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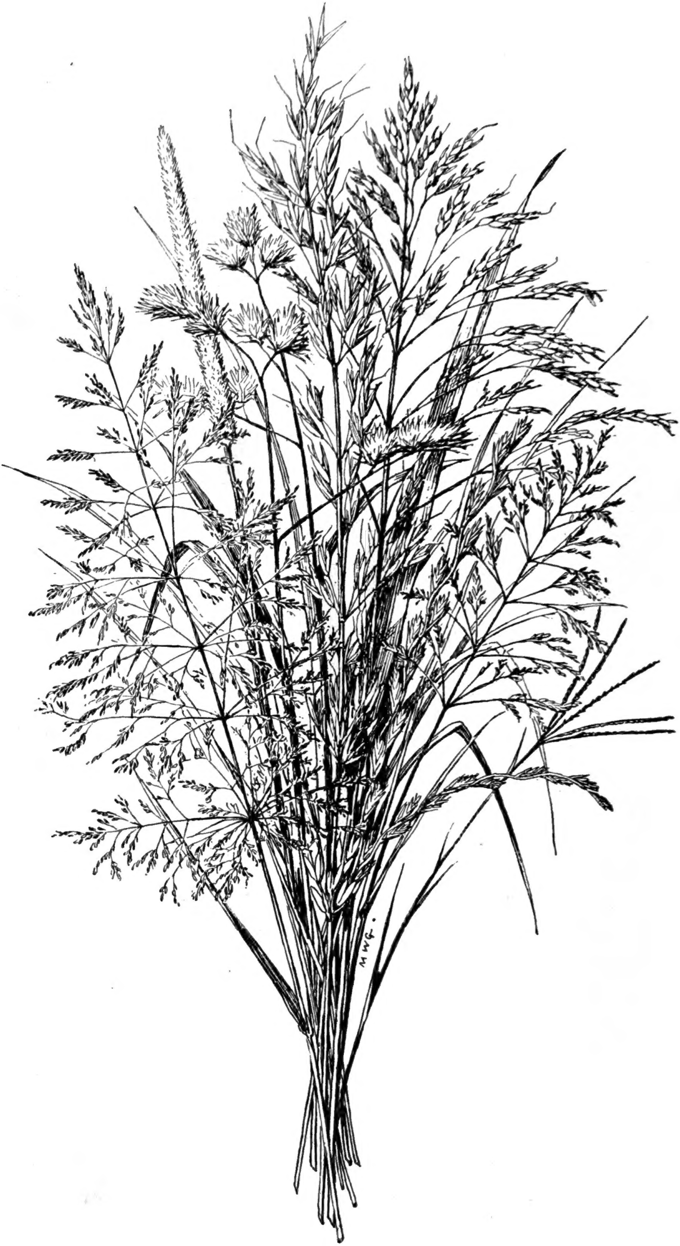
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A TEXT-BOOK OF GRASSES

WITH ESPECIAL REFERENCE TO THE ECONOMIC SPECIES OF THE UNITED STATES

BY

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New York
THE MACMILLAN COMPANY
1914

Set up and electrotyped. Published September, 1914.

Mount Pleasant Press
J. Horace McFarland Company
Harrisburg, Pa.

PREFACE

THE present work is primarily a text-book, but some technical information is included that might more properly be consigned to a reference book. To a considerable extent this reference matter is appended to text paragraphs in the form of notes in smaller type. Although the chief emphasis is placed on Systematic Agrostology, comprising Part II, a brief outline of Economic Agrostology is presented in Part I. In this part the clovers and other forage plants not belonging to the grass family are referred to in classifying the forage plants and their uses. The reader will observe that by the plan adopted the information on a given grass is not found segregated in a single paragraph or chapter but is scattered to meet the necessities of the classification used. The index makes these scattered paragraphs readily accessible.

The botanical information concerning each species will be found in the appropriate paragraph in Part II, but the economic information will be found classified in Part I, a part under the chapter on meadow plants, for example, and a part under the chapter on pasture plants. It seems to the author that this method has didactic advantages. In a reference book it might be more convenient to have all the information on one species placed in sequence. Part I is too elementary to meet the demands of a course in agronomy, but it is hoped that it may be found useful as a bridge to connect the subjects of Systematic Agrostology and Agronomic Agrostology.

The key to genera includes all the genera found growing wild or in common cultivation in the United States. More complete descriptions of the more important genera are added under each tribe. For use as a reference work it would have been desirable to give full descriptions of each genus. But again the author's course was modified by didactic requirements. It is unnecessary for the student to acquire information on the unimportant genera.

The nomenclature followed is that of the American Code. Synonyms are introduced whenever a species or genus has been commonly known under another name.

After careful consideration, the English system is used for all measurements except the small fractions of an inch. But for the smaller measurements the millimeter is adopted as the unit. The English system is as yet more familiar than the metric for the larger measurements. The small fractions of an inch however are inconvenient. The line might be used but is unfamiliar and is too large a unit. The millimeter meets the requirements as to convenience and size of unit, and is sufficiently familiar to botanical students.

The habit drawings have been made by Mrs. Mary Wright Gill, the detailed drawings of the spikelet by Mrs. Agnes Chase.

A. S. HITCHCOCK.

WASHINGTON, D. C.
May 12, 1914.

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PART I

ECONOMIC AGROSTOLOGY

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CHAPTER I

INTRODUCTION

Economic botany is that branch of the science of botany which treats of the uses of plants. All animals, man included, are dependent directly or indirectly upon plants for their existence. With the exception of water and a small amount of mineral matter such as salt, the food-supply of all animal life finally may be traced back to the constructive metabolism of plants, a process dependent upon photosynthesis. Many animals derive a whole or a part of their food from other animals, but sooner or later in the chain of relations between animals and their food-supply a point is reached where the ultimate derivation is from plants. The vegetable kingdom provides directly a large part of the food for man and for his domestic animals. It provides the fibers from which much of his clothing is made; much of the material for constructing his home and the articles with which it is furnished; many of the drugs, medicines, dyes, condiments, beverages, and a great variety of other useful articles or substances.

Of the natural families of plants that contribute their quota to supply the wants of man, the grass family exceeds all others in the amount and value of its products. To this family belong the grains, such as wheat, corn, and rice, that furnish the bulk of the vegetable food of the world for man, and feed for stock; the greater part of the pasture and meadow plants that furnish forage and hay; and many large grasses such as the sugar-cane, the sorghum, and the bamboos that are not usually classed with this family by those who are not botanists.

1. Agrostology.—Agrostology is that branch of botany which treats of grasses. The term is derived from two Greek words, agrostis (ἄγροστις from ἀγρός, a field) a kind of grass, and logos (λογος) speech. The subject is usually divided into two branches, economic agrostology and systematic agrostology. Like any other branch of botany, agrostology can be considered also from the standpoint of anatomy, morphology, or physiology. Up to the present time the study of grasses from these standpoints has not received distinctive recognition but has been merged with the anatomy, morphology, and physiology of plants in general, or has been included in systematic agrostology.

2. Economic agrostology.—This is that branch of economic botany which treats of grasses, or it is that branch of agrostology which treats of the uses of grasses. The uses of the grasses and their products are so many and various and touch so many industries that it is necessary to define the limits of the subject as it will be considered in this work. It is intended so far as practicable to restrict the discussion of economic agrostology to its botanical phases. The methods of growing grasses, that is, cultural methods, belong more properly, in case of the field crops, to agronomy; or, in case of the ornamental species to horticulture. The methods of obtaining the products of grasses and the course of the products after they leave the plant, such as the extraction of sugar from sugar-cane, or the threshing of grain and its subsequent conversion into flour and bread or into starch or alcohol, may belong to chemical technology. In the present work it is proposed to emphasize the botany connected with the economic phases of agrostology, but information will not be excluded from brief mention when necessary for a proper understanding of the subject, even though this information would fall naturally under some allied branch such as agronomy.

3. Systematic agrostology.—Systematic agrostology treats of grasses from the botanical as distinguished from the practical or economic side. Strictly speaking systematic agrostology should be synonymous with taxonomic agrostology; that is, it should concern itself with the botanical classification or natural relationship of grasses. In the present work it includes also such morphology as is necessary for a proper understanding of classification and also brief references to ecology and some general information less easily classified.

4. The uses of grasses.—In a future chapter grasses are technically defined and distinguished from other plants. The term grass is generally understood to include herbaceous plants with narrow leaves, such as timothy, blue-grass, and redtop. The farmer often understands by grass any small herbaceous plant, especially such as is used for forage. In this sense he includes among the grasses such leguminous plants as alfalfa and clover. There are a number of plants with narrow, grass-like leaves that also may be confused with the grasses. Among such plants are the sedges, rushes, and certain lilies or lily allies. On the other hand the layman may not recognize as grasses the larger members of the family, such as corn, sugar-cane, the giant reed, and the bamboos. In the popular mind even the grains may be excluded from the idea of grasses. Without introducing at this point the exact botanical definition of a grass, it may be said that grasses include such representative plants as timothy, wheat, corn, sugar-cane and bamboos, but exclude the clovers, the sedges, and the rushes.

5. The value of farm crops.—The total value of all crops produced in the United States in 1909 was $5,487,161,000.* In this respect, Illinois leads among the states. The following table gives the relative rank of the first ten states:

TABLE I

TOTAL VALUE (DOLLARS) OF ALL FARM CROPS IN 1909 FOR THE TEN LEADING STATES

1. Illinois	$372,270,470	6. Missouri	$220,663,724
2. Iowa	314,666,298	7. Kansas	214,859,597
3. Texas	298,133,466	8. New York	209,168,236
4. Ohio	230,337,981	9. Indiana	204,209,812
5. Georgia	226,595,436	10. Nebraska	196,125,632

The total value of the leading crops indicates the relative importance of those derived from the grass family as compared with those from other families:

TABLE II

TOTAL VALUE (DOLLARS) OF THE LEADING CROPS IN 1909

Cereals	$2,665,539,714
Hay and forage	824,004,877
Tobacco	104,302,856
Cotton and cotton-seed	824,696,287
Sugar crops	61,648,942
Vegetables	418,110,154
Fruits and nuts	222,024,216
Forest products of farms	195,306,283

The total valuation in Table I does not include forest products except such as are produced on farms. The

*The statistics of this and other tables are taken from the Thirteenth Census of the United States, Vol. V.

value of cereals includes that of buckwheat ($9,330,592), which is not a grass. To the value of hay and forage might be added that of grass seed ($15,137,683) classed under "other grains and seeds." Under "vegetables" is included potatoes as the most important single crop.

It will be observed from Table II that the value of cereals is about 48 per cent, of hay and forage 15 per cent, and of cotton 15 per cent, of the total value of all farm crops. By including grass seed, broom-corn, sorghum, and sugar-cane, and excluding buckwheat, it is found that about 64½ per cent of the value of farm crops is derived from members of the grass family. The value of hay and forage does not include that of pasture and range, which if taken into consideration would swell enormously the total value of the products of the grass family.

CHAPTER II

ECONOMIC CLASSIFICATION OF GRASSES

According to their uses, grasses may be classified into three main divisions,—grains, forage plants and lawn grasses; and four minor divisions,—ornamentals, soil-binders, sugar-producing grasses, and textile grasses, leaving a few unclassified. Another category of grasses, the weeds, being the antithesis of useful plants, might be included under economic grasses. A special chapter is devoted to them (Chapter IX).

GRAINS

6. **The term grain** is applied to those grasses whose fruit is used for food or for stock-feed. The fruit or seed is technically a caryopsis (Par. 162), or in popular language, a grain. The common grains are corn, sorghum, wheat, rye, barley, oats, rice, millet.

7. **Uses of the grains for food.**—The seeds are rich in starch and usually contain also a considerable quantity of protein. For this reason they are eminently fitted for use as food. In the United States, the grain of sorghum and millet is not used for human food, although both are extensively used for this purpose in some parts of the Old World, especially among primitive peoples. Oats, rye and barley, though used to a limited extent, are of secondary importance as food plants in America. The other three grains, wheat, corn, and rice, are of fundamental

importance as food plants for the white race both in America and the Old World. Wheat, oats, barley, and rye are usually designated by the American farmer as small grains, to distinguish them from corn. Rice is usually not included in this loose classification because its culture is confined to the moist regions of the coast, and it is not found in the grain-growing districts of the country. Emmer, spelt, and other species of wheat allied to our common bread wheat, are grown in the Old World, and the first mentioned is grown to a limited extent as a forage crop in America. (See Farmers' Bulletins Nos. 139, 466.) A classification of the grains with their botanical names is given in a future chapter.

All the grains cultivated in the United States are annuals. Certain plants that belong to other families are cultivated in various parts of the world for the seed which is ground into flour and used for food, and hence might be classed as grains. The only one of these used in this country is the buckwheat (*Fagopyrum esculentum L.*). Certain others are cultivated among primitive peoples in other parts of the world, as for example, the quinoa (*Chenopodium Quinoa* Willd.) in the Andes. The seeds of certain wild grasses, especially the Indian rice (*Zizania palustris*), have been used by the North American Indians for food.

8. Relative importance of the different grains.—The grains are used primarily for human food. Scarcely less important is their use as feed for domestic animals. Wheat and rice are used almost exclusively as human food, but all the others are used in part or, in the United States, almost wholly for stock feed. In Europe, to a much greater extent than in America, barley and rye serve as breadstuffs, while millet (*Chætochloa italica*) and proso millet

(*Panicum miliaceum*) are used for porridge or mush. In America the latter grains are fed to stock only. Certain varieties of sorghum furnish an important part of the human food-supply in Africa and China, while in this country other varieties, such as kafir, are used as stock feed. The most important grain is wheat, which is nearly all made into flour, forming the principal breadstuff. Corn is next in importance, furnishing a large part of the feed of domestic animals and serving also to a considerable extent for human food. Oats are produced chiefly for feeding horses, though some goes into oatmeal for human food.

In this country barley is raised chiefly in the cooler regions, and is of importance as a food for stock in those regions where, because of the short growing season or for other reasons, corn cannot be successfully grown, as in much of the West and Northwest. Large quantities are also used in the brewing industry. Rye as a grain is of comparatively little importance in the United States. Rice is of secondary importance in America because, requiring for its cultivation a warm climate and land that can be flooded, the area adapted to its growth is limited in extent, being confined to the low coastal region from North Carolina to eastern Texas. A variety known as upland rice is being grown in Louisiana and eastern Texas on drier land and is cultivated and harvested in the same manner as wheat. In the warmer parts of the Old World, especially in southeastern Asia, rice is the most important food plant grown.

9. Value and production of the cereals.—The value of the different cereals produced in the United States in 1909, excluding buckwheat, is shown in the following table:

TABLE III

THE VALUE (DOLLARS) OF CEREALS IN 1909

Corn	$1,438,553,919	Rye	$20,421,812
Wheat	657,656,801	Rice	16,019,607
Oats	414,697,422	Kafir and Milo	10,816,940
Barley	92,458,571	Emmer and Spelt	5,584,050

The production of cereals in the United States as compared with the total world production is shown in Table IV (see Farmers' Bulletin No. 581):

TABLE IV

PRODUCTION (BUSHELS) OF THE CEREALS FOR THE UNITED STATES AND FOR THE WORLD IN 1913

United States		*World*	
Corn	2,446,998,000	Corn	3,607,359,000
Wheat	763,380,000	Wheat	4,126,000,000
Oats	1,121,768,000	Oats	4,672,168,000
Barley	178,189,000	Barley	1,613,748,000
Rye	41,381,000	Rye	1,884,646,000

It is seen from this table that the United States produced about two-thirds of the corn, one-fifth of the wheat, and one-fourth of the oats of the world, but only a small part of the barley and rye.

Other countries leading in the production of corn are Argentina, Hungary and Mexico; of wheat, Russia, British India, France and Canada; of oats, Russia, Germany, Canada and France; of barley, Russia, Germany and Japan; of rye, Russia, Germany and Austria.

The value of the cereals produced by the ten leading states is shown in Table V:

TABLE V

THE VALUE (DOLLARS) OF THE CEREALS PRODUCED IN 1909 BY THE TEN LEADING STATES

1. Illinois	$297,523,098	6. North Dakota	$149,133,451
2. Iowa	230,205,315	7. Missouri	147,980,414
3. Kansas	169,109,449	8. Minnesota	140,864,148
4. Nebraska	153,666,652	9. Ohio	137,907,934
5. Indiana	151,898,146	10. South Dakota	98,953,050

TABLE VI

Production (Bushels) of Corn for the Five Leading States in 1909

1. Illinois	390,218,676	4. Missouri	191,427,087
2. Iowa	341,750,460	5. Nebraska	180,132,807
3. Indiana	195,496,433		

TABLE VII

Production (Bushels) of Wheat for the Five Leading States in 1909

1. North Dakota	116,781,886	4. Nebraska	47,685,745
2. Kansas	77,577,115	5. South Dakota	47,059,590
3. Minnesota	57,094,412		

TABLE VIII

Production (Bushels) of Oats for the Five Leading States in 1909

1. Illinois	150,386,074	4. Wisconsin	71,349,038
2. Iowa	128,198,055	5. North Dakota	65,886,702
3. Minnesota	93,897,717		

TABLE IX

Production (Bushels) of Barley for the Five Leading States in 1909

1. Minnesota	34,927,773	4. South Dakota	22,396,130
2. California	26,441,954	5. Wisconsin	22,156,041
3. North Dakota	26,365,758		

TABLE X

Production (Bushels) of Rye for the Five Leading States in 1909

1. Michigan	5,814,394	4. Pennsylvania	3,496,603
2. Wisconsin.	4,797,775	5. New York	2,010,601
3. Minnesota	4,426,028		

TABLE XI

Production (Bushels) of Emmer and Spelt for the Five Leading States in 1909

1. South Dakota	6,098,982	4. Kansas	785,362
2. North Dakota	2,564,732	5. Minnesota	757,339
3. Nebraska	1,221,975		

The production of grain from kafir and milo is indicated in Table XII. The statistics for these crops when grown for forage are included under "coarse forage:"

TABLE XII

PRODUCTION (BUSHELS) OF GRAIN OF KAFIR AND MILO FOR THE FIVE LEADING STATES IN 1909

1. Texas	5,860,444	4. California	938,049
2. Kansas	5,115,415	5. New Mexico	543,350
3. Oklahoma	4,658,752		

The production of rice has shifted in recent years from the South Atlantic coast to Louisiana and Texas, where upland rice is now grown. Over nine-tenths of the acreage of this crop is now in the two last-mentioned states:

TABLE XIII

PRODUCTION (BUSHELS) OF ROUGH RICE FOR THE FIVE LEADING STATES IN 1909

1. Louisiana	10,839,973	4. South Carolina	541,570
2. Texas	8,991,745	5. Georgia	148,698
3. Arkansas	1,282,830		

STARCH

10. All the grains mentioned may be used for the production of starch and alcohol.—From the commercial standpoint, the chief starch-producing plants of the world are corn, wheat, rice, potatoes and arrow-root. Wheat is usually too valuable a human food to be used for any other purpose. Corn is the chief source of starch in the United States, although the other grains may be used when available. In the manufacture of starch from corn, the grain is soaked but not allowed to ferment. The softened kernels are then ground in water and the starch purified. A bushel of corn will yield twenty-eight pounds of starch and thirteen pounds of refuse available as cattle food. In Europe the potato is the chief source of starch.

ALCOHOL

11. Another important product of the grains is alcohol.—For this purpose the starch is first converted by means of diastase into maltose, a kind of sugar, and the sugar is fermented by means of a yeast plant. The fermented liquor is distilled, the product being alcohol. The diastase is an unorganized ferment present in the germinating grains. This converts the stored starch of the seed into a soluble form, a sugar, which can be absorbed by the young plant. The grain to be used as a source of alcohol is allowed to germinate, is heated to kill the embryos, and is then fermented with yeast. This converts the sugar into alcohol and carbon dioxide. If beer is the product desired, barley is the grain usually employed and the process is stopped at this point. If a distilled liquor is desired, the material is distilled. The details of the manufacture of the various alcoholic products belong to the study of industrial chemistry. Wine is produced by fermentation from the juices of fruits containing sugar, especially the juice of the grape. This liquid, when distilled, produces a brandy.

MISCELLANEOUS USES OF THE GRAINS

12. In the manufacture of starch or alcohol, the grains furnish many other substances, often as by-products. Among these may be mentioned gluten meal and corn oil, the one from the protein and the other from the fat of the seed. Corn oil is expressed from the grain before the starch is extracted, or it is obtained from the residue in the fermentation vats in the manufacture of alcohol. Much of the commercial vinegar is produced from malt liquor, the alcohol being converted into acetic acid by means of ferments. Besides being used for the production of seed, the grasses mentioned above are extensively used for forage, a use which will be discussed in a future chapter. Corn in one of its varieties or species, sweet corn, is commonly used as a vegetable, the kernels being cooked when in the milk stage. Other varieties are cultivated for ornament and for pop-corn. The pith of the stalks of field corn has been used for many purposes, especially those involving the production of pure cellulose.

CHAPTER III

FORAGE PLANTS

Scarcely less important than the use of grasses for the production of human food is their use for forage. The domestic animals, upon which man depends in part for his food, in their turn depend upon wild or cultivated forage plants.

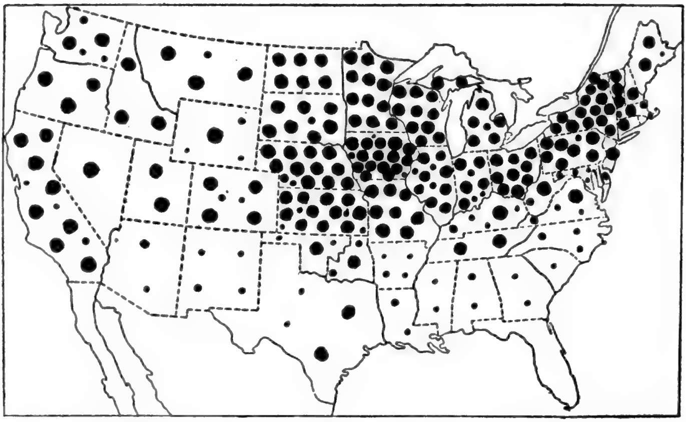


Fig. 1. Production of hay and forage in the United States. One large dot represents 500,000 tons; one small dot represents 100,000 tons.

