticated descendants, as should be the case if the environment causes fluctuations.

A. sterilis culta has not been submitted to the same tests. This variety, cultivated on the Mediterranean borders, has until recently never been carried to other climates. The influence of the cultural environment appears to be very rapid, since Buckmann according to Darwin (Variations of Animals and Plants under Domestication, p. 330, New York, 1897) in a few years of careful culture and selection, converted *A. fatua* into two cultivable races, almost identical with the races already cultivated.

In oats, the modifications of the wild types are in reality not deep. The suppression of the fragile articulations has been considered as having much too great importance in Avena, as in Triticum and Sorghum. The fragile rachis may become tenacious by the simple play of fluctuating characters. It is nevertheless worth while to remark that in the natural habitat, the fragility of the rachis is never lacking in the wild types. This transformation seems to take place only under the influence of cultivation.

Hybridization between the cultivated species of oats has not yet been methodically attempted to my knowledge, and there is here a very interesting open field. It is true that we have yet to determine in what degree a true hybridization will be possible. If *Avena fatua sativa* may be crossed with *A. sterilis*

culta, a progeny may be produced having very useful mixed characters. *A. abyssinica* will gain by being crossed with the really superior *A. strigosa*. But in the matter of hybridization there is much more to be gained from experimentation than from the mere discussion of theoretical views.

SUMMARY.

Until recently, *Avena fatua* has been regarded as the ancestor of the cultivated oats comprised under the term *Avena sativa*.

Study of the wild forms of *Avena sterilis* has led me to consider that the cultivated oats of the Mediterranean countries are descended from this wild species.

The Algerian oat, and the oats of Italy, possess morphological characters found in *Avena sterilis*.

Avena barbata has given rise to some cultivated forms, such as *Avena strigosa*.

These three wild types of Avena appear to have been modified by cultural influences. In various cultures of the cereals, of flax, etc., may be found mutational forms which nearly approach cultivated types. One series of forms is characterized by the reduction of the hairs on the glumes, in another series the awn is reduced, and a third series is distinguished by the solidity of the rachis, which becomes gradually less articulated. A variation of the nature of a monstrosity may also be observed, in which the glume is less compact, so that the caryopsis falls out before maturity. This mutation gives rise to "naked oats."

In conclusion, at least three wild species of Avena, under the influence of culture, may acquire characters fitting them for cultivation. These three species preserve the ancestral characters by which they are adapted to different climates.

Avena fatua gives rise to oats adapted to temperate and mountainous regions; *Avena sterilis*, to oats adapted to the southern countries, and to saline soils; *Avena barbata* to races adapted to dry countries.

PLANS FOR INTERNATIONAL CONGRESS

The American section of the international committee on arrangements for the second International Eugenics Congress met last month. Bleecker Van Wagenen and Frederick Adams Woods were the members present, while H. H. Laughlin, W. Bayard Cutting and C. B. Davenport met with them by invitation. An organizing committee for the next congress was selected, as follows: David Fairchild, Frederick Adams Woods, Raymond Pearl, E. L. Thorndyke, Vernon L. Kellogg, and C. B. Davenport, chairman, This committee met in New York city on January 2 and elected Henry Fairfield Osborne of New York as president of the congress, which will be held in that city in September, 1915.

The Promise of Mendelism

When it is remembered that in wheat, for example, resistance and nonresistance to the attacks of disease, earliness and lateness of ripening, good and bad milling quality, are all pairs of Mendelian allelomorphs, and that it is now possible to take a different example of each of these qualities from each of three different strains, and to combine them together in a single new variety with perfect certainty and in four generations, it does not require much imagination to foresee that every department of the animal and plant breeding industries must sooner or later benefit enormously from Mendel's discovery.—R. H. Lock: Recent Progress in the Study of Variation, Heredity and Evolution (1906).