13. The importance of forage plants is shown in part by the statistics given in the census report under the heading "hay and forage," which includes plants cut and used dry or green for forage, but does not include plants used for pasturage. The figures also include an insig-

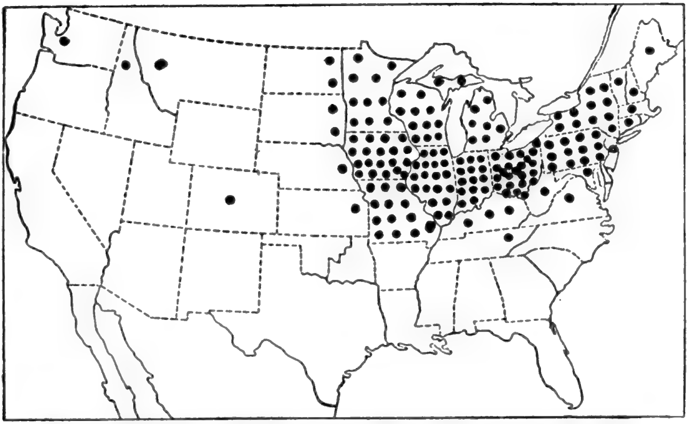


FIG. 2. Production of timothy in the United States. One dot represents 100,000 tons.

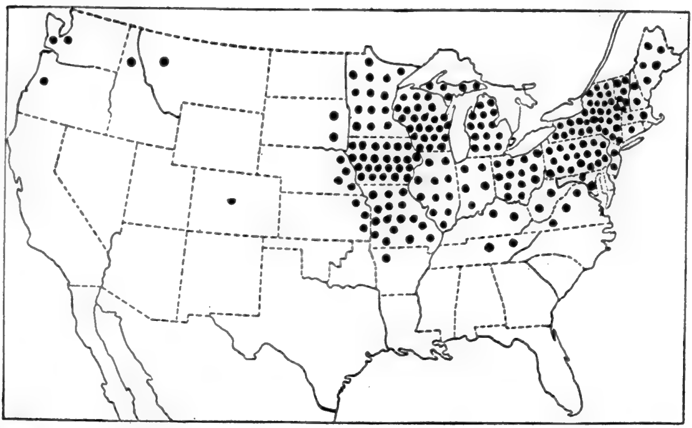


FIG. 3. Production of timothy and clover mixed in the United States. One dot represents 100,000 tons.

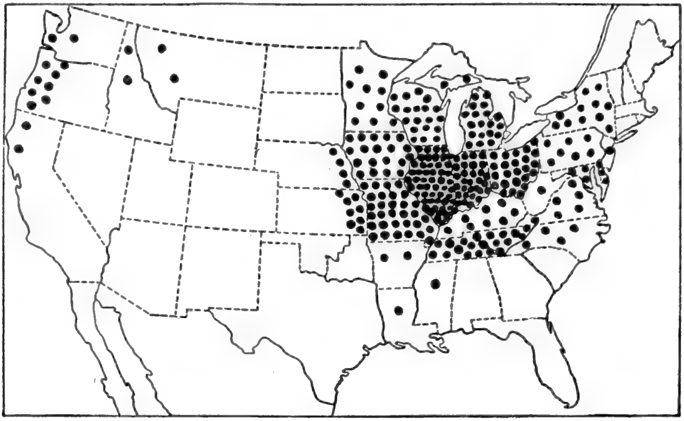


FIG. 4. Production of clover alone in the United States. One dot represents 10,000 tons.

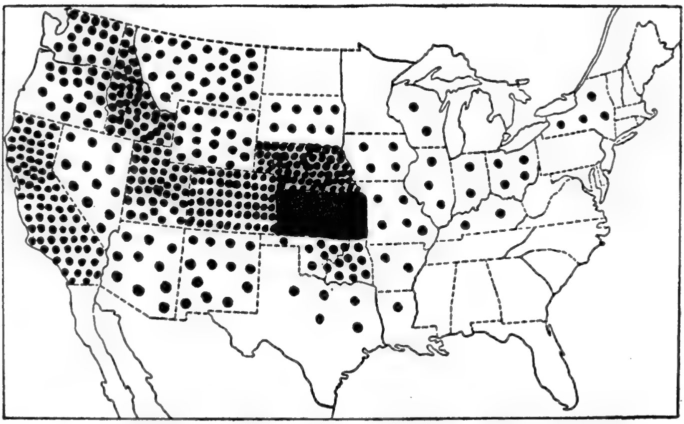


FIG. 5. Production of alfalfa in the United States. One dot represents 20,000 tons.

nificant amount of root forage. The total acreage in 1909 is given as 72,280,776, which produced 97,453,735 tons of forage valued at $824,004,877. The value of hay and forage as compared with other crops is shown in Table II (Par. 5).

The statistics partially classify the hay and forage as follows:

TABLE XIV

ACREAGE, PRODUCTION, AND VALUE OF HAY AND FORAGE FOR 1909 BY CLASSES

	Acres	Production (Tons)	Value (Dollars)
Timothy alone . . .	14,686,393	17,985,420	$188,082,895
Timothy and Clover mixed	19,542,382	24,748,555	257,280,330
Clover alone	2,443,263	3,158,324	29,334,356
Alfalfa	4,707,146	11,859,881	93,103,998
Millet or Hungarian grass	1,117,769	1,546,533	11,145,226
Other tame or cultivated grasses . . .	4,218,957	4,166,772	44,408,775
Wild, salt or prairie grasses	17,186,522	18,383,574	91,026,169
Grains cut green . .	4,324,878	5,367,292	61,686,131
Coarse forage	4,034,432	9,982,305	46,753,262

The production of hay and forage of the ten leading states is shown in Table XV. The production of all the states is graphically shown in Fig. 1.

TABLE XV

PRODUCTION (TONS) OF HAY AND FORAGE OF THE TEN LEADING STATES IN 1909

1. Iowa	7,823,181	6. Wisconsin	5,002,644
2. New York	7,055,429	7. Ohio	4,521,409
3. Minnesota	6,036,747	8. Illinois	4,354,466
4. Kansas	5,936,997	9. California	4,327,130
5. Nebraska	5,776,475	10. Missouri	4,091,342

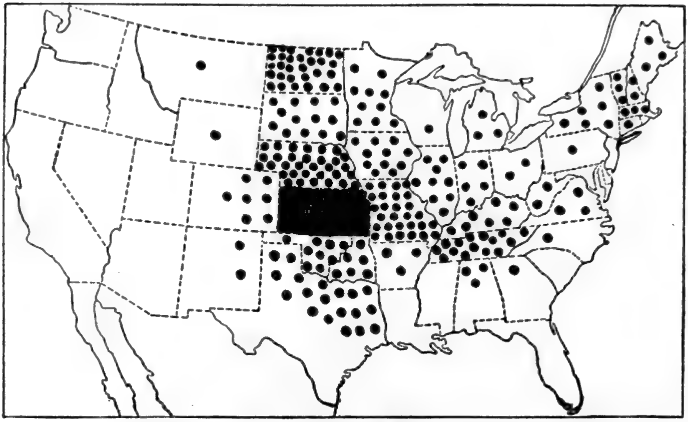


Fig. 6. Production of millet or Hungarian grass in the United States. One dot represents 5,000 tons.

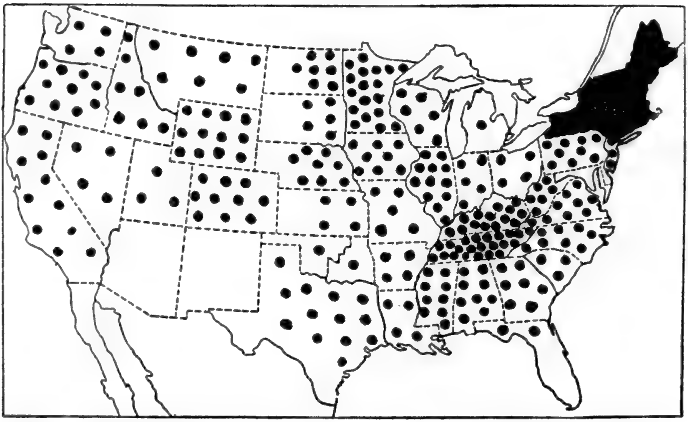


Fig. 7. Production of other tame or cultivated grasses in the United States. One dot represents 10,000 tons.

NATURAL CLASSIFICATION

14. In order to show the relative position of grasses among forage plants, a classification is here given based upon botanical relationships. Forage plants may be divided into three groups. These are: grasses, legumes, miscellaneous plants. The first group includes plants belonging to the grass family (Par. 118).

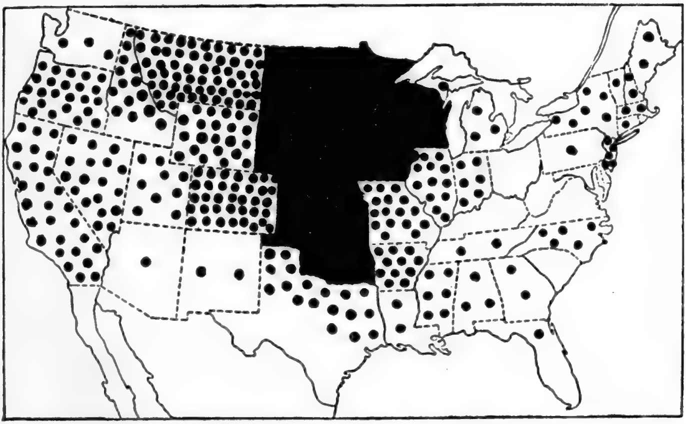


Fig. 8. Production of wild, salt or prairie grasses in the United States. One dot represents 10,000 tons.

15. Legumes.—The second group includes those belonging to the natural family Leguminosæ or Fabaceæ. The plants of this family are characterized by the fruit, which is a legume or pod. To this family belong the clovers, alfalfa, vetches, beans, peas, and many similar plants. The importance of legumes as forage plants depends upon their high protein content, and hence their greater nutritive value. Another important character of leguminous plants is their ability to transfer nitrogen

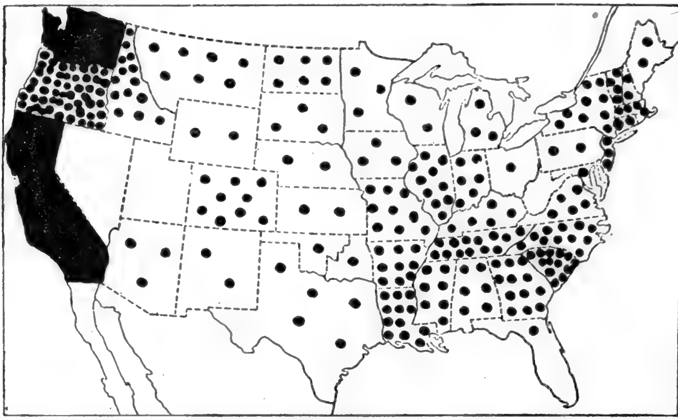


FIG. 9. Production of grains cut green in the United States. One dot represents 10,000 tons.

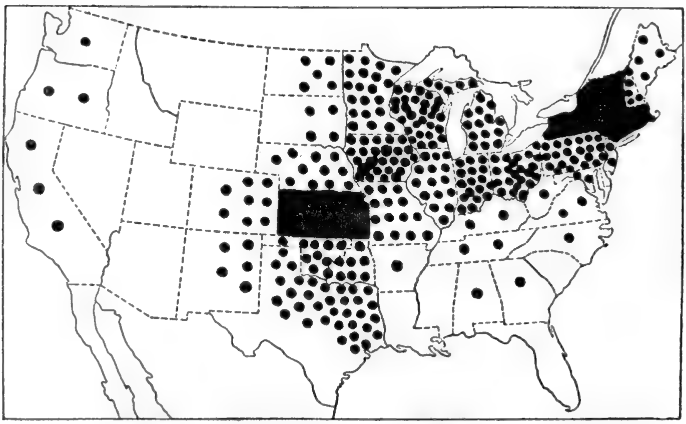


FIG. 10. Production of coarse forage in the United States. One dot represents 20,000 tons.

from the air to the soil, thus increasing the soil fertility. This transfer is accomplished by means of organisms contained in nodules upon the roots of legumes, these organisms, which are allied to bacteria, being able to extract free nitrogen from the air. The accumulated nitrogen is in part passed on to the host plant. After the removal or death of the latter, the roots or such portions as remain in the earth return to the soil in a form available for absorption such nitrogen as was stored in them. For this reason the fertility of soils is increased by the growing of legumes, the following crops being correspondingly improved. The various grasses cultivated for forage are usually grown in combination with legumes either simultaneously or successively, in order to increase the nutritive value of the product and at the same time to retain the fertility of the soil.

16. Miscellaneous.—The third group of forage plants includes all plants that do not belong to the grasses or the legumes. Certain plants of the mustard family, especially rape (see Farmers' Bulletin No. 164), are cultivated for forage. Most of the plants of this group, with the exception of rape, are native range plants, deriving their importance from their presence in arid or semi-arid regions. The most important of those found in America are the salt bushes (species of Atriplex) (see Farmers' Bulletin No. 108), winter fat (*Eurotia lanata* (Pursh) Moq.) and the prickly pear cactuses (species of Opuntia). The cultivation of the opuntias has recently been undertaken in the southwestern states and gives much promise (see Farmers' Bulletin No. 483). Species of Plantago, known to ranchmen as Indian wheat, are important winter grazing plants for sheep in the desert regions of Arizona and California.

CLASSIFICATION OF FORAGE PLANTS ACCORDING TO USE

17. According to the way in which they are used, forage plants may be divided into three classes. These are: pasture plants, meadow plants, soiling and silage plants.

PASTURE PLANTS

18. Pasture plants in the widest sense are those which furnish forage in situ, that is, those upon which stock graze. A pasture is an area supporting or containing pasture plants. In the restricted sense a pasture is a fenced area. In some localities the term is further restricted to areas of cultivated plants. Small pastures or areas of turf are sometimes known as paddocks. Pastures in the general sense may be divided into two classes, native pastures and cultivated pastures.

Native pastures

19. Native pastures include all areas of native vegetation upon which stock is grazed. Fenced pastures are common throughout the United States in connection with all farming operations that include the care of live-stock. Such pastures may include native prairie grass land, as is frequently the case in the region between the Mississippi River and the Rocky Mountains, or they may include areas that are wooded, that are rocky or sterile, that are too wet, or that are otherwise not well suited to field crops.

20. Ranges.—Unfenced native pasture land is usually referred to, especially in the western half of the United States, as range, and animals feeding or grazing upon such areas are said to be upon the range. During the last half of the last century vast areas in the West were utilized as range for stock, chiefly cattle and sheep. The usual practice in raising stock under range conditions is the ranch system. The ranch is the headquarters for the owner or manager of the farm and the stock. Here are the necessary buildings and other equipment. This central area is located near a stream or other water-supply, and more or less of the land in the vicinity is owned by the ranchman. The land lying beyond the limits of the ranch is open range, that is, unoccupied land, owned usually by the federal government, by the state, or by the bond-aided railroads. Such land at that time was of little value unless there was access to water. The result of these conditions was that the valley land along the streams was purchased for the use of the ranches, this ownership giving the use and virtual control of an indefinite area on the upland beyond. The cattle or sheep were herded on this range, the distance traveled being limited by the necessity of returning from time to time for water. Sheep are able to obtain water by eating snow, hence they can be herded during the winter upon desert regions lacking the ordinary water-supply, provided there is sufficient snowfall. It is therefore customary in the mountainous regions of the West to herd sheep in the mountains in the summer and take them out on the desert in the winter.

Within recent years the demand for farm land has increased and the amount of open range has correspondingly decreased. Ranchmen in many cases have been obliged to buy and fence pasture land for their stock. Another modification of the original ranch system results from the policy adopted by the federal government in connection with the national forests. These reserves were formerly available as open range, but now stock is excluded except as permission is obtained for grazing by leasing. The terms of the lease provide for a maximum number of stock at a definite price a head to graze over a limited area for a limited season. In the open range system it was customary for the ranchmen to arrange among themselves the use of the range. As they did not own or lease the open range they could not keep out rival ranchmen except by force. This not infrequently gave rise to strife, sometimes accompanied by bloodshed, between the opposing ranchmen or their herders, especially between the cattlemen and the sheepmen. The especial seriousness of the contests between the cattlemen and the sheepmen arose from the fact that cattle will not willingly graze after sheep probably because of some odor, whereas sheep will graze after cattle. Furthermore, sheep graze the forage much more closely than do cattle, so that after a band of sheep has passed over an area there is little or nothing left for the cattle.

In former years ranchmen of the more southern regions carried their stock through the winter upon the range, depending upon the dry but nutritious grass remaining from the preceding season. Not infrequently there was loss of stock during stormy weather. In the northerly regions, and now, in accordance with the best practice also in the South, supplementary feed is supplied to stock during the winter months.

21. Overgrazing.—Wild pasture land will permit of a certain amount of grazing without deterioration. Beyond this amount the grazing capacity becomes progressively reduced. This condition is caused partly by actual injury to the vegetation, partly by the reduction of its recuperative power, and partly by the fact that grazing animals select the best plants, thus exterminating the valuable species, whose place is taken by the unpalatable or worthless weeds. Range that has been grazed beyond its ability to recuperate is said to be overgrazed, and when the number of stock on a given area is too great, the range is said to be overstocked. The amount of stock which the range will carry depends upon the kind and amount of vegetation, the fertility of the soil, the rainfall, and various other conditions. The carrying capacity can be told only by experience. A range must be exceptionally good to average for a season one cow to every 5 acres, and such ranges would be found only in the less arid portion of the Great Plains where the grass is abundant.

Overgrazing may be the result of necessity. The ranchman having in his possession a certain amount of stock may be confronted with an unfavorable season or a diminished range. As the free range decreases owing to the use of the land for general farming, or is bought up and fenced in by the ranchmen for self-protection, the tendency to overstock becomes greater. Too often under these conditions, the stockman is confronted with the necessity of providing feed for the stock he has, without regard to the ultimate welfare of the range.

22. Rejuvenating worn-out ranges.—As vast regions have been made temporarily unfit for grazing by the attempt to carry on the range for successive seasons more stock than it would bear, there has been an increasing pressure for methods that would quickly rejuvenate these areas. It has been thought that the seeds of grasses or other plants that are as well or better adapted to the conditions than was the preceding vegetation might be sown on the range to advantage. Many experiments have been tried along this line but with little success. The area involved is too large and the expense is too great. There is the further difficulty of finding plants better adapted to the conditions than those that primarily occupied the soil.

The plants that tend to come in to replace those subdued by grazing are usually weedy annuals that have little forage value. Such are the numerous species of Old World brome-grasses that are now so common on the Pacific slope and in some portions of the region to the east of this. There is one exception to this, the annual herbaceous plant known as alfilaria or "filaree" (*Erodium cicutarium* (L.) L' Herit.) a member of the geranium family. This is an excellent forage plant and is gradually spreading on the ranges of the Southwest.

The only practicable method to rejuvenate worn-out ranges is to give them rest. If stock is kept from them they will in time return to a condition of productiveness. The length of time necessary for an overgrazed range to recuperate depends upon many conditions. If the overgrazing has been for a short period a single season of rest may be sufficient. If a considerable portion of the original vegetation has been destroyed two or three seasons may be necessary. In the latter case the resulting vegetation will probably be different from the original and may be less valuable. Thoughtful ranchmen are learning to conserve their ranges by regulation and rotation and by limiting the stock to the carrying capacity of the range. (See Bur. Pl. Ind. Bulletin No. 117 and Yearbook for 1906.)

Range grasses

23. The wild plants upon the range, unless they are positively distasteful because of bitter or acrid substances or are protected by spines, are all more or less grazed by stock, especially sheep. If there is an abundance of forage the animals select the more palatable and nutritious species. In overstocked areas the animals are forced more and more to eat unpalatable or even poisonous species.

On the prairies and plains of the western states, the grasses form the chief element of the forage. The most important single species probably is buffalo-grass (Par. 245). This is the dominant species on the Great Plains from the Dakotas to Texas and from the Rocky Mountains to the 100th meridian and beyond. This region is colloquially known as the "short-grass country," to distinguish it from the prairie regions to the east, where tall grasses prevail. On the plains of Texas and northern Mexico, the buffalo-grass is gradually replaced by a species of similar habit, the curly mesquite (Par. 212).

The grama-grasses in numerous species in the West and Southwest and on the table-land of Mexico form an important and nutritive constituent of the ranges. The most important of these is the blue grama, called in the Southwest merely grama, and on the plains grama-grass, extending from Manitoba to South America. Like buffalo-grass it is a "short grass" and is frequently confused with that species. The three grasses, buffalo-grass, curly mesquite and grama-grass, form a nutritious forage after they have been cured in the autumn by the dry climate of this region. Hence the range will support stock throughout the winter if the conditions are favorable. Fall or winter rains, or an early frost, decrease the value of the forage.

Other especially important western grasses are the various species of Agropyron, Andropogon and Muhlenbergia. Pine-grass is important in Oregon and Washington. The term "bunch-grass" is applied to diverse species in different regions. The name refers to any species that forms conspicuous tufts. In western Kansas it refers to *Sporobolus airoides;* in Oregon to *Agropyron spicatum;* in other localities to various other species. (See Yearbook for 1900.)

CHAPTER IV

CULTIVATED PASTURES

Experience has shown that, conditions being equal, a greater amount of forage can be grown from a given area if the plants used are cultivated. In the broad sense, the term cultivation is here used to include the sowing of seed or the setting out of plants. But cultivation in the usual sense means also that the soil has been prepared for the reception of the seeds or plants and may include still further the subsequent use of tillage implements. Cultivated pastures, besides producing a greater amount of forage, have the further advantage of the choice of plants to be grown. Forage plants are cultivated for several purposes, as previously indicated, but in the present chapter only their cultivation for pasture is discussed. Cultivated pastures are usually known as tame pastures, to distinguish them from wild or native pastures. In regions where native pastures are rare, the term pasture may imply that the area has been seeded. Tame pastures are conveniently divided into two kinds, permanent and temporary.

PERMANENT PASTURES

24. As permanent pastures are here included all pastures that are seeded down with the intention of using them for grazing for more than one season. The plants used for permanent pasture are primarily grasses. Legumes and other plants may be mixed with the grasses or may be used temporarily or incidentally for grazing but (except sometimes alfalfa) are never used alone for permanent pasture.

25. The two most important pasture-grasses are blue-grass and Bermuda-grass. Other pasture-grasses of some importance are redtop, brome-grass, orchard-grass, meadow fescue. Still others are occasionally sown in mixtures but in the aggregate are almost negligible from the commercial standpoint. Some of these are the various fescue grasses, such as sheep's fescue and red fescue, rye-grass, velvet-grass, and a few others. The most important legume used in permanent pasture mixtures is white clover.

Blue-grass

26. Blue-grass is the standard pasture-grass in the region lying east of the Great Plains and north of Arkansas and North Carolina and extending southward in the mountains. It is used occasionally in other parts of the country, but it does not succeed in the southern states. It thrives best on limestone soils and is not adapted to acid soils. The famous "blue-grass region" of Kentucky lies in the limestone country in the central and northern part of the state. The species is commonly called Kentucky blue-grass and in some localities, especially northward, it is called June-grass.

Blue-grass is an aggressive species and, in soil adapted to its growth, tends to spread. It thrives in partial shade, and, in regions where the summers are hot and dry, it invades the open woods, where it furnishes valuable pasture. An excellent way to utilize brush-land or open timber-land is to clear out the underbrush and weeds and sow the land to blue-grass. At first it is necessary to keep down the brush and weeds, but later the blue-grass dominates the undergrowth. In the alfalfa regions of the West, blue-grass is often looked upon as a weed, because of its tendency to invade alfalfa fields.

The chief objections to blue-grass are the tendency to lie dormant during the hot dry midsummer, the difficulty in establishing a stand, and the low forage yield. In spite of these objections, it leads all other pasture-grasses in the region where it thrives.

27. Establishing a blue-grass pasture.—Blue-grass is rather difficult to start, as the growth is slow the first year. About sixty pounds of seed an acre are sown. It is important to have good seed. Many of the failures to establish a good stand are due to sowing seed of low vitality. If the seed is good, thirty pounds to the acre should be sufficient. The seed is sown on prepared land, or with other crops such as clover, wheat or timothy, or with meadow grasses or in early spring upon the snow or upon frozen ground. The object of sowing with other crops is to utilize the land while the blue-grass is becoming established. In regions adapted to its growth, blue-grass will form a permanent pasture, since few plants can drive it out unless it is overgrazed.

Bermuda-grass

28. Bermuda is the standard pasture-grass for the South, occupying there the position of relative importance among grasses that blue-grass does in the North. Its distribution is from the blue-grass area to the Gulf of Mexico and west to east Texas. Bermuda-grass is common in the warmer parts of both hemispheres and in the United States extends into the arid regions of the West. In the latter regions it is of little importance from a commercial standpoint, since the climate is too dry for its development without irrigation. Under irrigation, other forage crops give better results. Although Bermuda-grass is found under a variety of conditions, it is not a shade-loving plant and thrives best in open ground. On the uplands of the South it leads all other pasture grasses but in the moist lowland along streams and along the coast it has a few competitors, especially carpet-grass (Par. 215) and St. Augustine-grass (Par. 223). It withstands heat and drought, is aggressive, forming a permanent pasture, and is nutritious. Sometimes legumes (especially bur clover (*Medicago arabica*) and Japan clover (*Lespedeza striata*) are combined with Bermuda.

29. Establishing a Bermuda pasture.—There are two methods of starting Bermuda: by sowing the seed and by planting cuttings. The seed is sown at the rate of six to eight pounds to the acre and pressed in with a roller. The more usual method is to plant cuttings of the stem or pieces of the sod. These are dropped at intervals in shallow furrows and covered with a plow or dropped upon a prepared surface and pressed in with the foot.

Bermuda-grass is very aggressive, for which reason it becomes a bad weed when it invades cultivated fields. In cultivated soil it produces hard, vigorous rootstocks that give it the name of wire-grass. It can be eradicated by plowing in the hot weather of midsummer, or by smothering out by means of rank-growing shade crops, such as cowpeas. Bermuda-grass does not usually produce seed in the United States except in Florida, Arizona and California; hence it invades fields slowly and with care can be kept out without much difficulty. The commercial seed is imported.

Other pasture-grasses

30. Besides the two important and well-known pasture-grasses mentioned for the North and the South, there are several others that are used to a considerable extent. Each has its special merits and its peculiar drawbacks. The acreage of some of these grasses is large but in all cases falls far below that of blue-grass and Bermuda-grass.

31. Brome-grass.—This is variously known as awnless brome, Hungarian-brome, and *Bromus inermis*, the last being its botanical name. It is one of the few grasses that has been successfully introduced into cultivation in recent times. The United States Department of Agriculture and the state experiment stations have demonstrated its adaptability to the conditions prevailing in the northwestern states. It has been shown to be an excellent pasture-grass for the region from Kansas to Manitoba and west to Washington, which is too dry for the eastern grasses. It gives good results east of this region, but must there compete with timothy, clover and blue-grass. Brome-grass is a native of Europe. (See Bur. Pl. Ind. Bulletin No. 111.)

32. Redtop.—This is a well-known widely distributed meadow-grass which will be further discussed under meadow-grasses. (Par. 48.) Its chief importance as a pasture-grass is due to the fact that it thrives on acid soil where blue-grass fails. It is a good pasture-grass for moist localities in the timothy region and especially in the coastal region from Virginia to New England. Redtop is called "herd's-grass" in Pennsylvania and in some other localities.

33. Orchard-grass.—This is an excellent species for the blue-grass region, especially when combined with other grasses. Its chief faults are that it grows in tussocks and that the seed is expensive. The former drawback militates chiefly against its use as a meadow-grass as the hummocks interfere with mowing. It withstands drought somewhat better than does timothy or blue-grass, hence is useful along the western edge of the timothy region. In eastern Kansas, it is used as a pasture-grass in combination with meadow fescues. (See Bur. Pl. Ind. Bulletin No. 100.)

34. Meadow fescue.—This is a common European forage-grass which has many excellent qualities but has not been extensively grown in the United States. It does not compete with timothy and blue-grass chiefly because the seed is more expensive and less reliable, faults it shares with several other good grasses. It is adapted to the same region as timothy and blue-grass. A taller form or agricultural variety with more open panicle is grown under the name of tall fescue. The seed of meadow fescue produced in the United States is nearly all grown in eastern Kansas. Meadow fescue is sometimes incorrectly called English blue-grass. (See Farmers' Bulletin No. 361.)

35. Rye-grasses.—Of these there are two kinds, the English rye-grass and Italian rye-grass. These are both standard forage-grasses of Europe but are infrequent in cultivation in this country. They are excellent grasses and deserve a wider use. The poor quality and high cost of the seed, together with the traditional importance attached to timothy and blue-grass, probably account for their restricted use.

Canada blue-grass.—This grass will not compete with Kentucky blue-grass on limestone soils, but in portions of the humid region where the latter does not thrive it serves a useful purpose. Nearly all the American seed is grown in the province of Ontario, Canada. (See Farmers' Bulletin No. 402.)

Tall meadow oat-grass.—This is a good grass with poor seed habits, the seed shattering out badly in harvesting and handling. The species is adapted to the timothy region but is only sparingly grown.

Velvet-grass.—This species is of little value except on sterile soil where other grasses will not grow. It is well established on the Pacific coast, especially from northern California to British Columbia, where it is common in swamps, grass-land, waste places and open ground generally. It is not much utilized for forage except on the sandy land around the Columbia River. Animals do not relish the hay unless they have acquired a taste for it.

36. Southern pasture-grasses.—In the moist regions along the Gulf coast, carpet-grass is a valuable and nutritious grass. This is a native of the tropics extending into the southern United States. It thrives in open, moist land where it forms a green carpet. It is not cultivated, but comes into natural pastures voluntarily and persists because it withstands grazing and trampling. Another species found especially in mucky soil along the Atlantic coast from South Carolina to southern Florida is St. Augustine-grass. This is similar in its habits to carpet-grass. (See Farmers' Bulletin No. 509.)

37. Two common tropical grasses, Pará-grass and Guinea-grass, should be mentioned although except in the extreme southern portion they are not hardy in the United States. Pará-grass, a native of Brazil and cultivated in the lowlands throughout tropical America, is occasionally used for pasture in southern Florida and southern Texas. It is useful in wet or almost swampy land, where it will furnish a large quantity of forage. Pará-grass does not well withstand grazing because its extensive stolons, being above ground, are killed or injured by trampling. Guinea-grass grows on drier land than that best suited to Pará-grass. It is extensively used for pasture, hay and green fodder at low altitudes in the tropics. It withstands grazing well and its numerous basal shoots furnish a large amount of palatable forage.

TEMPORARY PASTURE

38. Temporary pasture, as here understood, refers to pasture obtained incidentally from plants grown for other purposes, or to that obtained from annual plants. The usual kind of temporary pasture is that from plants grown primarily for hay. It is a common practice to graze meadows after the hay has been cut. Care must be taken that the meadow is not grazed too closely and the plants are not injured by the trampling of animals in wet weather. Alfalfa is commonly grazed in the West, where this may be the chief forage crop grown. There is objection to allowing cattle and sheep to graze on alfalfa and clover since these legumes are likely to cause bloating. Fall-sown grain is often used for pasture, and standing corn-stalks furnish considerable fodder after the corn has been removed by husking in the field.

Annual plants for pasture

39. Grains, especially rye, are sometimes grown primarily for pasture, being sown usually in the summer or fall. Sorghum in some of its varieties is grown for pasture in the South and Middle West. Rescue-grass is used in some parts of the South for winter pasture. Rye-grass can also be used to advantage for winter pasture in the South as it grows rapidly and produces feed sooner than perennial pasture-grasses. Rape and sometimes other cruciferous plants such as turnips and kale are sown for pastures. Various legumes may be used for this purpose, often in connection with their use as green manure or as a cover-crop.

CHAPTER V

MEADOW PLANTS

MEADOW PLANTS are those used for hay. A meadow is an area upon which are growing plants that are to be cut for hay. Meadows may be conveniently divided into two classes, wild or native meadows, and tame or cultivated meadows.

The hay product of the United States is one of the most valuable of the agricultural crops, the total yield of hay and forage according to the thirteenth census being 97,453,735 tons, valued at $824,004,877.

NATIVE MEADOWS

40. There are three kinds of native meadows, according to the grass that grows upon them. These are prairie, fresh marsh, and salt marsh. In all cases the chief portion of the forage is made up of various species of grasses, the other plants being incidental or even harmful. Prairie hay is cut from native prairie that is sufficiently dry to be used for field crops. Because available for cultivation, the area of prairie meadow is decreasing as the land is gradually broken by the plow. Open grass-land, such as swales, or the low areas along streams or ponds that are intermediate between arable land and swamps, is often reserved permanently for meadow.

In the prairie region and in the eastern portion of the Great Plains, the chief constituents of prairie hay are bluestem (*Andropogon furcatus*), little bluestem (*Andropogon scoparius*), switch-grass (*Panicum virgatum*), Indian reed (*Sorghastrum nutans*), purple-top (*Tridens flavus*), tall grama (*Bouteloua curtipendula*), and wild rye (*Elymus virginicus*, and *E. canadensis*). In the swales or "sloughs," as they are called in that region, the chief grass is cord-grass or slough-grass (*Spartina Michauxiana*). An important hay-grass in depressions or valleys on the plains is Colorado bluestem (*Agropyron Smithii*). Throughout the mountain regions of the West the native hay may consist of a great variety of indigenous grasses, the species of Poa, Calamagrostis, Agropyron, and *Elymus glaucus* usually predominating.

On the western ranches where irrigation water is available, it is customary to flood the meadow land in the valleys. If too much water is applied, or if it is allowed to stand on the meadow for too long a time, the valuable grasses are gradually replaced by less nutritious plants, especially by wire-grass, which is a kind of rush (*Juncus balticus* Willd.).

41. The commercial production of wild hay is chiefly in the area from Oklahoma to Manitoba, including the eastern portion of the Great Plains and extending eastward through Minnesota into Wisconsin. In the northern portion of this area, a large proportion of the wild hay is cut from marsh land, the most important constituents being bluejoint (*Calamagrostis canadensis*) and reed canary-grass (*Phalaris arundinacea*). Much of this hay land is too wet for cultivation. At the time of harvest the soil is sufficiently dry to support the mower and horses. In the marshes of Wisconsin and Minnesota the soil is so moist that broad shoes are sometimes attached to the horses' feet to prevent them from sinking into the soft ground.

42. Salt marsh-grass is utilized for hay in many localities along the seacoast. Large areas of marsh land subject to the diurnal tides or to occasional high tides are useful for no other purpose than the grass crop that they produce. When utilized for hay these marshes are drained by open ditches. In some cases the sea is kept out by dikes, in which case the land becomes productive and valuable. The hay from salt marshes is of considerable value for fodder, the value depending on the kind of grass and the degree of salinity of the soil. Much of this hay is used for litter for stock and for packing-material. The chief constitutents of salt marsh-hay are switch-grass (*Panicum virgatum*), little bluestem (*Andropogon scoparius*), black-grass, a kind of rush (*Juncus Gerardii* Loisel.), all of value for forage, and several species of Spartina, or cord-grass (*Spartina glabra* and *S. juncea* being the most important), these latter being used chiefly for packing.

TAME MEADOWS

43. Tame meadows may be divided into two classes, permanent and temporary. It is only to the former class that the term meadow is popularly applied.

Permanent meadows

44. Permanent meadows are those that have been seeded down with forage plants with the intention of maintaining them for a series of years to produce hay. The chief meadow plants used in the United States are: of the legumes, alfalfa, red clover and to a limited extent alsike clover; among the grasses, timothy and redtop.

45. Alfalfa (*Medicago sativa* L.) is the most important forage crop in the United States. In the irrigated regions of the West it is almost the only forage plant grown and is there used for both hay and pasture. Alfalfa was introduced from Europe by the Spaniards and attained importance in our western states simultaneously with irrigation. Its use spread eastward in the arid and semi-arid regions until it reached the borders of the timothy region. Within recent years this crop has been successfully introduced in many parts of the East and South. It does not thrive on an acid soil, hence the necessity of using lime in many parts of the East in preparing the land for alfalfa. Where a good stand is obtained, a permanent meadow is formed, yielding cuttings every four to six weeks during the growing season, two or three cuttings in the more northern regions, as many as ten in the hot southern valleys of California. The meadow lasts indefinitely, but sooner or later suffers from the incursions of various weeds and must be broken up and reseeded. As alfalfa is not a grass, it will not be further discussed here, but the student is referred for detailed information to Farmers' Bulletin No. 339 from the United States Department of Agriculture.

46. The clovers are legumes belonging to the genus Trifolium. Certain allied plants are also known as clover but with a modifying term, such as bur clover (*Medicago arabica* Huds.), sweet clover (*Melilotus alba* Desv.), Japan clover (*Lespedeza striata* (Thunb.) Hook. & Arn.), all belonging to the family Leguminosæ. The true clovers include the common red clover (*Trifolium pratense* L.), which is usually referred to merely as clover, alsike (*T. hybridum* L.), white clover (*T. repens* L.), and crimson clover (*T. incarnatum* L.). The first two are used for meadow, the third for pastures and lawns, the fourth as a cover, soiling and green manure crop as well as for hay.

The most important of the clovers and one of our most important forage plants is red clover. This thrives in the humid region (Par. 110) and is often sown with timothy. Its chief use is for hay but it is also used as a cover-crop and for green manure. In common with alfalfa and other legumes, or even with rape, there is danger of causing bloating in cattle and sheep pastured upon clover.

Alsike is better adapted than is red clover to wet soil and hence is utilized in meadows too wet for the latter and is usually sown with redtop. Alsike is of some importance as a forage plant but the amount used in comparison with red clover is insignificant. (See Farmers' Bulletins No. 455 on red clover, No. 550 on crimson clover, No. 485 on sweet clover, No. 441 on Japan clover.)

47. Timothy is the great meadow-grass of the northeastern states which produces the standard hay of the market. Timothy is not so nutritious as some other grasses, yet it is the leading meadow-grass because it combines as does no other grass the requisite qualities. It is palatable, fairly nutritious, easily grown, and the the seed is cheap and of good quality. The cheapness of the seed is much influenced by the good seed habits of the plant. It produces seed abundantly and the heads grow to about the same height, ripen about the same time, and do not wastefully shatter the seed.

Timothy is grown alone or with clover, and in either case may be sown with the addition of a nurse-crop of grain. It may be sown with wheat in the fall, the clover being added in the spring, or with clover in the fall, no nurse-crop being used. The addition of the nurse-crop is an attempt to gain time while the timothy and clover are getting started. The term nurse-crop is applied to any quick-growing crop that supposedly protects another crop while it is young. Wheat sown in the fall produces a crop the following summer, and the timothy and clover have a better start than if sown after the wheat is cut. However, in most cases if the timothy and clover are sown together in the fall on well-prepared land, no time is lost, for a full hay crop will be produced the following year.

If well seeded down timothy will produce crops for several years, but experience has shown that the best results are obtained by making the meadow a part of a rotation. On good, arable land, with suitable application of fertilizer, a timothy and clover meadow will yield heavy crops the first and second crop-year. After this the amount of the crop decreases. Hence it is more profitable to plow up and plant to another crop such as corn, sometimes with an intervening year devoted to pasture.

48. Redtop.—On lands where timothy is at its best, there is no competing meadow-grass; but, on soil too moist for the best results with timothy, which is often also acid soil, redtop is the most satisfactory meadow-grass. The region where redtop is most extensively grown is the Atlantic slope from New England to Maryland, although it is also grown to a limited extent throughout the timothy region. It can also be grown to advantage somewhat farther south than can timothy.

49. Johnson-grass is an excellent meadow-grass for the states from Georgia to Texas. It yields large crops of nutritious and palatable hay and can be grown easily and cheaply. On the other hand it is a very aggressive species, propagating readily by seed and by strong underground creeping stems or rootstocks. When once in possession of a field it is difficult to eradicate. For this reason, in spite of its good qualities, it is looked upon as a pernicious weed. It is not wise to introduce this species on land that is free from it. A meadow should be a part of a rotation, and Johnson-grass does not readily give up its place to the following crop. When a permanent meadow is desired, this grass, if its weedy habit be not taken into consideration, is probably the best for the purpose in those parts of the South, such as the black soil of central Texas, where it reaches its highest development. It is less satisfactory as a pasture-grass since, not well withstanding grazing, the yield decreases after two or three years. If a farm is already infested with Johnson-grass it is well to take advantage of its useful qualities as a meadow-grass. As this species tends to become sod-bound in a few years owing to the rapid multiplication of rootstocks, the field should be plowed every two or three years.

50. Eradication of Johnson-grass.—Johnson-grass can be eradicated, but the process requires more care than in the case of most weeds. Plowing in the fall with a turning plow, harrowing out and removing the rootstocks, sowing the field to early-maturing grain, oats or rye, cut for hay in the spring, and following with a cultivated crop, will keep the grass in subjection. In the region where Johnson-grass reaches its greatest development, alfalfa also thrives. Hence an excellent method to utilize an infested field is to sow alfalfa. This is done in the fall after the field has been plowed and harrowed to remove the rootstocks. The alfalfa soon smothers out most of the Johnson-grass, and the hay is not injured by the presence of such of the latter as may remain. Johnson-grass shares with sorghum the tendency to poison stock through the production, under certain conditions, of hydrocyanic acid. (See Farmers' Bulletin No. 279.)

51. Other meadow-grasses.—Various grasses other than the three mentioned are recommended for meadow mixtures but none is used to any considerable extent. Orchard-grass is a desirable grass, yielding a good crop of nutritious hay. The chief objection to it is that it grows in heavy tussocks that make an uneven bed for a mowing machine. Furthermore the seed is rather expensive. The cost of the seed also militates against meadow fescue, another good meadow-grass. The prestige of timothy is probably one of the reasons why some of the less known grasses are not used to a greater extent. Tall meadow oat-grass and the two rye-grasses, English and Italian, are often recommended for mixtures. Velvet-grass is of little value except on sandy land where better grasses will not thrive. Other grasses mentioned in seed catalogues and occasionally used in mixtures are rough-stalked meadow-grass, fowl meadow-grass, crested dog's-tail, sweet vernal-grass, and meadow foxtail.

It should be added that the two important pasture-grasses, blue-grass and Bermuda, are sometimes used for hay in the regions where they reach their maximum development. Guinea-grass is occasionally used for hay in the tropics, for which purpose, because of its numerous leafy basal shoots, it is well adapted; but farm practice in the warm regions usually calls for a soiling crop rather than a hay crop.

52. Slender wheat-grass.—The only native meadow-grass whose seed has become a commercial product is slender wheat-grass (*Agropyron tenerum*). It is a native bunch-grass of the western states and is adapted to the semi-arid region of the Northwest, where it should form a permanent meadow or pasture. It has not been sufficiently tested as yet to determine its comparative value.

Temporary meadows

53. Under temporary meadows are included annual crops sown or planted for hay, although fields of such crops are not often popularly designated as meadows. The plants most used for this purpose are: the grains, foxtail millet, sorghum, corn and certain legumes, such as cowpea and field pea. Several other plants are used locally or sporadically.

54. Grain hay.—Probably the most important group of annual plants used for the production of annual meadows is that of the grains. From the commercial standpoint grain hay is of importance only in the western states and particularly on the Pacific coast. In this portion of the United States, except in the mountain meadows, there is little native vegetation suitable for hay. Under irrigation, alfalfa is the standard forage crop; but, over a large area where the rainfall, though small, comes chiefly during the winter, it is possible to grow crops of grain without irrigation. The grains used for hay in the Pacific coast states are mostly wheat and oats. In some localities barley, especially beardless barley, is used. Another important constituent of the grain hay is wild oats (*Avena fatua, A. fatua glabrata,* and *A. barbata*). This is widely distributed, and an abundant volunteer crop may appear in a field after a grain crop is harvested. In Washington and Oregon chess or cheat is sometimes cultivated for hay.

55. The relative importance of grain hay may be estimated from the data for California taken from the report of the thirteenth census and given in the following table. Important as is the alfalfa crop, its value is exceeded by that of grain hay.

TABLE XVI

ACREAGE, PRODUCTION AND VALUE OF GRAIN HAY IN CALIFORNIA COMPARED WITH THE TOTAL HAY AND FORAGE AND WITH ALFALFA

Crop	Acres	Amount (tons)	Value
Hay and forage	2,533,347	4,327,130	$42,187,215
Alfalfa	484,134	1,639,707	13,088,530
Grain hay	1,604,745	2,019,526	24,056,727

In the eastern states, grain hay, especially oats, is used on the farm in the sheaf, but nowhere does it reach any considerable commercial importance. Straw, as a by-product of grain-growing, is of some importance. Its use as forage is of secondary rank and is mostly confined to the farm, the mature straw having little nutritive value. When it enters commercial channels it is mostly for bedding and packing, though specially prepared straw may have other uses such as the making of hats.

MILLETS

56. By millet is meant foxtail millet as distinguished from several other grasses called millet, but with a modifying term, such as proso millet (Par. 217), pearl millet (Par. 221), Japanese barnyard millet (Par. 218) and African millet (Par. 210). Millet as grown in the United States is found in two forms, common millet and Hungarian-grass (Par. 220). A form of common millet was much advertised a few years ago as Golden Wonder millet. The variety known as German millet is also a form of the common millet, differing chiefly in its longer season of growth. Millet is grown in the eastern half of the United States, especially in the region from Oklahoma to Iowa. It produces an abundance of nutritive and palatable hay relished by all kinds of stock and in general is a valuable forage plant. Horses sometimes appear to suffer injury if fed millet exclusively but cattle and sheep are free from this danger. If cut too late the bristles of the seed-heads may become troublesome. It can be sown after a grain crop or in place of other crops when there has been a failure to secure a stand. The tenderness of the growing plants render early sowing impracticable. (See Farmers' Bulletin No. 101.)

57. Sorghum is grown in many parts of the world and, according to the variety, for many different purposes. The seed is used for food for man in parts of the Old World, and in the United States that of certain forms, such as kafir, is used for stock feed. One variety is called broom-corn (Par. 211). The saccharine sorghums or sorgo contain much sugar in the sap and are used for the commercial production of sugar (Par. 97). The saccharine varieties such as the Orange and Amber, and also some of the non-saccharine such as kafir and milo, are grown for forage. Those which are grown for the seed may furnish forage also, the stalks being cut and shocked as in corn, the grain being thrashed out or the heads cut off and the remainder used as rough forage. In the semi-arid region where drought-resistant hay crops are needed, sorghum is much used as a hay crop. For this purpose it is sown or drilled thickly, so as to produce numerous slender stems, and the crop mowed and cured as hay. In some parts of the Middle West, sorghum is known as "cane." (See Farmers' Bulletins Nos. 246, 288, 322, 448, 552.)

58. Corn or maize is sometimes sown thickly and used for hay as is described above for sorghum. The most common use of corn as forage is in connection with its use as a grain crop. The corn may then be treated in two general ways. It may be allowed to mature in the field, the grain being taken away, allowing the standing stalks to remain. This is known as husking the corn from the row or from the field. The stalks are then pastured during the winter, the animals feeding upon the dead leaves and upon any ears that may have been overlooked by the husker. Mature cornstalks, however, have little nutritive value. The other way is to cut the cornstalks and shock them in the field, before the ears are mature and while the leaves are yet green. The shocks remain until the forage is cured and the ears have matured. The ears may be husked in the field and the forage stored in stacks or sheds or the shocks may be hauled to the barns where the husking is done either by hand or by machinery. The forage or corn-fodder produced in this way is much more nutritious than that which is matured before husking, and the grain suffers little loss by the process. Corn and kafir are sometimes cut and bound in bundles by machinery, a process which lessens the labor of shocking.

59. Other grasses producing hay or coarse fodder.—Several other grasses are used locally for the production of coarse hay. Some of these have undoubted merit but usually must compete with the more important species mentioned previously. Others are native or weedy species that are utilized locally. A more complete account of some of these grasses is given in Part II.

60. Japanese barnyard millet.—Several varieties are grown in Asia and have been tried in America, but with little success. One variety has been advertised under the name of billion-dollar grass. They require plenty of water to produce crops, and in the humid regions will not compete with other grasses. They have some value under irrigation in the Southwest.

61. Proso millet.—This is the common millet of Europe, where it is grown extensively for forage and for the seed, the latter being used for food for animals and also among the poorer classes for man. In this country it has been tried repeatedly, but the results have not been very satisfactory. It does not compete with other plants for forage, but produces under favorable conditions an abundance of seed. This may prove valuable for poultry. The seed can be used also for stock, but shatters rather readily. Proso millet is also called broom-corn millet because of the resemblance of the inflorescence to that of broom-corn. Another name is hog millet.

62. Pearl millet and teosinte are sometimes used for hay, but usually for soiling (Par. 75).

Texas millet is a native weedy species found in the valley of the Colorado River and neighboring valleys in southeast Texas. The volunteer crop on rich land is cut for hay, this being of good quality. Texas millet is also known as Colorado-grass.

Crab-grass may be mentioned here, as it is frequently cut for hay in the South, where it appears in fields as a weed. The hay is of good quality, but is mostly used on the farm and does not often appear on the market.

Chess or *cheat* (*Bromus secalinus*) is grown for hay locally in Oregon, especially in the Willamette Valley. This in other regions is a weed in grain fields but there has been utilized successfully.

63. Several annual legumes are used for the production of hay or coarse forage. They are usually used as a cover-crop or as green manure in connection with other farm processes. They are used extensively, especially in the South, as a part of a rotation in order to maintain the fertility of the soil. As stated previously (Par. 15), the legumes have the power to add nitrogen to the soil by means of the root nodules and the nitrogen-fixing organisms contained therein. The choice of the legume for this purpose depends largely upon the secondary uses that can be made of the crop. It may be made into hay or may be cut green and used for soiling or for silage (Par. 76). In the timothy region, clover is a staple crop (Par. 46). In the South, where no perennial legume is adapted to the conditions prevailing over most of the region, annual legumes are used. It is true that alfalfa is grown with success in many parts of the South, such as the alluvial valleys of the Mississippi and Red Rivers, and the black soil of central Alabama, but even here an annual crop may be desired for the other purposes mentioned above. The commonest of the annual legumes in the South are the cowpea and velvet bean. In the North, the field pea is much used, and in middle regions vetch and crimson clover.

64. The cowpea (*Vigna sinensis* (Torner) Savi.) is a trailing vine with trifoliate leaves and slender, bean-like pods. Some varieties are bushy and trail only slightly. The cowpea is the standard legume for the South. Its use has extended gradually northward until some varieties are now grown as far as Michigan. It is a warm-weather species and cannot be sown until the season is well advanced. In the South this limitation presents little difficulty, but in the North only quick-growing and more hardy varieties can be used. The hay from cowpea is excellent in quality, but, like all succulent forage, requires special care in harvesting and curing. It should be remembered that the feeding value of a legume like the cowpea is much greater than its fertilizing value. Hence the dual use of the crop, the greater part of the vines and leaves being used for hay or green feed, the remainder being turned under for green manure. When grown on sterile soil it may be necessary to turn under a larger proportion in order to produce humus. (See Farmers' Bulletin No. 318.)

65. Velvet bean (*Stizolobium Deeringianum* Bort).—This coarse rank-growing vine is similar to the cowpea but gives a much greater growth. The velvet bean is not so hardy as the cowpea and is used only in the South. It has given excellent results in Florida. (See Farmers' Bulletin No. 509, and Bur. Pl. Ind. Bulletin No. 179).

66. The vetches are upright or reclining plants with tendrils at the ends of the compound leaves. In a general way they resemble the garden pea, but the leaflets and flowers are smaller. There are two common kinds of vetch in use in the United States—spring vetch (*Vicia sativa* L.) and hairy vetch (*V. villosa* Roth). The one most grown is the latter, since it better withstands drought. The vetches are usually sown with grain, the latter supporting the vetch, thus producing a combination that can be harvested with greater ease than can the vetch alone. Vetch may be used as a winter crop in the South or as a summer crop in the North. (See Farmers' Bulletins Nos. 515, 529.)

67. Crimson clover (*Trifolium incarnatum* L.).—This is a tall clover with long heads of crimson flowers. It is rather extensively used in the region from New Jersey to North Carolina. It should be cut when in flower. If cut later the fuzzy hairs around the head prove troublesome, especially to horses. (See Farmers' Bulletin No. 579.)

Field pea (*Pisum arvense* L.). The field pea, resembling the garden pea in habit, is much used in Canada and our more northern states. The field pea requires a cool, moist climate, hence is not adapted to the regions farther south. It is usually sown with grain for the reasons mentioned under vetches. (See Farmers' Bulletin No. 224.)

The soybean (*Soja Soja* (L.) Karst., *Glycine hispida* Maxim.) is an upright plant that tends to become bushy. In southeastern Asia, where the species is native, it is extensively cultivated, the seed being used for human food. In the United States the soybean is grown for both seed and forage. The seed, rich in protein, is used for feeding stock, usually in the form of soybean meal. As a forage plant, it can be utilized for hay or for pasture. The soybean is adapted to the cotton-belt and northward into the southern part of the corn-belt. Being much more drought-resistant than the cowpea it can be grown in the southern part of the Great Plains. (See Farmers' Bulletin No. 372.)

Sweet clover (*Melilotus alba*) is a vigorous grower and makes excellent hay, the chief objection being that stock do not readily eat it until they have acquired a taste for it. The plant is a biennial, producing the flowers the second season. The hay should be cut before seed is formed. Sweet clover is also known as Bokhara clover. (See Farmers' Bulletin No. 485.)

Florida beggar-weed (*Meibomia tortuosa* (Swartz) Kuntze). This has been used with success in Florida and the Gulf states. It is a tall plant with trifoliate leaves and flat, constricted pods that break up into one-seeded joints that adhere to wool or clothing by means of a covering of hook-like hairs. (See Farmers' Bulletin No. 509.)

CHAPTER VI

HAY AND GREEN FEED

THE product of meadows may be fed immediately or it may be preserved. If it is fed immediately, the process is known as soiling, and crops grown for this purpose are called soiling crops. To preserve forage it must be protected from decomposition or rotting. This may be accomplished by removing a sufficient proportion of water by drying, in which case the product is called hay. Or the forage may be preserved green, the destructive decomposition being prevented by the exclusion of the air. The preserved product is then called silage.

HAY

68. In the wide sense, hay is dried vegetation used as food for animals. In this sense ripened buffalo-grass and standing cornstalks, grazed during winter, are hay. In the restricted sense, the word hay is applied to the cut and dried or cured product of meadows, more particularly the product of the smaller grasses and clovers. The coarse hay of cornstalks and other large grasses is more often called fodder. Ordinarily meadow hay is made by cutting with a mower and allowing the cut material to lie in the sun until partly dried, after which it is raked into windrows, then placed in bunches or cocks and finally in stacks or under a roof. The process is varied to suit conditions. The object is to remove sufficient moisture to prevent molding when stored. In dry, sunny weather little difficulty is experienced in producing good hay; but, in humid climates, hay-making is a process requiring much care. Rain and dew delay the drying and reduce the quality of the hay, or they may render the product entirely worthless. It is readily seen that weather conditions become an important factor in hay-making. Putting hay in cocks and covering with some kind of impervious shield is an attempt to prevent the absorption of water.

69. In arid regions the hay may be cut and stacked the same day, but in humid regions the curing may extend over several days with the corresponding risk from rain. Succulent plants, such as clover, alfalfa and cowpea, demand especial care because the stems require a longer time than the leaves for curing. The foliage drops off readily and is lost when there is much delay in curing. As the leaves are the most important part, this loss becomes serious. The vines of cowpea and velvet bean are so succulent that special methods of curing are frequently adopted. It is a common practice in the South to cure the vines on upright racks or poles so as to allow a circulation of air. A single pole with the vines arranged around it, makes a tall, slender bunch or cock that gives much lateral surface in proportion to the area of the top.

70. Stacks.—Hay that is stacked in the open deteriorates on the exposed portion and there is a considerable percentage of loss from the weathering of the outer portion of the stack. Careful building of the stack and a covering of reeds or canvas reduces the loss. Hay stored in barns suffers practically no loss, and in sheds only in proportion to the exposed surface. On the large ranches of the West it is impracticable to store in barns the large quantity of hay produced, and the climatic conditions render this unnecessary.

71. Hay in the West.—When hay is made on a large scale such as prevails on many western ranches, the process involves the use of several appliances not often seen on the smaller farms of the East. The mower and horse-rake are common everywhere. To transport the bunches of grass hay to the stack a sweep or bull rake is often used. This is an implement with large teeth, that slides along the ground and under the bunches. For alfalfa it is better to load on wagons as the sweep tends to shatter the foliage. The sweep can not be used for long distances. At the stack the hay is transferred from the wagons or from the sweeps by large forks worked by horse-power. These forks are operated in connection with some form of pole derrick, or less frequently with a cable derrick. Nets or slings are often used to unload wagons. These are placed at intervals in the load, which can then be hoisted off in three or four parts with a derrick.

72. The standard hay on city markets in the East is timothy and all other kinds are estimated in comparison with timothy. The demand here is for hay suitable for horses, and custom has come to consider timothy as best satisfying this demand. Clover mixed with timothy may increase the feeding value but may also reduce the market value in these markets. The demand for timothy in preference to other hay is largely due to the wishes of the livery stables, timothy being considered by horsemen to be the best hay for livery horses.

In localities in which prairie hay enters the market, it is demanded in preference to alfalfa for livery horses.

73. Baled hay.—In recent years the baling of hay has become an important industry and baled hay has almost replaced bulk hay upon the market. Of course all hay that enters commercial channels is baled, bulk hay being confined to the local market. Even for use upon the farm or ranch the hay may be baled for convenience in hauling and storing. As baled hay occupies only 140 to 160 cubic feet to the ton there is a great saving of space over hay sold in bulk. The standard bale weighs 70 to 250 pounds; the small bale, much used in the South, 70 to 100 pounds; the medium bale, 100 to 150 pounds, and the large bale, requiring two men to handle, 150 to 250 pounds.

Any kind of hay, straw, or fodder may be baled, but the baled hay in commerce in the United States consists mostly of timothy, prairie hay, alfalfa, and grain hay, the latter largely confined to the Pacific coast. The classes of hay recognized in the East by the National Hay Association are timothy, clover-mixed (timothy and clover), clover, and prairie, with two to five grades each. For transportation to trans-oceanic points, especially Alaska and the Philippines, the hay may be double compressed. For this purpose hay obtained by loosening ordinary bales is compressed by powerful hydraulic or electric presses similar to those used for compressing the cylindrical bales of cotton. The resulting bale is very compact, the square form occupying 85 cubic feet to the ton, and the cylindrical bales only 55 cubic feet. (See Farmers' Bulletin No. 508.)

SOILING AND SILAGE CROPS

74. Soiling is the system of feeding to animals in inclosures green forage recently cut from the growing plants.

Silage is the system of preserving fresh green forage in suitable more or less air-tight receptacles.

Both these systems are attempts to furnish green feed without turning the animals out to pasture. These systems are most used and have reached their highest development in connection with dairying. The advantages are that the quantity and kind of material fed can be controlled, that there is less waste than in pasturing, that crops can be utilized which would be impracticable for pasture, and that stock are saved the work of traveling about in search of food. Silage still further has the advantage of continuing the supply of green feed through the winter.

75. Soiling.—The practice of soiling is well adapted to intensive farming. When the price of land is high it is usually more economical to raise large crops of forage on well-fertilized fields and feed green than to have pasture, since the latter can not produce so great a quantity of feed. On the other hand the labor required for soiling is much greater. The cost of labor compared with the price of the products as milk or beef, determines the system to use. By proper care in selecting crops, a continuous yield of green forage may be obtained through a large portion of the growing season.

Many crops are used for soiling, but in the main they are annuals and often succulent plants. They include the grains, the succulent grasses, such as corn, or sorghum, and the annual legumes mentioned before (Par. 63). Perennial grasses and clovers may also be used, but the advantage is less, as they do not give so large a yield as do annuals. Teosinte and pearl millet are used locally with success, the former giving, on the rich moist valley lands of Louisiana, enormous yields of forage.

76. Silage.—In this process the green forage is placed in an air-tight receptacle called a silo. This may consist of a pit or room in a barn, or more commonly a separate, usually cylindrical structure or building. In this is placed the forage usually as it comes from a cutting machine. The material is packed tight by tramping in order to exclude as much air as possible. If necessary, water is added to facilitate the packing. If properly prepared the silage or ensilage will keep for many months. The material is canned on a gigantic scale though it has not been sterilized. More or less fermentation takes place but not of a character to interfere with its feeding value, nor with its palatability for stock that has become accustomed to the the characteristic taste of silage. If the packing of the silo has been done carelessly the material rots and is worthless.

The silo is built tall and narrow in order to give greater pressure, thus packing the silage more closely. Furthermore, the smaller surface exposed at the top gives less opportunity for spoiling. The top layer exposed to the air rots and must be discarded, unless the feeding is commenced as soon as the silo is filled. The top layer may be of chaff or other material of little value. If there is a leak in the silo the silage will spoil at this point. The silo may be made of cement, brick or any other building material, but because of the lower cost is usually made of wood. It should be at least 24 feet high to give the necessary pressure and bulk.

The silage should be fed rapidly enough to prevent the exposed upper layer from having time to spoil. For this reason it is not expedient to feed less than ten cows. It is essential to pack the silage tightly as it is placed in the silo. This forces out most of the air. The fermentation uses up the small amount of air remaining and if there are no leaks the fermentation ceases.

Any kind of forage may be preserved in a silo, but the plant most used for the purpose is corn. For silage, the corn should be planted more thickly than when grown for grain. The crop should be made to yield the maximum amount of grain, rather than the largest ears. The corn should be cut when the grain is glazed, as at this stage there is the maximum amount of dry matter. In the North, varieties should be chosen that will reach the glazed stage before frost. (See Farmers' Bulletin No. 556.)

CHAPTER VII

LAWNS

A LAWN is an open area covered with grass and kept closely mown. The term is applied especially to tracts near dwellings, but may be applied to closely mown areas near other buildings or in parks. Other plants than grasses are occasionally used, wholly or in part, such as white clover. The lawn is primarily for ornament, complete in itself or part of a general place in landscape gardening.

77. Essentials for a lawn.—An ideal lawn consists of a firm even sod supporting a vigorous growth of vegetation of uniform texture and pleasing color, the whole kept closely mown. With rare exceptions the conditions can be supplied only by grasses. A grass to be suitable for lawns should propagate by rootstocks or stolons, should be fine and soft in texture, and should be dark green in color. The most popular lawn-grass is Kentucky bluegrass. The only other grasses that fulfil the requirements mentioned are Rhode Island bent and creeping bent, both varieties of redtop. Another important lawn-grass is Bermuda-grass. Several other grasses are used for special conditions (Par. 81).

78. Blue-grass is an ideal lawn-grass throughout the region to which it is adapted. It thrives best in a moist moderately cool climate and on limestone soils. Blue-grass forms a firm even sod which, under proper conditions and treatment, is permanent. The texture is fine and soft and the dark green color is agreeable to the eye. It can be grown successfully without irrigation in the northeastern states as far south as Virginia and Tennessee, and farther in the mountains, and west to Minnesota and eastern Kansas, also in the humid region of Oregon and Washington, and in the western mountains. Throughout most of the northern half of the United States beyond the limits mentioned it can be grown with the aid of irrigation. Even in the humid region it may be necessary to supply water during the dry periods in the summer.

In the southern half of the United States, except in the mountains, blue-grass does not thrive even when irrigated, although, except in the lower coastal plain, it may with special care make a fair growth. In the humid region it may fail because of the character of the soil. Thriving best on limestone soils, it fails to give good results on acid soils. Hence, blue-grass is not adapted to much of the coastal region from New England to Virginia. Often it is practicable to correct the soil acidity by the addition of lime.

79. Rhode Island bent is especially adapted to that portion of the humid region in which blue-grass fails because of soil acidity, as it thrives under moist, moderately acid conditions. Rhode Island bent does not produce vigorous creeping rootstocks as does blue-grass, but nevertheless will form a fairly firm and uniform sod. For a description of Rhode Island bent and its relation to redtop, see Par. 234. Creeping bent is another form of redtop, with creeping or stoloniferous stems, which produces a lawn of good color and texture.

80. Bermuda-grass answers all the requirements of an ideal lawn grass except that of color. To many people the light gray-green color is not so pleasing to the eye as the dark green of the blue-grass. In the southern portion of the United States where the climate is too hot in summer for blue-grass, Bermuda-grass is the common lawn-grass, except in certain localities along the coast. It is the only lawn-grass that will withstand the summer conditions on the uplands of the South. The foliage is not resistant to frost, hence lawns turn brown or yellow in winter, but the plants are not killed except by greater cold than usually prevails south of Virginia. St. Lucie-grass is a variety of Bermuda especially adapted to lawns, as it is fine in texture. This form is much used in Florida.

81. Less important lawn-grasses.—*St. Augustine-grass* is a coarse-leaved species used on moist, mucky soil of the lower coastal region. It is in use as far north as Wilmington, North Carolina. As the seed is not on the market it is propagated by cuttings.

Carpet-grass is another species, with comparatively coarse foliage and creeping or stoloniferous stems, adapted to the moist region of the Gulf coast. It occurs naturally there and tends to invade the open moist grassland of pastures and lawns. The seed is not on the market but the plant may be propagated by cuttings.

Canada blue-grass is sometimes used on sterile clay or lime-poor soils of the humid regions, where blue-grass does not thrive.

Fescue grasses are rarely used alone but are often sown in mixtures. Various-leaved fescue is used under trees on lawns as it thrives better than other grasses in partial shade. All the fescues used for lawn mixtures, red fescue, hard fescue, sheep's fescue, firm-leaved fescue and various-leaved fescue have short, firm leaves that require little cutting, but they are all bunch grasses and it is difficult to produce with them a uniform turf.

Buffalo-grass gives excellent results in the semi-arid region of the Great Plains. The seed is not on the market but the grass is easily grown from cuttings. It forms a firm sod like Bermuda-grass and has the same objection of being light green in color. Buffalo-grass requires no mowing as the foliage remains short and curly.

Rye-grass is sometimes used for lawns though it possesses few of the necessary characteristics. It is used chiefly in mixtures to produce quick results as it grows vigorously the first season. It is coarse and bunchy and not suited to a lawn when sown alone.

Korean lawn-grass is coming into use along the coast from South Carolina to Florida.

82. Lawn mixtures.—One of the characteristics of an ideal lawn is uniformity of texture. This can be obtained only when a lawn is made up of a single species. To produce a lawn of uniform texture requires special care. From the standpoint of practicability it may not always be convenient or even possible to fulfil the conditions necessary for an ideal lawn. Hence, the use of mixtures by which better results in some ways may be obtained than by using a single species. This applies particularly to the humid regions. The character or condition of the soil may be such as to prevent the production of a uniform stand of a single species. It is well known that a properly chosen mixture will in these cases produce a thicker turf and will do so in a shorter time than if a single species is grown.

The chief or even the only objection to a mixture is the lack of uniformity. A closely mown lawn will show variations in color corresponding to the different species of which it is composed. Rye-grass is sometimes included in a mixture to give quick returns, the other components developing later. Grain, especially rye, may be used for the same purpose. This practice is not to be recommended if a first-class lawn is desired. It is to be looked upon as a makeshift to take the place of careful preparation of the soil.

White clover is often used in mixtures, the only disadvantage being that it interferes with the uniformity of appearance. On the other hand, it has a distinct advantage in that it acts as a soil renovator and tends to maintain its fertility, this being due to the presence of nitrogen-fixing nodules on the roots (Par. 15).

83. Preparation of the soil.—It is necessary that the soil intended for a lawn should be placed in the best possible condition for receiving the seed. It should be rendered light and porous to the depth of 10 inches or more by suitable tilth, should be well drained, and should be of the best consistency, that is of the combination of sand, clay and humus known as rich loam. It is usually necessary in addition to thorough tillage to fertilize the soil. Well-rotted barnyard manure, free from weed seed, is the best fertilizer, but not always easy to obtain. Commercial fertilizer may be used alone or with barnyard manure, the amount depending on the nature of the soil. Poor soil may take 400 pounds an acre of bone-meal. Wood-ashes supply potash and render heavy soils lighter. Lime should be added when necessary to counteract acidity if blue-grass is to be used.

84. Seeding.—Only the highest grade seed should be used. There is great variation in the weight of blue-grass seed, depending on the proportion of chaff. Good seed should weigh about 22 pounds to the bushel. Of such seed three bushels should be sown to the acre. The seed should be sown evenly and rolled or lightly raked in. The seeds are small and should not be covered deeply. It is important to keep the lawn as free as possible from weeds while becoming established. After the grasses have formed a firm sod or turf, weeds have little chance to intrude. If the soil and the applied manure be free from weed seeds, the task of weeding during the first season will be much simplified.

85. Subsequent care.—The lawn should be frequently mowed, watered, weeded, and rolled if it is to be brought to its maximum effectiveness. If unfavorable circumstances have caused the death of the grass in spots or if in small areas the grass failed to grow, here the weeds appear later. Such spots should be reseeded. It is much easier to obtain a uniform stand at the first sowing than to patch up afterward an irregular stand. Some weedy grasses make a good appearance early in the season but later die out, leaving unsightly bare patches in the summer. This is true of crab-grass and annual blue-grass (*Poa annua*).

86. Watering.—Blue-grass lawns usually require for their best development more water than is supplied by the natural rainfall. This is especially true during the dry periods that usually occur during summer. Artificial watering by garden hose is the usual method of meeting the deficit. The water should be applied in the late afternoon or evening as damage may result from watering during the heat of the day. Water should not be applied in full force direct from the nozzle, as the soil may be washed away from the roots. A spray nozzle prevents this. Thorough soaking from time to time is better than more frequent light sprinkling. Light and frequent sprinkling encourages a shallow root-system, readily injured by drought.

87. Turfing.—On account of the care and trouble necessary to seed a lawn it is a common practice in cities to produce results quickly by laying on fresh turf cut from an old grass plot. If properly done this will give good results. The turf or sod should be pure grass free from weeds and should be laid on well-prepared, rich, loamy soil such as described under seeding. The custom of applying a layer of vegetation, part grass and part a miscellaneous collection of weeds, to a soil consisting of the refuse from the building operations will never give satisfactory results. Such a lawn is a permanent source of regret and no amount of faithful watering can materially improve it. It is better to dig it up and start again in the proper manner. (See Farmers' Bulletin No. 494.)

CHAPTER VIII

GRASSES FOR MISCELLANEOUS PURPOSES

Besides the three chief uses of grasses, there are others of considerable but comparatively minor importance. These uses will be considered under the following heads: Ornamental grasses, Soil-binders, Sugar-producing grasses, Textile grasses, and other uses.

ORNAMENTAL GRASSES

88. Grasses may be grown for ornament because of their handsome inflorescence, such as that of the plume-grasses, or the alleged beauty of the foliage, such as that of the ribbon-grass and other grasses with variegated leaves. Some are used for making dry bouquets, the delicate inflorescence holding its form after being detached.

There are three large species that are commonly used for lawn decoration. They are plume-grass, giant reed, and Eulalia. Plume-grass has long narrow leaves tapering to a fine point and a large white or pink feathery plume 1 to 2 feet long. The leaves are in a large cluster at the base and the plume is raised on a tall slender stalk several feet high (Par. 246). Another plume-grass less frequently seen in America is the Ravenna-grass (Par. 206). Giant reed has broad leaves scattered along the stem as in corn, and a large oblong plume (Par. 247). Eulalia has clusters of long narrow leaves at the base and a slender stalk rising a little above the leaves, bearing rather small (6 to 12 inches long) fan-shaped brownish plumes (Par. 204). Another grass of this habit, *Thysolæna agrostis,* is often grown in the tropics. A common ornamental garden grass is ribbon-grass or gardener's garters. Several small grasses are grown for bouquets, such as trembling or quaking grass.

89. The bamboos are important ornamentals in the tropical regions and are much cultivated in Florida and California. A few species are hardy farther north. Among these may be mentioned *Arundinaria japonica,* a shrubby form growing 5 to 10 feet high, and certain species of Phyllostachys. There are several species of Phyllostachys introduced in cultivation but their specific identity is in doubt as many have not been known to flower.

SOIL-BINDING GRASSES

90. In order to prevent banks and slopes from washing or sand-dunes from blowing, they may be planted with grass or other vegetation. Such plants are known as soil-binders. More particularly, those that hold sand-dunes in place are called sand-binders. Any kind of vegetation will hold soil or sand in place, but plants used by man for this purpose are provided with strong creeping rootstocks that quickly penetrate and bind the soil. Grasses most frequently used for the holding of banks and slopes are Bermuda-grass in the South and Kentucky blue-grass in the humid region. The giant reed is used along irrigation ditches in the Southwest. Japanese honeysuckle (*Lonicera japonica* Thunb.) is proving excellent for holding slopes in Maryland and Virginia.

91. Sand-dunes.—The fixing of shifting sand-dunes is an important industry in Europe where much waste land has been reclaimed. In the United States there are several areas of sand-dunes, the most important being on Cape Cod near Provincetown, Cape Henry, Virginia, along the south end and east side of Lake Michigan, and along the Columbia River, Oregon, in the semi-arid region. Sand-dunes are formed by the wind blowing the dry sand. Dunes that are bare of vegetation shift gradually as the prevailing wind blows the sand over the crest. When vegetation becomes established the wind is unable to move the sand and the dunes become fixed.

Moving dunes may do much damage when formed in the vicinity of the works of man by covering up buildings or railroad tracks, or, when formed near streams or harbors, by diverting the course of the one or filling the other, or when formed near a forest which they may overwhelm. Sand-dunes are formed along the sandy shores of the ocean or of large lakes when the prevailing winds are from the water. The waves are constantly throwing up sand which, when dry, is blown upon the beach, forming hills. The same often occurs along rivers in dry regions, as along the Columbia above the Dallas, and along the Arkansas in western Kansas.

92. Reclaiming sand-dunes.—Moving dunes are worthless for agricultural purposes and may be a menace to property. The first step in reclaiming such dunes is to fix the sand by applying a covering to prevent its being shifted by the wind. Interior dunes have been successfully fixed in Europe by covering with cut heather, a common plant in sandy wastes. In other places brush or rows of sticks thrust into the sand have served the purpose. One of the most successful methods has been the planting of beach-grass. After the shifting of the sand has been prevented by any of these methods, trees are planted which in time produce a forest, the dunes being thus permanently fixed. The waste land has now become productive, as the forest under proper care yields an income. The trees cannot be started on the shifting sand.

93. Sand-binders.—Except near the seashore the function of grass or of an inert covering is temporary, as the land is ultimately converted into forest. Along the seashore where a barrier dune is formed the action of the spray from the ocean prevents the growth of trees. On this barrier dune which protects the forest in the rear from the aggressive action of the sand, the grass covering must remain indefinitely and must be kept in condition by constant attention after it is planted.

A sand-binder must be a plant that will thrive in the sand, and that possesses an abundance of vigorous creeping rootstocks that will bind the sand and prevent its being blown by the wind. The best sand-binder is beach-grass, or marram-grass (*Ammophila arenaria*), a native of the sea beaches of Europe and of Atlantic North America as far south as North Carolina. It is also found along the shores of the Great Lakes. An important character of beach-grass is that it thrives best where the sand is drifting. Here it continually rejuvenates and grows up through the sand as it is covered. A few other grasses have been tried but none give as good results.

94. Fixing sand with beach-grass.—Beach-grass is propagated by transplanting and not from seed. The planting is best done in the fall between maturity, which is about September, and the time when the ground freezes. It can also be done in spring before growth starts. Plants for the purpose are chosen from a nearby plot where the grass is growing vigorously. Those chosen should be two years old and should have one or two nodes on the rootstock at the base. It is from these nodes that the roots spring. The planting is best done on a cloudy day. A hole is made by thrusting a spade or other sharp implement into the sand, the plant is placed in the opening and the sand pressed around it with the foot. If beach-grass does not grow in the vicinity, it may be necessary to establish a preliminary plantation. It is useless to attempt to grow beach-grass in interior arid regions.

In America, notable fixation work has been done near Provincetown, Massachusetts, at Manatee and other points along the east shore of Lake Michigan, and at Golden Gate Park, San Francisco. The latter place was once a sandy waste but is now a beautiful park. The preliminary steps here were the planting of beach-grass. (See Bur. Pl. Ind. Bulletins Nos. 57, 65.)

SUGAR-PRODUCING GRASSES

95. The sugar of commerce is obtained from four sources, sugar-cane, sugar beet, sorghum, and sugar maple. The amount from the last two is comparatively insignificant. Chemically, commercial sugar is cane-sugar or sucrose.

96. The sugar-cane is a large perennial grass grown in all tropical countries. In the United States its growth is chiefly confined to the lowlands of Louisiana. This state in 1900 produced 132,000 tons of sugar. The same year the two largest sugar-producing countries yielded, Java 650,000 tons, and Cuba 440,000 tons. These figures refer to sugar from sugar-cane.* It is interesting to note that Europe produced the same year over 4,000,000 tons of beet-sugar, or a third more than the total world production of sugar from the cane. The thirteenth census report

*Sadtler, Industrial Organic Chemistry, ed. 3, pp. 166, 167.

states that in 1909 Louisiana produced 4,941,996 tons of sugar-cane, which was an increase of 57 per cent over that produced in 1899.

Sugar is contained in the juice of the cane, this being extracted from the stalks by crushing between rollers. The juice is neutralized with lime, boiled and clarified, and concentrated in vacuum pans. The sugar separates in crystals. The remaining liquid is called molasses. Rum is made by distilling fermented molasses. The sugar-cane often flowers abundantly in the tropics, but rarely produces seed. It is propagated by cuttings of the stem.

97. Sorgho, or sorghum.—As indicated in Par. 57 there are several varieties of sorghum, some of which, the saccharine sorghums, have a sweet juice containing enough cane-sugar to make the extraction a commercial possibility. In the region from Kansas to North Carolina a small amount of sorghum is grown for the production of sugar, most of which appears on the market in the form of syrup. The total amount of sorghum syrup produced in the United States in 1909 was 16,532,282 gallons.* The five leading states were Kentucky, 2,733,683; Tennessee, 2,076,339; Missouri, 1,788,391; Arkansas, 1,140,532; North Carolina, 1,099,346.

TEXTILE GRASSES

98. The most important textile grass is esparto, the fiber of which is used for paper and cordage. It is grown chiefly in Spain and North Africa. In Algiers the grass is called alfa. Annually there are imported into England over 200,000 tons of esparto to be used for the manufacture of paper. Two species of grasses furnish the esparto of commerce—*Stipa tenacissima* and *Lygeum sparteum.*

*13th Census.

OTHER USES

99. The bamboos are of vast importance to the native people of the regions where these gigantic grasses grow. The culms or stems are used for building purposes, the split bamboo is woven into mats, screens and a variety of other articles, the sections of the stems with the solid partitions are used as utensils, and the fiber is used for paper. The wood is extremely hard, durable and flexible. The bamboo is probably put to a greater variety of uses than is any other plant. The straw hats known on the market as Bangkok hats are made from bamboo. *Ischæmum angustifolium* is used in India as a substitute or adulterant of jute for cotton baling for the American trade. Rice straw is extensively used in Japan and other eastern countries for matting, a large proportion of the wrapping of heavy freight being of this material. Rice is also used for paper, although the so-called rice-paper is made from the bark of the paper mulberry. The straw of grains is used for making straw hats, an especially fine quality being used in Italy.

100. Green-manuring.—Grasses, especially the grains, are used, as are legumes and some other plants, for green-manuring. For this purpose, the plants are turned under by plowing about the time they reach maturity. Heavy soils are made lighter, since the green vegetation tends to produce humus. It is usually more profitable to combine green-manuring with pasturing as one can scarcely afford to give up an entire season to a crop for turning under. Furthermore, land that most needs the manure will give the smallest crop to turn under. Stable manure accomplishes results much sooner, but, of course, is not always available. (See Farmers' Bulletin No. 278.)

CHAPTER IX

WEEDS

A WEED is a plant troublesome to man. In the more restricted sense it is an herbaceous plant that becomes aggressively troublesome in cultivated fields. Plants may become weeds because of their intrusiveness, as bindweed (*Convolvulus arvensis* L.) and Canada thistle (*Cirsium arvense* (L.) Scop.) or they may be able quickly to occupy waste land, dooryards, or roadsides, as knotweed (*Polygonum aviculare* L.), horseweed (*Erigeron canadensis* L.) and ragweed (*Ambrosia trifida* L.). Others may become weeds in pastures because, not being eaten by stock, they thrive at the expense of the palatable species.

101. Classes of weeds.—Weeds may be divided into three classes according to method of growth. These are annuals and biennials, perennials with crowns, and perennials with rhizomes or creeping roots. Methods of eradicating depend upon the group to which the weed belongs. Annual weeds may become abundant, but are not difficult to eradicate as they may be pulled up or removed by cultivation. Perennial weeds with crowns are usually not aggressive but may become conspicuous in pastures, especially those that are over-grazed. Certain kinds of plants usually classed with this group differ in having an upright fleshy caudex capable of producing adventitious buds and shoots. These may become troublesome weeds in pastures or lawns. The dandelion (*Taraxacum Taraxa-*

cum (L.) Karst., *T. officinale* Weber.) is a familiar example of this group. Cutting off the plant below the crown does not destroy the dandelion, as adventitious buds may be produced on the cut root from which new shoots develop.

102. Perennial weeds with creeping rhizomes or creeping propagating roots include the most troublesome species, as the widely spreading rhizomes or roots are difficult to remove completely from the soil. Portions of the rhizomes remaining in the soil may give rise to new shoots. Creeping propagating roots are to be distinguished from creeping rhizomes or rootstocks, which are modified stems. Creeping roots possess no scales or modified leaves, but have the structure of roots. They will, however, if they are propagating roots, have the power to produce adventitious buds. Some weeds with creeping roots are bindweed (*Convolvulus arvensis* L.) and sheep sorrel (*Rumex Acetosella* L.). None of the weedy grasses possesses creeping roots. Creeping rhizomes indicate their character as modified stems by the presence of scales that mark the nodes at regular intervals. To this group belong the white morning-glory (*Convolvulus Sepium* L.), the nut-grass (*Cyperus rotundus* L.) and Johnson-grass.

103. Weedy grasses.—Grasses may be of all degrees of weediness. Many species that are classed as weeds are harmless since they are found only in waste places or along roadsides. Among these are goose-grass, crowfoot-grass and old-witch grass. Only a few of the more important weedy grasses will be mentioned here.

104. Annual weeds.—In the eastern states the common species are green foxtail, yellow foxtail, and upon sandy land, the sandbur. Here, and more especially in the South, crab-grass is a common weed. All these yield readily to cultivation. Crab-grass is particularly troublesome because it thrives late in the season after the usual cultivation of the crops has ceased. Two important weeds in blue-grass lawns are crab-grass and annual blue-grass. The latter thrives in the spring, making an appearance pleasing to the eye, but later dies, leaving unsightly bare spots. In the same way crab-grass, later in the season, leaves brown patches as the plants die.

105. On the Pacific coast other species of grasses become weeds. A very noticeable group are the annual species of Bromus. They are of some value as forage when young but soon become too dry and prickly from the awns of the inflorescence to be palatable. The principal species are *Bromus commutatus, B. hordeaceus, B. rubens, B. tectorum* and *B. villosus* (Par. 260). Another species, *B. secalinus,* the common cheat or chess, is found in grain fields throughout the northern United States. The wild oat is abundant on the Pacific coast in grain fields and on fallow lands, but possesses a mitigating character in that it can be used for hay (Par. 239). Several weedy species belong to the genus Hordeum, the inflorescence of which possesses numerous rough awns that are troublesome when mixed with hay. There are three annual species, *H. pusillum, H. Gussoneanum* and *H. murinum.* The last is a common weed in alfalfa fields where it is called foxtail and barley-grass.

106. Perennial weedy grasses.—Of the group that lack creeping rhizomes there are few that are troublesome. One of the worst of them is *Hordeum jubatum,* which in the West often infests alfalfa fields. It is called squirrel-tail-grass, but locally is known as foxtail in Wyoming, barley-grass in Utah, and tickle-grass in Nevada.

Many species become conspicuous in overgrazed pastures or ranges because not eaten readily by stock. To this group belong the spear grasses, species of Aristida, whose sharp fruits with the triple awns become a nuisance or even a serious pest. These fruits and others such as those of Hordeum and Sitanion work their way into the nostrils and eyes of animals and into the wool of sheep, or form hair-balls in the stomach.

107. The seriously troublesome weeds in cultivated soil are those possessing creeping rhizomes. There are three species of grasses that belong in this category. They are Bermuda-grass, Johnson-grass and quack-grass. Bermuda-grass has already been mentioned (Par. 28). In cultivated soil the rhizomes become large and vigorous and the plant is usually known then as wire-grass. Bermuda is a common weed in corn and cotton fields throughout the southern states. Johnson-grass is exceedingly troublesome in the black soils of the southern states (Par. 49). Quack-grass is a bad weed in the humid region of the northeastern states. It is also called quick-grass, quitch-grass and couch-grass.

These three species, like all weeds with rhizomes, cannot be eradicated by pulling them up or by cultivation unless all of the rhizomes are removed, since a single piece of rhizome may give rise to a shoot. They may be greatly reduced in this way, however. On a large scale they may be kept in subjection by plowing and harrowing out the rhizomes, after which they are burned or removed or spread so as to be dried out by the sun. Another general method for eradicating such weeds is to smother them with a vigorous crop, such as grain or alfalfa. Small patches may be attacked to advantage with the hoe, cutting off all the green shoots. If this is done frequently the rhizomes are exhausted of their vitality and are unable to produce more shoots.

CHAPTER X

GRASS-CROP AREAS

In previous chapters, reference has been made under each grass crop to the area in the United States in which it thrives. In this chapter a résumé will be given of the conditions and limitations of these areas. The crop areas depend entirely upon climatic conditions. Soil conditions modify or limit the distribution of crops within each area. So far as crops are concerned, the climatic conditions are moisture and temperature.

108. Moisture.—The moisture, so far as it concerns crop areas, depends on the annual rainfall and its seasonal distribution. Locally crops may receive water by seepage from rivers and springs but such sources have no effect on the general distribution of crops. The seasonal distribution of the rainfall is of as much importance as the annual rainfall, for the crops require water during the growing season. The amount of water required by a crop varies with the evaporation, which depends in part upon the humidity. Without going into the physical and meteorological details, it will readily be understood that latitude and altitude modify greatly the relation between a crop and its water-requirement. There is also an intimate connection between temperature and rainfall. Soil conditions modify the water requirement in various ways, but not sufficiently to have any material effect on the large crop areas.

109. The temperature affects evaporation and hence the water-requirement. It also affects directly the growth of crops. There is an optimum temperature for each crop at which it thrives best. The temperature through the growing season is of the most importance, though for perennials the minimum winter temperature may be a limiting factor.

110. The timothy area.—This area extends from New England to the southern boundary of Virginia and farther south in the mountains and west to Minnesota and eastern Kansas, approximately to the 96th meridian. In general this is the humid area. The rainfall is sufficient on the average for the growing, without irrigation, of the common meadow- and pasture-grasses, timothy and blue-grass, and the legume, red clover. The rainfall is distributed through the summer or growing season.

There are other humid regions in the United States in the mountains of the western portion, isolated areas where the rainfall is sufficient and the altitude not too great. Timothy can be raised in Colorado up to about 9,000 or even 10,000 feet altitude. At higher latitudes the altitudinal limit is lower. The most important humid region of the West is the upper Pacific coast region lying west of the Cascades and extending from Puget Sound south into northern California. This differs from the eastern humid region in having cooler summers and milder winters with considerable rainfall. This region is eminently adapted to pasture crops because of the mild, moist winters. It is not so well adapted to hay crops because of the difficulty of curing hay in the moist climate. (See Farmers' Bulletin No. 271.)

In the northern part of the timothy area, the Canada field pea is much used (Par. 67). In the eastern part along the coast where the soil is often acid, redtop becomes the dominant forage grass (Par. 32).

111. The Bermuda-grass area.—This area occupies the region south of the timothy area and west to include eastern Texas. Approximately this is also the cotton region. The annual rainfall is sufficient for such forage plants as timothy and clover but the summers are too long and hot for the development of these crops. Some of the annual plants of the timothy region such as the grains, vetches, and crimson clover, can be grown in the south as winter forage crops. The rye-grasses, though short-lived perennials, can be treated as annuals and will give good results when sown in the fall for winter forage. (See Farmers' Bulletin No. 509.)

112. The Great Plains.—This is the area lying between the Rocky Mountains and the two areas mentioned above and extending from north to south across the United States, and beyond its boundaries in each direction. The annual rainfall along the eastern border is about 30 inches. This decreases westward until it is about 15 inches at the base of the mountains. This amount is too small for the production of crops adapted to the humid region but many specially adapted crops can be raised without irrigation in the eastern half of the belt. The region is devoid of forest except along the streams of the eastern part. Before the land was occupied by man these plains were covered with grass, the dominant species being buffalo-grass, grama-grass and curly mesquite, all low grasses that form a close sod. The early settlers used the sod to make sod houses.

The Great Plains are eminently adapted to stock-grazing and there are throughout, but more particularly in the western part, numerous large stock ranches. The water of the comparatively few streams is supplemented by wells, many of which are over 100 feet deep, and by dams in the ravines or "draws" that catch and hold the run-off from the storm water. The rainfall may come in torrential storms and much of the water, instead of being absorbed by the soil, runs off in the watercourses and is lost to the area. The native vegetation has already been described (Par. 23).

113. Forage crops for the Great Plains.—Within recent years a large part of the eastern half of this belt has been converted into farms, and much of the native sod has been placed under cultivation. As modern methods for dry-farming come into more general use, and crops especially adapted to dry regions are more widely grown, more and more of the Great Plains will be utilized for the growing of crops. In the western part of the belt irrigation is practised in many places either by ditches from the larger rivers, as the Platte and Arkansas, or from deep wells by means of windmills or gasoline engines, or from ponds that catch the storm water. The forage crops adapted to this region are millet (Par. 56) for the eastern half of the belt; brome-grass (Par 31) for the region from Nebraska to Montana and Minnesota; and the sorghums for the region from Kansas to Texas. Kafir is grown for grain and forage. It is usually planted in rows and cultivated. Saccharine sorghums, such as the Amber and Orange varieties, are much grown for hay. For this purpose they are sown thickly and mowed with a machine.

The grains grown for the seed over the eastern and central portion of the belt furnish also no inconsiderable amount of forage. It is a common practice in the winter wheat region to pasture the wheat fields in the fall and early winter. The most important forage crop is alfalfa.

With proper care in preparation of the soil and in seeding, this leguminous crop can be grown without irrigation over a very considerable portion of the area.

114. The arid region.—This includes all the region west of the Great Plains where the rainfall is insufficient for the growth of crops without the aid of irrigation. Besides the two main mountain systems, the Rocky Mountains and the Sierra Nevada, there are numerous smaller ranges throughout the region between. The term Great Basin strictly applies to that portion such as most of Utah and Nevada which has no drainage to the sea, This name is often applied in a loose way to the whole region between the two mountain systems mentioned. The general level of this interior region is at 4,000 to 5,000 feet altitude. Usually at higher altitudes in the mountains the climate is increasingly moist. Above about 8,000 feet the climate is usually humid and the slopes are in general more or less forested.

The climate of the plains and valleys is arid. Crops are raised only as water for irrigation can be obtained from the streams. Much of the area is sufficiently arid to be called a desert. This is especially so in the southern part where the summers are longer. Under favorable conditions crops can be raised by applying the methods of dry-land farming. Such may be the case at the base of a mountain slope where there is sub-irrigation through seepage from the mountain. The great proportion of this arid region is used for stock-grazing in so far as it can be used at all for agricultural purposes. Most of the grazing is in the mountains but there is some forage on the desert which is utilized if water for stock is available (Par. 20). Where there is snow in winter, sheep can be pastured, the animals depending on the snow for their water-supply.

115. The Pacific slope.—In the great interior valley of California and northward through eastern Oregon, eastern Washington and northern Idaho, the rainfall comes mostly in the winter, this season being comparatively mild. Under these conditions the winter season is adapted to the growth without irrigation of annual crops such as grain. The summers are hot and dry, and irrigation is necessary for summer crops such as alfalfa. The region to the northwest of this is humid (Par. 110).

116. The relative importance of the different kinds of forage in the different regions of the United States.—The production (tons) of the kinds of forage mentioned by the thirteenth census report is given in the following table, each being arranged by states. The production of each kind of forage in the United States is shown in Figs. 2 to 10.

TABLE XVII

THE PRODUCTION (TONS) OF HAY AND FORAGE FOR 1909, BY THE TEN LEADING STATES, OF EACH KIND OF FORAGE

Timothy

1. Ohio	2,348,660	6. Pennsylvania	1,200,073
2. Iowa	1,952,956	7. New York	1,159,083
3. Illinois	1,947,572	8. Wisconsin	1,110,446
4. Indiana	1,442,218	9. Minnesota	1,101,510
5. Missouri	1,334,556	10. Michigan	929,165

Timothy and clover mixed

1. Iowa	3,732,186	6. Missouri	1,630,211
2. New York	3,215,021	7. Minnesota	1,433,075
3. Wisconsin	2,477,311	8. Ohio	1,346,347
4. Michigan	1,991,618	9. Illinois	1,123,254
5. Pennsylvania	1,830,852	10. Vermont	628,098

Clover alone

1. Illinois	539,790	6. Tennessee	201,926
2. Indiana	314,818	7. Iowa	195,579
3. Missouri	309,209	8. Wisconsin	193,786
4. Ohio	239,492	9. New York	114,864
5. Michigan	216,862	10. Minnesota	106,334

TABLE XVII, continued

Alfalfa

1. Kansas	1,998,689	6. Utah	791,355
2. California	1,639,707	7. Montana	599,747
3. Nebraska	1,522,136	8. Wyoming	397,669
4. Colorado	1,265,915	9. Oregon	375,445
5. Idaho	964,529	10. Washington	357,595

Millet or Hungarian grass

1. Kansas	290,661	6. Tennessee	76,311
2. Nebraska	160,684	7. Oklahoma	75,591
3. North Dakota	149,429	8. South Dakota	65,844
4. Missouri	141,626	9. Iowa	54,346
5. Texas	95,352	10. Minnesota	50,383

Other tame or cultivated grasses

1. New York	412,479	6. Connecticut	159,365
2. Maine	258,789	7. Massachusetts	150,723
3. Tennessee	218,482	8. Kentucky	139,382
4. Minnesota	188,371	9. Texas	138,758
5. Vermont	160,014	10. New Hampshire	131,621

Wild, salt, or prairie grasses

1. Nebraska	3,097,822	6. Iowa	1,178,000
2. South Dakota	2,798,263	7. Oklahoma	607,120
3. Minnesota	2,714,121	8. Montana	589,860
4. North Dakota	2,372,618	9. Wisconsin	497,622
5. Kansas	1,737,632	10. Colorado	368,408

Grains cut green

1. California	2,019,526	6. South Carolina	133,996
2. Oregon	509,030	7. Georgia	128,929
3. Washington	499,955	8. Louisiana	127,126
4. Idaho	140,098	9. North Carolina	118,687
5. Tennessee	136,674	10. Illinois	99,828

Coarse forage

1. New York	1,876,795	6. Vermont	452,461
2. Kansas	1,263,231	7. Ohio	443,512
3. Texas	688,274	8. Pennsylvania	422,925
4. Wisconsin	571,441	9. Minnesota	401,614
5. Iowa	510,184	10. Michigan	379,279

117. Remarks on Table XVII.—In order to understand the classification of the forage plants in the census report, the following extract is quoted from "Instructions for Clerks in Tabulation Subdivision II, Agriculture," being a part of Inquiry 43, concerning hay and forage crops.

(*a*) Tabulate as "clover alone" all crops reported after that designation, as well as all reported as "alsike," "red clover," "crimson clover;" also other clovers unmixed with other grasses. The same crops reported as mixed with timothy or herd's grass should be tabulated as "timothy and clover mixed." When reported as mixed with grasses other than timothy or herd's-grass, they should be tabulated as "other tame or cultivated grasses."

(*b*) Tabulate as "other tame or cultivated grasses" all crops reported after that designation, as well as all reported as "redtop," "June-grass," "orchard-grass," "blue-grass," and "Johnson-grass;" also all combinations of these grasses with any of the clover crops mentioned in paragraph *a*, preceding, or with timothy.

(*c*) Tabulate as "wild, salt, or prairie grasses" all crops reported after that designation, as well as all reported as "marsh-grass," "swamp-grass," "slough-grass," "bluestem," "daisies," and "buttercups."

(*d*) Tabulate as "grains cut green" all crops reported after that designation without specific names, or with the name "oats," "wheat," "barley," "rye," "peas," "cowpeas," "soybeans," "velvet-beans," or "vetches." Keep a memorandum of the names of all crops reported with specific names and tabulated as "grains cut green."

(*e*) Tabulate as "coarse forage" all crops reported after that designation without specific names, or with the name "corn" (see paragraph *i* below), "sweet corn," "cane," "sorghum," "Kafir corn," "Jerusalem corn," "milo maize," or kindred crops.

Timothy and clover, alone and mixed, constitute the first three items of the classification under hay and forage. These plants are grown in the humid region (Par. 110), though the New England states, with the exception of Vermont, are not represented. Ohio, Iowa, Illinois, New York, Wisconsin and Minnesota are represented in each of the lists of ten leading states for these forage plants.

The leading alfalfa states are all west of the Missouri River, although it is note-worthy that the state of first rank, Kansas, lies on the eastern border of the region. With the exception of Tennessee, the leading millet states lie between the Mississippi River and the Rocky Mountains.

The states leading in the production of forage classified as "other tame or cultivated grasses" are those of the New England division, together with the adjacent state of New York, and the more remote states of Minnesota, Kentucky, Tennessee and Texas. In the northeastern states the most important element is redtop. In Texas, as in other southern states, Johnson-grass is an important factor. In Tennessee and Kentucky orchard-grass is an important forage plant. The states leading in the production of wild hay, with the exception of Wisconsin, lie in the Great Plains region where the bulk of the product is made up of mixed prairie grasses. In Wisconsin an important factor is blue-joint (*Calamagrostis canadensis*).

Most of the elements in the classification of hay and forage represent summer-grown crops. The category referred to as "grains cut green" assumes importance in two regions, the Pacific coast and the southern states. In the first region the best conditions for grain-growing obtain in the winter season, during which the greatest rainfall of the year occurs. Because of these conditions hay made from grain is the most available forage. In the second region cowpea hay is an important crop. Canada field pea, an important crop along our northern border, is included in the figures for "grains cut green." Under the last heading, "coarse forage," are included corn and sorghum cut for forage.

LIST OF GOVERNMENT PUBLICATIONS REFERRING TO FORAGE CROPS AND SPECIAL USES OF GRASSES

The list is not complete but indicates the more important recent publications. The bulletins of the state experiment stations should also be consulted by the student. Another important series is that of the circulars and bulletins of the Division of Agrostology, United States Department of Agriculture. These bulletins are now out of print but the series can be consulted in the libraries of educational institutions.

United States Department of Agriculture, Bureau of Plant Industry, Bulletins

Nos.

4. Range Improvement in Arizona.
11. Johnson-Grass.
12. Stock Ranges of Northwestern California.
13. Experiments in Range Improvement in Central Texas.
15. Forage Conditions on the Northern Border of the Great Basin.
19. Kentucky Blue-Grass Seed.
31. Cultivated Forage Crops of the Northwestern States.
38. Forage Conditions and Problems in Eastern Oregon.
57. Methods Used for Controlling and Reclaiming Sand-Dunes.
59. Pasture, Meadow, and Forage Crops in Nebraska.
65. Reclamation of Cape Cod Sand-Dunes.
67. Range Investigations in Arizona.
72. III. Extermination of Johnson-Grass.
74. Prickly Pear and Other Cacti as Food for Stock.
75. Range Management in the State of Washington.
82. Grass Lands of the South Alaska Coast.
84. The Seeds of the Blue-Grasses.
94. Farm Practice with Forage Crops in Western Oregon.
100. VI. Orchard-Grass.
111. IV. Forage Crops for Hogs in Kansas and Oklahoma.
111. V. The Culture and Uses of Brome-Grass.
117. Reseeding of Depleted Range and Native Pastures.
118. Peruvian Alfalfa.

124. The Prickly Pear as a Farm Crop.
127. The Improvement of Mountain Meadows.
140. The Spineless Prickly Pears.
169. Variegated Alfalfa.
175. History and Distribution of Sorghum.
177. A Protected Stock Range in Arizona.
179. The Florida Velvet Bean.
197. The Soybean.
203. Importance and Improvement of the Grain Sorghums.
209. Grimm Alfalfa.
229. Agricultural Varieties of the Cowpea.
237. Grain Sorghum Production in the San Antonio Region of Texas.
253. The Kaoliangs: A New Group of Grain Sorghums.
258. Some New Alfalfa Varieties for Pastures.

Farmers' Bulletins

Nos.
72. Cattle Ranges of the Southwest.
101. Millets.
108. Saltbushes.
139. Emmer.
164. Rape as a Forage Crop.
174. Broom-Corn.
194. Alfalfa Seed.
246. Saccharine Sorghums for Forage.
248. The Lawn.
260. Seed of Red Clover and Its Impurities.
271. Forage Crop Practices in Western Oregon and Western Washington.
279. Method of Eradicating Johnson-Grass.
288. Nonsaccharine Sorghums.
292. Cost of Filling Silos.
300. Some Important Grasses and Forage Plants of the Gulf Coast Region.
312. A Successful Southern Hay Farm.
318. Cowpeas.
322. Milo as a Dry-Land Grain Crop.
323. Clover Farming on Sandy Jack-Pine Lands of the North.
331. Forage Crops for Hogs in Kansas and Oklahoma.

339. Alfalfa.
361. Meadow Fescue.
362. Conditions Affecting Value of Market Hay.
372. Soybeans.
373. Irrigation of Alfalfa.
382. The Adulteration of Forage-Plant Seeds.
402. Canada Blue-Grass.
441. Lespedeza or Japan Clover.
448. Better Grain-Sorghum Crops.
458. Best Two Sweet Sorghums for Forage.
464. Eradication of Quack-Grass.
466. Winter Emmer.
485. Sweet Clover.
494. Lawn Soils and Lawns.
495. Alfalfa Seed Production.
502. Timothy Production on Irrigated Land in Northwestern States.
508. Market Hay
509. Forage Crops for Cotton Region.
515. Vetches.
529. Vetch-Growing in the Southern States
550. Crimson Clover: Growing the Crop.
552. Kafir as a Grain Crop.
556. The Making and Feeding of Silage.
578. The Making and Feeding of Silage.
579. Crimson Clover: Utilization.

Articles in the Yearbooks of the Department of Agriculture

1894. Grasses as Sand- and Soil-Binders.
1895. Canadian Field Peas.
Forage Conditions of the Prairie Region.
Grasses of Salt Marshes.
1896. Timothy in the Prairie Region.
Cowpeas.
1897. Lawns and Lawn-Making.
Leguminous Forage Crops.
1898. Millets.
Sand-Binding Grasses.
Grass Seed and Its Impurities.

1898. Forage Plants for Cultivation on Alkali Soils.
1899. Succulent Forage for Farm and Dairy.
1900. Our Native Pasture Plants.
1901. Grazing in Forest Reserves.
1906. Range Management.
1908. Search for New Leguminous Farm Crops.
1912. Some New Grasses for the South.

PART II

SYSTEMATIC AGROSTOLOGY

CHAPTER XI

MORPHOLOGY OF THE VEGETATIVE ORGANS

Morphology treats of the form and structure of organs, especially as to their developmental relations. For example, morphological study indicates that a fundamental organ may develop into a foliage leaf, into a scale or bract, or into the parts of the flower. In order to understand the natural classification of plants, it is first necessary to be familiar with their morphology. To interpret and use descriptions, it is necessary to understand the terminology used in morphology. The subject will be considered under two heads, morphology of the vegetative organs and morphology of the floral organs.

GENERAL CHARACTERISTICS OF GRASSES

118. Grasses are included in the natural botanical family Poaceæ or Gramineæ.—They are usually distinguished by having long narrow 2-ranked blades, clasping sheaths, small greenish flowers collected in a compact or open inflorescence. The flowers have no proper perianth nor floral envelopes, but consist of a pistil and usually 3 stamens inclosed between 2 small bracts. Further details will be given under the appropriate headings.

There are a few other groups of plants that resemble grasses in general appearance. The natural order Poales, Graminales or Glumifloræ, includes the grasses and sedges

(Cyperaceæ). Many sedges have grass-like blades, but differ in having 3-ranked leaves and in having flowers supported by a single bract. In rushes (Juncaceæ) the essential organs of the flowers are surrounded by a small greenish 6-parted perianth, and the fruit consists of a capsule with several or many seeds. A few plants belonging to the lily family and other allied groups have grass-like blades, but the flowers possess a proper perianth that is sometimes greenish but often conspicuously colored.

Familiar examples of plants belonging to the grass family are, blue-grass, timothy, redtop, wheat, rice and other grains, corn, sorghum, sugar-cane and bamboos.

119. Gross anatomy.—It is assumed that the student is familiar with the fundamental distinction between the primary organs of the phanerogams. He may be reminded, only, that the plant consists of shoot and root, that the shoot consists of the stem and leaves borne upon it, and that the inflorescence consists of modified shoots.

Grasses may be annual or perennial. In cooler regions certain annual species may germinate in the fall, live over winter as a small tuft and send up flower stalks the following spring. These are known as winter annuals.

120. Perennial herbaceous species are mostly of two kinds. In the first kind a crown is formed by the persistent bases of the culms, the upper portions of which die back each year. The young shoots of the ensuing season are produced from buds arising within the sheaths They grow up alongside the old stems and together form a compact mass. Such grasses form tufts or tussocks and are commonly called bunch-grasses. The orchard-grass is a familiar example. Some authors refer to the shoots of bunch-grasses as being intravaginal.

In the second kind of perennial, the new shoots arise from rhizomes or rootstocks. These are modified shoots that burst through the sheaths and creep horizontally below the surface of the soil. Grasses such as the bluegrass, with well-developed rhizomes, tend to form a compact sod. The young shoots or innovations of such grasses are sometimes referred to as extravaginal. The various forms assumed by rhizomes will be discussed under the subject of the stem.

Besides these two chief kinds of perennial grasses, there are those (such as the buffalo-grass) that produce stolons by which a sod is formed. Still another method of persisting through unfavorable seasons is found in many grasses growing in the water or mud. The lower prostrate or decumbent portion branches freely and persists while the upper portion dies back. The older portion dies sooner or later so that the original base of the plant disappears and one finds only a tangled mass of creeping and rooting stems.

The stems of grasses vary in height from an inch or less to several feet in herbaceous species. Some of the larger bamboos arise to the height of over 100 feet and may be a foot in diameter. Certain climbing species clamber up through the branches of trees to the height of 30 feet or more.

121. Distribution.—Grasses are found in all parts of the world where there is sufficient soil to permit growth. They are found from the tropics to the arctic regions, from sea-level up to the limits of perpetual snow. They are found in woods, plain, swamp and desert, on the floor of the deepest forest, on the sandy seashore, in moist gorges and on rocky cliffs. In the main, however, grasses love sunlight, and are found in greatest abundance in open land such as prairies and pine barrens. In mangrove swamps grasses are rare and in thick forest only a few broad-bladed shade-loving species are found.

The species of grasses are frequently gregarious, forming large masses more or less to the exclusion of other plants. Familiar examples are the large areas of Indian rice and of Phragmites in swamps, and the zones of *Homalocenchrus oryzoides* around ponds. On prairies and plains, grasses are usually the dominant vegetation, though the species may mingle more than in the swamp plants mentioned above. During the flowering period, a particular species may appear to the casual observer to be the only species present, but close examination usually proves the presence of various other species, some of which may in their turn appear dominant at another period.

THE ROOT AND STEM

122. The roots of grasses are fibrous. They are usually found at the base of the plant, but in decumbent or prostrate stems they may be produced at the nodes. Supporting or prop roots are sometimes produced in erect stems at nodes above the surface of the soil as in Indian corn. Underground stems which may have the appearance of roots will be discussed in another paragraph.

123. The stem of grasses, known as the culm, is made up of a series of nodes and internodes. The nodes are the more or less swollen joints at which the leaves originate. The internodes when young are solid, that is, filled with pith, but at maturity the pith usually disappears leaving the culm in the form of a tube with solid partitions at the nodes. The wheat straw is a familiar example of this structure. In some grasses, such as the corn and sorghum, the internodes retain the pithy interior.

The nodes are capable of growth after the maturity of the internodes. By virtue of this character the culm is able to change its direction by bending at the nodes, the latter increasing in length on the outer side. This tendency may be observed in decumbent culms, the terminal portion remaining erect while the basal portion may become prostrate. In such cases the nodes first elongate on the under side and later on the upper side as the successive internodes become horizontal. The node is usually indicated externally by a more or less well-marked zone showing a difference in color, texture or pubescence. The swelling often present near the node is a part of the sheath and will be described in connection with that organ.

In young shoots, the leaves grow at first much faster than the internodes, so that the terminal portion or bud consists of several sheaths fairly well developed, one within the other, while the corresponding internodes are very short. Later these internodes elongate rapidly, separating the leaves. By this means the youngest portion of the shoot is always well protected by the surrounding sheaths.

The culms are usually cylindrical or nearly so, but may be distinctly flattened. They are never 3-angled as in sedges. The mature culm in proportion to its weight has great strength, especially to resist bending. This condition is aided by the tubular shape and by the hard tissue of the walls. In addition to the sclerenchyma fibers, so abundantly produced as to form a solid ring of tissue with the vascular bundles, there is usually deposited a considerable quantity of silica.

124. Duration.—The culms of most grasses are herbaceous and die down at least to the surface of the soil. In bamboos and a few other groups (such as Lasiacis and Arundo) the culms are woody and persist many years. Transitional forms are not uncommon, especially in desert regions where the base of the culms becomes perennial, the new shoots arising from this more or less elongated and woody portion.

125. Stems modified for propagation.—The usual form of propagating stem is the rhizome or rootstock (Fig. 58). Rhizomes are creeping underground stems that may be distinguished from roots by the presence of reduced leaves in the form of scales. The terminal bud is hard and sharp so that the rhizome is able to force its way through the soil. Rhizomes vary greatly in size and consistency, being slender or almost thread-like in some species and thick and firm in others, but are rarely succulent enough to be called fleshy. From the rhizomes are sent up the vertical shoots, sometimes a single shoot the following season, sometimes several during the same season.

In sandy soil, especially on sand-dunes, the system of rhizomes reaches its greatest development. Beach-grass (Ammophila) and species of Spartina (such as *S. juncea*) produce a branching network, a single element of which may be many feet in length. Under favorable circumstances of isolation, a vigorous rhizome may be traced a long distance by the line of vertical shoots produced. Swamp-grasses are usually provided with a well-developed rhizome system, by which they may form a layer over soft mud or even upon the surface of water.

Grasses that grow in ordinary alluvial soil and that produce copious slender rhizomes form a firm sod and are useful for lawns.

Examples: Blue-grass and Bermuda-grass.

Between species with well-marked rhizomes such as described above and species in which the rhizomes are absent there are many transitions. The rhizomes may be short and thick with the scales close together, the plants forming loose tufts. Or the rhizomes may be slender but short and ascending, the plants also forming loose tufts. In certain species, usually classed as bunch-grasses, in which the tuft grows by accretions at the outer edge, the new shoots must bend outward and upward to reach the light. In large tufts the outer shoots have decumbent bases which may simulate short rhizomes. In some cases, especially in desert regions, such tufts may assume the form of fairy rings, dying out at the center and expanding at the circumference, until finally the living zone breaks up into isolated tufts, each to become a new center of growth.

126. Stolons.—When the modified propagating stems are produced above the surface of the soil they are called stolons or runners. They differ also from rhizomes in that they bear foliage-leaves instead of scales, although these leaves are usually different in size or shape from those produced upon the foliage-shoots. Stolons are to be distinguished from shoots of creeping prostrate or decumbent plants in that they are modified creeping stems, that is, they differ from the ordinary erect or ascending shoots of the same plant and have the distinct function of propagation. The buffalo-grass produces stolons so abundantly that the plant forms a firm sod upon large areas of the Great Plains (Fig. 48). It was from such sod that pioneers in this region made their sod houses. In the tropics stolon-producing species are more numerous than in the cooler regions. Pará-grass, when growing in new soil, produces vigorous stolons as much as 20 feet long.

The common carpet-grass of our southern states produces strong stolons which, on overhanging banks or in other favorable situations, may reach a length of several feet. Some species produce rhizomes or stolons according to the conditions under which they are growing. Bermuda-grass forms strong rhizomes several inches below the surface in cultivated soil but in hard uncultivated soil produces stolons, and not infrequently both may be found in the same mass of sod.

127. Corms.—Another and rarer form of modified underground stem is the corm. This is a hard globular thickening at the base of the plant. In *Panicum bulbosum*, a grass found in the mountain valleys of New Mexico and Arizona, these corms are well marked, sometimes as much as an inch in diameter, and may occur in groups of several attached in one mass. Rudimentary corms are found at the base of the stems of timothy, Cinna and many species of Melica. A variety of the tall oat-grass produces corms in moniliform strings. The corms are produced by the thickening of a single internode. If there is more than one corm on the same shoot the constriction between is the node. In Melica the thickening is greatest at the base of the internode resulting in a flask-shaped corm. Buds arise not on the corms but at the constrictions, as these are the nodes. The masses of corms mentioned as being found in *Panicum bulbosum* include together with the living corms persistent old corms at the base of the stems of previous years' growth, these being connected by short rhizomes.

128. Artificial propagation by means of stems.—Sugar-cane is propagated by planting pieces of the stems or canes, the buds at the nodes developing into shoots. Para-grass and Bermuda-grass are propagated by planting pieces of the stolons or rhizomes. A common method in case of the latter grass is to cut sod into small pieces by means of an ax or a feed-cutter and to drop these upon prepared ground, forcing them in by pressure of the foot. Or, so readily do these pieces of stems grow, they may be sown broadcast and harrowed in or pressed in with a roller.

THE LEAF

129. The leaf is a lateral organ of the stem borne singly at the nodes. A normally developed foliage-leaf consists of two parts, the sheath and the blade. The sheath envelopes the culm above the node; the blade is the long narrow flat portion to which the name leaf is often applied. At the junction of the sheath and blade is found an appendage called the ligule.

Leaves are arranged on the culm alternately, in two ranks or rows. That is, the blade of a leaf at one node is on the side opposite the one below, while the third blade is above the first and on the same side of the culm. This universal arrangement, easy to observe in corn, is often obscured by the twisting of the culm or sheaths, by which the leaves may appear to be more or less in one rank or to be spirally arranged.

When the internodes of a shoot have failed to elongate so that the leaves remain in a tuft or fascicle, the actual distichous arrangement of the leaves is distorted by the mutual pressure of these organs, by which they may appear to radiate in all directions.

Leaves may be reduced to scales or bracts. Reduced leaves that appear on a shoot below the foliage-leaves are called scales. Those that appear above the foliage-leaves are called bracts.

130. Leaf-base and blade.—As regards development, the leaves of flowering plants consist of two portions—the leaf-base and the blade. The leaf-base is prominent in the early development of the organ, but generally includes only a small portion of the mature leaf. In the leaves of common deciduous forest trees, the swollen portion at the base of the petiole represents the leaf-base. In reduced leaves, the leaf-base often includes a relatively greater portion or may even be the only portion developed. In grasses, the sheath represents the leaf-base. In scales and bracts, the blades have failed to develop or consist of a mere tip or point.

131. The prophyllum.—At the point where a branch shoot originates from a main shoot, there is produced on the side next to the parent shoot a 2-keeled organ called the prophyllum. Through pressure the back of the prophyllum between the keels is concave against the parent shoot, while the two lateral portions, outside the keels, bend forward clasping the new shoot. At first the prophyllum completely covers the young shoot or bud, but later is spread or opened as the shoot develops.

The various subdivisions of the leaf will now be discussed more in detail.

132. The sheath is the lower portion of the leaf that encircles the culm above the node from which it arises. From the developmental standpoint it represents the leaf-base. The sheath is usually open from the base on the side opposite the blade, the right and left margins of successive sheaths overlapping alternately.

The sheath usually fits close to the stem but may be loose or inflated, especially the uppermost. The old sheaths at the base of the shoots may persist in perennial grasses and assume a characteristic appearance.

The uppermost sheath of *Sporobolus cryptandrus* (Torr.) Gray and allied species becomes inflated and spathe-like, more or less inclosing the inflorescence. The spathe-like sheaths are conspicuous in *Andropogon Elliottii* Chapm. Certain water-grasses, notably *Paspalum repens* Berg., have inflated sheaths that act as floats to sustain the stems on the surface of the water. In some grasses, especially those of dry regions, the dead sheaths persist as separated fibers or as a network of fibers. In other species such as *Muhlenbergia gracilis* (H. B. K.) Kunth and more conspicuously in *M. straminea* Hitchc., the sheaths become flat and ribbon-like and persist as a curly mass resembling shavings, simulating old blades.

In some species the sheaths are united by the margins to form a tube nearly or quite to the top.

Examples: Bromus, Danthonia, Festuca, Melica, Panicularia.

Though the sheaths normally encircle the culm, a spreading branch may pull the subtending sheath away from the culm, in which case the sheath usually encircles the branch.

133. Sheath nodes.—Many grasses present at the base of the sheath a distinct swelling which at first sight appears to be the node of the culm. If this portion of the stem is split open longitudinally it is readily seen that the prominent swelling is on the sheath and that the stem node is just below as will be indicated by the cross partition. The sheath-node is often differentiated also by its color or pubescence.

134. The collar.—At the junction of the sheath and blade there is in nearly all grasses a distinct line of demarkation. On the inside is the ligule (Par. 135). On the outside or back is a line, zone or ridge which is differentiated in color, texture, markings or pubescence. This zone is called the collar.

135. The ligule is an appendage on the inside of a grass leaf at the junction of the sheath and blade. The usual form of the ligule is a membrane extending across the top of the sheath at first tightly clasping the culm, the membrane being longest in the middle portion. The shape and appearance of the ligule are characteristic of each species and are often used for taxonomic purposes.

The ligule may be truncate or even somewhat concave on the upper margin. It is nerveless but may be 1-keeled (*Dactylis glomerata*) or apparently 2-keeled by the extension upward of the base of the blade on each side. Not infrequently the ligular tissue extends down the margins of the sheath. Sometimes the ligule is lacerate or ciliate, or may appear as a row of hairs (*Panicum Lindheimeri* Nash and its allies). The ligule is obsolete in some species (*Panicum sphærocarpon* Ell.) and entirely absent in others (*Echinochloa crus-galli* (L.) Beauv.) In *Anthochloa colusana* (Davy) Scribn. there is no differentiation into sheath and blade, hence no collar or ligule. The exact morphology of these leaves has not been investigated. It may be the sheath that is obsolete.

136. The blade is the usually flat part of the leaf beyond the sheath and is the chief foliage organ of the plant. In most grasses the blade is many times longer than wide but in many tropical species and in a few of the temperate regions it is short and broad, from oval to lanceolate in outline (see Fig. 29). Grasses with this kind of blade are mostly confined to the damp forest regions of the tropics.

In such grasses the shoots are often strongly dorsiventral, the blades being turned into the plane of the culm, and the shoots usually prostrate, procumbent or ascending. The genera Oplismenus, Ichnanthus, Senites, Pharus and many species of Panicum (as *P. trichoides*) furnish familiar examples of species with broad short blades that are found on the floor of tropical forests. These blades often resemble those of other families of plants, especially Commelynaceæ. The bamboos and the bamboo-panicums (Lasiacis) usually have broad, comparatively short blades. In some cases the broad blades are unsymmetrical, one side being much wider than the other. These oblique blades are common in Olyreæ.

In contrast to the broad surface mentioned above, the blades may be very narrow, when they are said to be filiform or capillary. Often the blades are rolled, thus appearing much narrower than they are when unrolled.

Convolute blades are those in which one margin is rolled over the other. Involute blades are those in which both margins are rolled inward toward the center, the upper surface being inside. Revolute blades are those in which the margins are rolled outward, the lower surface being inside. Conduplicate blades are folded so that the upper surface of the two halves come in contact as in *Poa Fendleriana* and its allies. In common blue-grass one may observe all gradations between flat and completely conduplicate blades. Certain blades that appear to be rolled may be thickened into a slender terete or cylindrical form, the upper surface being represented by a mere groove (forms of *Festuca ovina, Andropogon Urbanianus*).

Petiole.—In some leaves especially those of shade grasses mentioned above, there is a more or less well-marked petiole at the base of the blade.

Examples: Orthoclada, Senites, Ichnanthus, many bamboos.

137. Nervation.—The vascular system of the grass blade consists of a strong main central axis, the midrib, and few to several smaller bundles called nerves, on each side parallel to the midrib. These nerves are continuations of corresponding nerves in the sheaths and they can usually be traced with the naked eye through the region of the collar. The anastomosing bundles, or cross-veins, are usually indistinguishable to the unaided eye. The broad blades of shade grasses (except Pharus and Leptaspis) present arcuate nerves diverging at the base and converging at the apex, with numerous often conspicuous cross-veins, thus simulating the so-called netted-veined blades of dicotyledons.

Besides the various genera already mentioned as having broad blades are the following which also present well-marked cross-veins: Olyreæ, Centhotheca, Senites, Orthoclada, Pariana, many bamboos, and a few other genera. Pharus differs in having straight parallel lateral nerves that diverge from the midrib nearly throughout its length and join with a strong marginal nerve, instead of converging at the apex (Fig. 29). Leptaspis resembles Pharus, but Streptochæta is intermediate.

138. Auricles.—Some grasses bear, one on either side at the base of the blade, appendages known as auricles. These auricles are characteristic of the tribe Hordeæ and are found in certain species of other tribes.

Wheat, rye and barley show prominent auricles. Rice and *Festuca elatior* and its allies are examples outside the Hordeæ. A very unusual development of the blade is shown in *Phyllorachis sagittata* Trim. and *Spodiopogon sagittifolius* Rendle. The base of the blade is extended into a long lobe on either side of the short petiole.

139. Roll-leaves.—In a preceding paragraph (Par. 136), casual mention was made of blades in which, by rolling in various ways, the exposed surface is reduced. This rolling of the blade is a xerophytic character and tends, by reduction of the evaporating surface, to lessen the loss of moisture. Such reduction of surface is characteristic of grasses of plains and desert regions, of sandy soil, especially along the seacoast, and of saline marshes. In some cases the blades are permanently rolled, in other cases they are flat under favorable conditions of atmospheric moisture but readily roll when the moisture decreases. This rolling is a normal protective process and should not be confused with wilting. The blades of roll-leaves are marked on one or both surfaces with parallel channels and ridges, the latter being the nerves. The tissues of the ridges are firm and resistant while the cells of the channels are larger and thin-walled. These large cells, called bulliform cells, readily give off moisture. When the air is moist they remain turgescent, thus pushing the ridges apart and holding the surface flat or at least partly open. As the air grows drier the bulliform cells become flaccid and the blade closes or rolls. To further aid the blades of xerophytic grasses to resist too great a loss of water, the stomata are usually arranged along the sides of the channels and are not exposed when the blade rolls.

Examples of roll-leaves are forms of *Festuca ovina* and species of Stipa and Spartina.

SCALES AND BRACTS

140. Scales are the reduced leaves found upon shoots below the foliage-leaves. They may be observed near the base of shoots of all perennial grasses, occupying generally the portion below the surface of the soil and often a portion for a short distance above the soil. These scales, by overlapping above the growing point as a bud, protect the shoot as it pushes through the ground. Usually there is a gradual transition from scales to foliage-leaves, but sometimes the change is abrupt. In large grasses such as *Gynerium sagittatum*, the portion of the culm occupied by scales is much greater and may extend several feet above the surface of the soil. Bamboos, especially the vigorous shoots of the large species, furnish excellent examples of scales. These throw up a culm several inches in thickness, covered with large scales, and grow many feet in height before they develop foliage-branches. In perennial stemmed bamboos may be observed scales also upon the lower portion of branches. These scales often show transitions to foliage-leaves, the upper bearing rudimentary blades.

Scales are always produced upon rhizomes. Their chief function appears to be that of protection to the growing point as the rhizome is forced through the soil. The scales develop rapidly in the form of a bud at the end, overlapping and sharp-pointed. The terminal portion of some vigorous rhizomes is as hard as wood and as sharp as an awl. By the elongation of the internodes, the scales behind the growing point are separated and may become lacerated or otherwise lose their original shape.

141. Bracts are reduced leaves that are borne on shoots above the foliage-leaves. They may be discussed under two heads, those that are in or near the inflorescence, and those that are specially modified in the spikelet. The latter will be considered in a future paragraph dealing with the spikelet.

Among flowering plants in general, bracts are usually found subtending each branch of the inflorescence down to the individual flower. In grasses these bracts are rarely present. In large panicles, as in some species of Bromus, the lower branches may be subtended by small bracts or there is at least a ridge representing a bract. Sheathing bracts are found in various genera, especially among Andropogoneæ, at the base of the entire inflorescence or of certain portions of it. In some grasses, the uppermost leaf below the inflorescence may have a much-reduced blade, for example many species of Poa, but such leaves are usually classed with the foliage-leaves rather than with bracts. A peculiarly specialized bract is found at the base of the individual inflorescence of Job's tears (Par. 203). It is urn-shaped, bony, and incloses the pistillate inflorescence. At maturity it breaks away as a bead-like 1-seeded fruit.

CHAPTER XII

MORPHOLOGY OF THE FLORAL ORGANS

The floral organs of phanerogams are known to be highly differentiated or specialized shoots, the receptacle representing a stem, and the stamens and pistils representing greatly modified leaves. In the grasses the flowers are nearly always devoid of floral envelopes, the calyx and corolla being absent or represented only by the lodicules. The flower then is reduced to the essential organs, the stamens and pistil, the protection usually afforded by the floral envelopes being here afforded by bracts.

THE INFLORESCENCE OR FLOWER-CLUSTER

142. The flowers of grasses are usually segregated upon distinct shoots that are easily distinguished from the foliage-shoots or the foliage portion of a shoot. These aggregations of flowers constitute the inflorescence.

An inflorescence is always terminal upon the shoot, and commonly these shoots are the main foliage-shoots of the plant, as in wheat, blue-grass, timothy and sorghum. In addition to the inflorescence terminating the main culm and leafy branches, others may arise from the axils of the leaves. Such lateral inflorescences are, of course, terminal upon lateral branches, but since such branches bear no foliage-leaves the inflorescences are said to be lateral or axillary. In some grasses such as bamboos, bamboo-panicums, and less commonly in herbaceous genera, the culms produce foliage-branches some or all of which may end in an inflorescence.

The unit of the inflorescence is the spikelet, which consists of one or more flowers with the subtending floral bracts. The common forms of inflorescence are the spike, the raceme and the panicle.

143. Kinds of inflorescence.—*The spike.*—The spikelets are sessile along an elongated axis. Familiar examples of this form are the members of the tribe Hordeæ, as wheat and rye (Figs. 57–62).

The raceme.—The spikelets are pediceled and borne along an elongated axis. Simple forms of meadow fescue and sheep's fescue show racemes. The individual inflorescence of Paspalum is apparently a spike, but really a spike-like raceme.

The panicle.—The spikelets are pediceled and the inflorescence is repeatedly branched. The oat- and bluegrass are familiar examples (Fig. 54).

Mixed inflorescences.—True spikes, except in the Hordeæ, are rare, as is also the simple raceme. An inflorescence that is apparently a spike often shows that the spikelets are not sessile but more or less pediceled. Such an inflorescence is properly a spike-like raceme. Similarly a panicle may be so contracted that the pedicels and short branches are hidden and the inflorescence appears to be a spike, but in precise language should be called a spike-like panicle (Fig. 38).

The component parts of the inflorescences of the genera Paspalum and Syntherisma (e.g., crab-grass) are spike-like racemes. The so-called spikes or heads of timothy and canary-grass are spike-like panicles.

In the genus Andropogon what appears to be a spike consists of a jointed axis, each joint bearing a pair of spikelets, one sessile the other pediceled. The inflorescence is therefore generally referred to as a raceme or as composed of racemes (Fig. 16).

Simple racemes with elongated pedicels are not common. Simple panicles in which the spikelets are racemosely arranged above and more or less paniculate below are frequent. The meadow fescue and other fescue grasses usually bear this kind of an inflorescence.

Compound inflorescence.—This term has received no very precise application. It is usually applied to a large inflorescence made up of numerous smaller inflorescences, especially if the latter have their distinctness emphasized by sheathing bracts as in *Cymbopogon Nardus* and many other Andropogoneæ.

144. Unisexual inflorescences.—The spikelets that make up an inflorescence are usually alike, and consist of perfect flowers. But sometimes the spikelets are unisexual, the male and female spikelets being in distinct and usually dissimilar inflorescences. There are a few diœcious genera such as Spinifex, Bulbilis, Scleropogon, Gynerium and Jouvea. In these the inflorescence of the staminate plants is very different in appearance from that of the pistillate plants. Sometimes the difference is so great that the different forms might easily be considered by the casual observer to belong to distinct species or even to distinct genera. There are cases where the two forms have been described by botanists as belonging to distinct genera. In the common buffalo-grass of the plains the staminate inflorescence consists of 1 to 3 one-sided spikes raised on a peduncle a few inches long (Fig. 48), while the pistillate inflorescence is hidden among the foliage close to the surface of the ground (Fig. 49). Sometimes (e.g. Distichlis) the staminate and pistillate inflorescences are similar though not alike (Fig. 52).

Fournier described the genus Jouvea from pistillate specimens. Staminate plants of the same species (*J. straminea* Fourn.) he referred to Brizopyrum. The staminate specimens of *Jouvea pilosa* (Presl) Scribn. were first described under Brizopyrum. The staminate plants of *Bulbilis dactyloides* were first described under Sesleria.

145. Monœcious genera, in which the staminate and pistillate flowers are borne in distinct and dissimilar portions of the inflorescence, are not common. These include Tripsacum, Olyra, Zizania, and a few related genera. In Tripsacum the staminate flowers occupy the terminal portion of the spikes. In Olyra and Zizania (Fig. 31) the staminate flowers are in the lower part of a panicle. In a very few genera, the staminate and pistillate inflorescences occupy different parts of the same plant. Zea and Euchlæna belong to this group. The tassel of the corn is the staminate inflorescence; the ear is the pistillate inflorescence. Not a few grasses, as many Andropogoneæ, produce unisexual spikelets that are interspersed with perfect spikelets, usually in some definite relation, but all in the same inflorescence (Fig. 16).

146. The axis of inflorescence.—The usual form is slender and cylindrical, but it may take on a variety of other shapes. In the spike of Hordeæ, the axis is somewhat zig-zag by the alternate insertion of the large spikelets at the nodes. The internodes or joints are flattened or concave toward the spikelet and convex on the opposite side. In many Hordeæ the axis disarticulates at the nodes at maturity. Such disarticulation often occurs also in other groups, especially among the Andropogoneæ. The axis is sometimes greatly thickened and the surface hollowed out, the spikelets fitting into the cavities. Such is the case in Tripsacum, Manisuris and several other genera of these tribes, and also in Stenotaphrum (Fig. 28). In the latter, however, the inflorescence is really branched, shortened branchlets with 2 spikelets being borne in each of the cavities of the axis. Sometimes, as in Tripsacum and Euchlæna (Fig. 11), the axis disarticulates and the 1-seeded joints become hard bead-like fruits. The cob of an ear of corn is a greatly thickened axis of inflorescence, the structure of which is discussed in Par. 202.

The spikes and spike-like racemes of Chlorideæ and of many Paniceæ are 1-sided. Here the axis has developed so unsymmetrically that the 2 rows of spikelets have been forced to one side. The axis may appear thin and much flattened as in many species of Paspalum (e. g., *P. repens* and *P. stellatum*) or somewhat triangular with a row of spikelets on each of 2 sides, as in crab-grass.

The name rachis is usually applied to the axis of spikes, and spike-like racemes or panicles, or to the axis of any contracted inflorescence or portion of an inflorescence.

147. Branching of panicles.—The main branches of a panicle are known as the primary branches. Those which arise from these are secondary branches and this name may be applied to branches of the third or higher order. The ultimate branches or branchlets which are the stalks of the individual spikelets are the pedicels and will be considered when the structure of the spikelet is discussed. The primary branches of a panicle often appear to be verticillate or at least more than one from a node. It will be observed however that in many cases there is 1 primary branch and that the others are secondary branches developed at the base of a primary branch. If the verticils are composed of primary branches the aggregation is due to the failure of the internodes to elongate.

If the several branches originating at one node all stand at one side of the main axis and those at the next node stand on the opposite side, it indicates that there is 1 primary branch and the others are basal secondary or even tertiary branches. Blue-grass and cultivated oat illustrate this. The former normally has 5 branches at the lower node of the inflorescence, one of which, the longer central one, is a primary branch, the others being branches of higher order.

148. Motor organs.—In the axils of the primary branches of open or spreading panicles, and often in the axils of some of the secondary branches, are to be found swellings or cushions of tissue. These are motor organs whose function is to spread the branches of the panicle at the proper time. This opening takes place when the spikelets on the branch have reached the stage of anthesis, and progresses from above downward, the branches at the base being the last to develop and open. The movement is brought about by an increase in size due to turgidity thereby spreading the branch. Usually these motor organs act only during anthesis and then harden, but sometimes by losing their turgidity they later bring about a contraction of the panicle, as in *Dactylis glomerata* (Fig. 53) and *Agrostis alba*.

Occasionally the ultimate branches of the inflorescence do not end in a spikelet. Such branches are known as sterile branches. The bristles conspicuous in the spike-like panicles of Chætochloa are sterile branchlets.

THE SPIKELET

149. The spikelets are the units of the inflorescence and are borne upon its ultimate branches, the stalks being called the pedicels. The spikelet consists of a short axis bearing 1 or more flowers in the axils of 2-ranked imbricated bracts. As an example of a typical spikelet, that of *Eragrostis cilianensis* (*E. megastachya*) may be considered (Fig. 51). The lower pair of bracts are empty and are called glumes. The lower is the first glume; the upper the second glume. The midnerve is the keel. The bracts above the glumes are regularly arranged on a slender axis or rachilla, alternately in 2 ranks. These are called lemmas. In the axil of each lemma, except 1 or more of the reduced uppermost, there is a flower, and between the flower and the axis a second smaller bract called the palea. The lemmas are also keeled and have a pair of lateral nerves. The palea is 2-keeled, and is inclosed within the margins of the lemma. The lemma and palea together with the inclosed sexual organs are called the floret.

The spikelet may be interpreted as a specialized branch, bearing a series of bracts, or modified leaves, the lower pair (glumes) being empty, the others (lemmas) bearing a much specialized branchlet (the flower) in the axil, the palea being the prophyllum.

The terminology here adopted differs somewhat from that in common use in early works on agrostology. The terms with which the student is more likely to come in contact are: For glume, the terms empty glume and empty scale; for lemma, the terms flowering glume, flowering scale and lower palea or palet; for palea the altered spelling palet. The objection to the term scale is that this name is applied only to modified leaves on a shoot below the foliage-leaves. The modified leaves of the spikelet are, then, to be included under the general designation, bracts. It seems desirable, however, that special terms be adopted for these parts as they are so often used. In this the writer is following the leading contemporary works on plant morphology. Again, for the sake of brevity and precision, there is a distinct advantage in using separate terms for the bracts containing flowers, and for the empty pair at the base of the spikelet. Morphologically the glumes and lemmas are equivalent, and hence the terms empty glume and flowering glume are entirely proper. But the constant difference in relation and function justifies the greater distinction of the terms employed for them and the reduction of these terms to a single word. The term lemma was first used by C. V. Piper.*

Linnæus called the glumes the calyx, and the lemma and palea the corolla, to coördinate the terms with those used in other groups of plants. The individual glumes, lemmas and paleas he called valves. He speaks of the calyx of Panicum as being 1-flowered and 3-valved; of the corolla as being 2-valved; the calyx of Phleum is 1-flowered and 2-valved; the calyx of Poa is 2-valved but contains many flowers; the calyx of Uniola is 6-valved (referring to the several empty bracts at the base of the spikelet) and contains many flowers.

According to Kunth, the spikelet of Sporobolus consists of 2 glumes and 2 paleas; Panicum of 2 glumes, a lower masculine or neutral flower with 1 or 2 paleas and an upper perfect flower with 2 paleas.

Gray (Man., ed. 5) uses the same terminology as Kunth. Watson (Gray, Man., ed. 6) uses the terms empty glumes and flowering glumes.

Bentham (Benth. & Hook. Gen. Pl.) calls all the bracts of the spikelet glumes and applies the term palea properly. If the glume incloses a flower it is a flowering glume, otherwise an empty glume. Hence the spikelet of Sporobolus is said to have 3 glumes, 2 empty and 1 flowering; of Panicum to have 4 glumes, the fourth and sometimes the third a flowering glume.

Stapf. (Fl. Cap.) uses the terms glumes; valves for lemmas, and pales for paleas.

The spikelet described above may be considered typical and represents the usual structure in the tribe Festuceæ. There are many departures from this type form, however. The glumes may be 1 or none; the flowers in the spikelet may be reduced to 1 or to 1 perfect flower with additional staminate or sterile flowers above or below; the glumes or lemmas may be modified in various ways; or the whole spikelet may be sterile. These modi-

*Contr. U. S. Nat. Herb. 10: 8. March 30, 1906.
Science, N. S. 23: 790. May 18, 1906.

fications will be discussed in detail later. Unisexual spikelets have been mentioned under Par. 144.

150. Sterile spikelets.—Sterile spikelets are those which differ from the spikelets with which they are associated, in lacking sexual organs. For convenience the term is sometimes made to include spikelets that contain stamens, when such spikelets are the equivalents of the sterile ones. In Andropogon the spikelets are in pairs, a sessile fertile one and a second pediceled one, which in different species may be staminate, empty or reduced to the pedicel (Fig. 16). This second or pediceled spikelet is generally referred to as the sterile spikelet. In some genera in other tribes sterile spikelets occur, usually in a definite relation to the fertile ones. These sterile spikelets are prominent in Achyrodes and Cynosurus. In Hordeum the spikelets are in clusters of 3, but usually the 2 lateral are sterile. In *Phalaris paradoxa* the spikelets are in groups of 7 of which 6 are sterile. Sterile spikelets (when lacking stamens) are sometimes called neuter or neutral spikelets. Staminate spikelets, except those referred to above which have a definite position and are the equivalents of neuter spikelets, should not be called sterile spikelets.

151. The pedicel is the stalk of the individual spikelet and represents the ultimate branching of the inflorescence. If the pedicel is so short that it is not evident the spikelet is said to be sessile. On the other hand the pedicels may be elongated and extremely slender as in Orthoclada. Sometimes they are slender and nodding, so that the spikelets vibrate or tremble in the breeze, as in *Briza media*, the quaking-grass. The pedicel may be jointed below the spikelet, in which case the spikelet disarticulates from the pedicel at maturity. This is true of most of tribe Paniceæ. In the series Poæoideæ the pedicel is usually not jointed below the spikelet but the rachilla may be articulated below the first lemma, so that at maturity the upper part of the spikelet falls away leaving the glumes. There are exceptions in both groups. In many species of Eragrostis the rachilla remains attached to the pedicel and the lemmas fall away.

The pedicel is sometimes differently developed in the same inflorescence, as in many Andropogoneæ, where the spikelets are in pairs, one being sessile and fertile, the other pediceled and bearing a staminate spikelet or only a bract which may represent a glume, or the spikelet may be aborted, the pedicel persisting as a naked stalk.

The pedicel may be grown fast to the axis as in Rytilix and Manisuris.

152. The glumes are the 2 empty bracts at the base of the spikelet and are called respectively the first and second glume. They usually differ in shape, nervation or texture or in other particulars from the lemmas above them. Frequently the first glume is smaller than the second and often has fewer nerves. Sometimes this reduction goes so far that the first glume is only a vestige or it may be altogether wanting. Syntherisma shows various stages in the elimination of the first glume, and in Paspalum the first glume is generally absent or represented by a slight ridge. However there are species of Paspalum in which the first glume may be present or absent in the same raceme (*P. distichum,* Paspalum § Dimorphostachys). The first glume in Eriochloa is usually represented by a cup-shaped ridge below the normally shaped second glume, but is present in certain species. Both glumes are absent in a few genera, such as Reimarochloa and Homalocenchrus.

The student should take careful note of the theoretical relations of the parts of the spikelet, since it is a knowledge of these relations that enables one to assign a morphological status to an absent organ. The glumes and lemmas are morphologically equivalent, namely bracts. But in the great majority of species of grasses the lower 2 bracts of the spikelet are empty and the others above contain flowers. By definition the lower pair are called glumes and those above are called lemmas. The glumes are nearly always differentiated structurally from the lemmas.

The theory of the evolution of organisms teaches us to trace the development, progressively or retrogressively, of organs through groups of allied species. Such an examination will usually enable us to interpret correctly the morphology of the organs. For example, we wish to know the morphology of the spikelet of Reimarochloa and Homalocenchrus. In the former we have a spikelet consisting of 1 empty bract and 1 flowering bract. How is this to be interpreted? In the first place we are confident that the genus belongs to the large tribe Paniceæ and that it is closely allied to Paspalum and Panicum. The typical spikelet of the Paniceæ consists of 4 bracts, the uppermost of which contains a perfect flower. This bract, by definition a fertile lemma, is distinctly different from those below. The first and second bracts are empty and by definition are glumes. The third is by definition also a lemma even though it contains no flower. An examination of the spikelets of various genera shows that there are all gradations between species in which the lower lemma, usually called the sterile lemma, contains a perfect flower (Isachne) to those which contain stamens, or only a palea, and finally to those which are empty. This, of course, confirms the statement that the third bract is a lemma. No transitions are found between the glumes and the lemma. But we do find a tendency on the part of the glumes to retrogress in size. The first glume is usually smaller than the second, and the retrogression can easily be traced through its slight development in Syntherisma and Panicum to its disappearance in Paspalum. Similarly the second glume shows a tendency to disappear, culminating in its absence in Reimarochloa. Furthermore, there is no tendency for the second glume to disappear before the first. From the above we conclude that the single empty bract below the fertile lemma in Reimarochloa is the sterile lemma, that is, it is homologous with the third bract or sterile lemma of the typical spikelet of the tribe.

We may also conclude that the 2 organs inclosing the flower of Homalocenchrus are lemma and palea and that the 2 glumes are absent, since in Oryza, a closely allied genus, the glumes are present, though small.

The glumes are sometimes awned, but less frequently so than are the lemmas. They are variously modified and distorted in a few genera, the first glumes of a group of spikelets together forming a sort of involucre around the group (Anthephora), thickened like a bird's head (Lopholepis), globose and pitted (Rytilix). The large second glume is covered with hooks in Nazia so that the group of spikelets becomes a bur. In Alopecurus the glumes are connate, that is, grown together along the edges to form a cup (Fig. 39).

153. Anomalous glumes.—The glumes of some genera of Hordeæ show certain anomalies. In Lolium and in a few allied genera the spikelets are sessile on a flattened rachis but stand edgewise to this instead of crosswise as is usual in other genera (Fig. 57). But one glume (the second) is present and this on the outer side of the spikelet. It is longer and larger than the lemmas, sometimes longer than the spikelet, and looks like a subtending bract. In the terminal spikelet of the spike, however, both glumes are developed. In Sitanion and some species of allied genera the glumes are reduced to subulate awns, these forming a sort of involucre to the groups of spikelets. In certain species of Elymus (e.g., *E. virginicus* L.) the glumes of the lateral spikelets stand in pairs in front of the spikelets.

Hochstetter states that the glumes of Hordeum and many species of Elymus are single but cleft into 2 parts. Schenck thinks that they are sterile spikelets. (For full discussion, see Bot. Jahrb. Engler 40: 97. 1907.)

154. The lemmas are the bracts of the spikelet above the glumes. They ordinarily subtend flowers but sometimes are empty. The lemmas vary from 1 to many (as many as 50 in Eragrostis) and except in Streptochæta are in 2 ranks upon the rachilla. As is usually the case with bracts, the lemma represents the leaf-base, the blade not being developed.

Streptochæta is an anomalous Brazilian genus in which the lemmas are spirally arranged.

In the more primitive forms of grasses, the lemmas are usually bract-like in appearance and in a general way resemble the glumes, being greenish, keeled and nerved. In more modified forms such as Andropogoneæ, the lemmas are often thin and delicate, being entirely inclosed by the enlarged and indurated glumes. On the other hand, the lemma may be hardened, as in most Paniceæ, where the lemma of the fertile floret is hard, usually smooth and nerveless. Modification is carried to a greater extent in the lemma than in any other organ of the grass plant. For this reason the form of the lemma is of great importance in classification, its shape, texture and nerving being uniform within definite limits in any given genus. In those genera, such as Andropogon and its relatives, Hilaria, Anthephora and the like, in which the glumes are enlarged, indurated or otherwise specialized, the lemmas are found to be thin or small or otherwise to show but little modification.

In grasses having unspecialized or but slightly modified glumes, as in most of the genera, the lemmas are usually strongly characteristic. The lemma, whether bearing a fertile flower or empty, as in the lower lemma in most species of Paniceæ, or modified into a cluster of awns, as in some species of Chlorideæ, is to be recognized by its position on the rachilla. In canary-grass (*Phalaris canariensis* L.) there are 2 minute bracts at the base of the fertile lemma. These are greatly reduced lemmas. The indurated lemma of Stipa and Aristida is peculiar in that it assumes a cylindrical form and extends downward into a hard, sharp-pointed callus (Figs. 35, 36). At maturity the fruits, by means of this sharp point and by the hygroscopic awns at the apex, are able to bury themselves in the soil. Certain genera of Andropogoneæ (Heteropogon, Chrysopogon) produce fruits similar in general appearance to those of Stipa, but in the former the fruit is developed from a spikelet instead of from a floret.

In Heteropogon and other genera of Andropogoneæ with stout awns, the first glume is indurated, cylindrical and sharp-pointed at base as in the lemma in Stipa. Within this are the second glume, the sterile lemma and the fertile lemma, all thin and hyaline, the latter bearing the long stout awn.

155. Sterile florets and sterile lemmas.—Sterile florets are those which differ from the perfect florets of the spikelet in which they are found in lacking pistils. They may also lack stamens, and consist of a lemma and palea, or the palea also may be lacking. The lemma of such a floret is called a sterile lemma. If a lower floret lacks stamens, then the lemma is the same as the third empty glume of some authors, when they refer to bracts above the first pair. In many genera of the series Poaoideæ the upper florets are reduced to sterile florets. In Melica there may be 2 or 3 sterile lemmas successively convolute one within another. In most of the genera of Panicoideæ there is a sterile floret below a terminal perfect one. The sterile floret of Panicum and its allies has been mentioned before (Par. 152). The sterile lemma of Andropogoneæ, also below the perfect floret as in Paniceæ, is membranaceous, thinner than the glumes, often very delicate. In the tribe Phalarideæ, there are usually 2 sterile florets at the base of the terminal fertile floret (Fig. 34). These lateral florets may be empty (Phalaris, Anthoxanthum) or staminate (Savastana).

156. The awns are bristle-like continuations of the nerves of the glumes or lemmas. Awns involve vascular tissue while hairs of various kinds (trichomes) involve only epidermal tissue. The commonest position for the awn is terminal as in Festuca, where the midnerve is extended as a bristle. Often the apex of the lemma is cleft and the awn arises from between the lobes or teeth. Occasionally the 2 teeth thus formed are also awned. Sometimes the lateral nerves of the lemma extend into teeth or awns (Tridens).

In the cases mentioned, the central awn is terminal. Sometimes the awn arises below the apex of the lemma even nearly at the base, in which case it is said to be dorsal. When the awn is dorsal, the lemma shows no midnerve above the point of attachment of the awn or rather above the point where the midnerve separates from the tissue of the lemmas, thus forming an awn (Fig. 45). The awns of Aristida (Fig. 35) are usually trifid, with divergent often much-elongated branches (as much as 4 inches long in a South American species). In Pappophorum the lemma is divided at the summit into many awns. In other genera the awns are hooked, or bent, or variously divided, sometimes smooth, but usually scabrous, sometimes plumose. In several genera the awn is jointed at the base and deciduous, as in Oryzopsis, Nassella, Piptochætium.

Morphologically the awn is thought to represent the blade, and the lemma the sheath of a primary leaf. If the awn is dorsal the free portion of the lemma above the insertion of the awn probably represents the ligule. (See Domin, Ann. Jard. Bot. Buitenzorg 24:200. 1910.)

157. Twisted awns.—Not infrequently the awns are spirally twisted. This torsion is well shown in the large awns of certain species of Stipa, such as the porcupine-grass of the prairies (*S. spartea* Trin.). The awns are several inches long, stout at base but tapering to a fine point (Fig. 36). The awn at first is straight and untwisted, but at maturity it bends at 2 points and becomes closely spirally twisted up to the second bend. The torsion is very sensitive to atmospheric moisture so that the awn becomes less twisted or almost straight in moist air and twists tightly again in dry air. Twisted awns are found especially in Andropogoneæ (Fig. 16), Aveneæ (Fig. 44), and Stipa.

158. The palea is the bract standing between the flower and the rachilla. It is usually 2-nerved or 2-keeled with the space between the nerves concave and with the margins bent forward about the flower. It is homologous with the prophyllum which it resembles in structure. The palea is usually embraced by the lemma at the margins, or sometimes entirely inclosed as in Stipa and Aristida, although it may project more or less at the apex. Though the palea is usually 2-nerved, it is apparently 1-nerved in a few genera because the 2 nerves are so close together (e.g., Cinna). So-called 1-nerved paleas occur only in 1-flowered spikelets. The apex of the palea is usually rounded or notched but may be toothed, the teeth being rarely awned. The keels are usually smooth or scabrous but may be ciliate (Eragrostis), winged (Pleuropogon), or the margins may be greatly enlarged (Ixophorus). The palea is reduced to a nerveless scale or may be obsolete in Agrostis and in species of Andropogon. The palea usually falls from the rachilla together with the lemma but may be persistent upon the axis (e. g., Eragrostis, Fig. 51).

159. The lodicules are small organs found at the base of the floret, outside the stamens. They are usually 2 in number, standing in front of the lemma, close together. A third lodicule is present in a few genera and is placed in front of the palea. In the anomalous bamboo genus Ochlandra there are several lodicules. The function of the lodicules is to open the floret at anthesis. They become turgid and thus spread the lemma and palea apart, later collapsing and allowing the floret to close by its own elasticity. The lodicules are interpreted by some to be homologous with the divisions of a perianth of which only 2 divisions have usually persisted.

160. The stamen consists of a delicate filiform filament and a 2-celled anther, opening by longitudinal slits. The anthers are basifixed but so deeply sagittate, as to appear versatile. There are usually 3 stamens, 1 standing in front of the lemma and 1 opposite each edge of the palea. Sometimes there is a second whorl inside of the first and alternating with it, making 6 stamens (most bamboos, many Oryzeæ). There are various departures from these numbers. There may be only 2 (Diarrhena), or only 1 (Cinna), rarely 4 in 2 whorls, and in certain anomalous genera more than 6 (Pariana, Luziola, Ochlandra). The filaments are more or less connate in a few bamboos and in Streptochæta.

From the standpoint of evolution, the species with 6 stamens in 2 whorls probably represent a more primitive form as this structure would tend to show relationship with the lilies. The species with 1 and 2 stamens evidently show a reduction from the usual 3-stamened type by the abortion of 1 or more of its members.

161. The pistil is single, with a 1-celled ovary, 2 styles and 2 stigmas. Occasionally there are 3 styles (Streptochæta, some bamboos), or only 1 (Nardus). There is apparently only 1 also in corn (the "silk") but this arises from the union of 2. When there are 2 styles or 2 sessile stigmas they arise not from the apex of the ovary but from the sides near the apex. Sometimes there is a single style that divides into 2 branches. The styles of corn are unusually long and slender thus raising the stigmas out of the large bracts or husks surrounding the ear. The stigmas usually consist of papillate or plumose continuations of the styles. The ovary contains a single ovule grown to the side of the ovary without a funiculus, the micropyle turned downward. In Streptochæta and Streptogyne the long spirally twisted styles and stigmas of adjacent spikelets become interlaced at maturity.

According to Hackel and others, the pistil is 1-carpeled; according to Walker, it is made up of 3 carpels (Walker, "On the Structure of the Pistils of Some Grasses." Univ. Nebr. Studies 6: No. 3. 1906.)

162. The fruit is usually a caryopsis, the seed being adherent to the pericarp. The seed-coat is poorly developed and the pericarp acts as a seed-coat. The caryopsis is sometimes more or less united with the palea, rarely also with the lemma. The caryopsis is, however, often inclosed within the lemma and palea without being adherent to them.

As in flowering plants in general the fruit in the restricted sense is the ripened ovary and its contents. In a wider sense the fruit is the ripened ovary together with the adjacent parts which may aid in protection, germination or dispersal. In the present discussion the term fruit is used in both senses.

The fruit of Panicum and allied genera consists of the hard, tightly closed fertile lemma and palea within which is the caryopsis (Fig. 21). Not infrequently the awn of the lemma is involved in the fruit and performs an important function in dispersal or in connection with germination. This is the case with Stipa (Fig. 36), Aristida (Fig. 35), Heteropogen and many Aveneæ. The fruit may include the surrounding sterile branchlets forming a bur, as in Cenchrus (Fig. 27); a greatly hardened inclosing bract, as in Coix (Fig. 12); the joints of the rachis in which the spikelet is partially inclosed, as in Tripsacum; or a combination of rachis joint and long-awned sterile spikelets, as in Sitanion and Hordeum.

Rarely the ovary ripens into some form other than a caryopsis. In a few genera such as Sporobolus and Eleusine, it becomes an utricle, the pericarp being thin and not grown to the seed. In many species of Sporobolus, for example *S. airoides* Torr. and *S. indicus* (L.) R. Br., the pericarp tends to split vertically into 2 valves, thus being dehiscent. The pericarp of Eleusine breaks away irregularly. The fruit becomes a nut or a berry in certain bamboos.

163. The seed consists of an embryo at the base on one side and of endosperm occupying the remaining portion. If the surface of a caryopsis is examined, the position of the embryo is outlined as a depressed usually oval area at the base on the front side, that is, on the side facing the lemma. On the opposite side, next the palea, is the mark called the hilum, which indicates the place where the seed was attached to the wall of the ovary (pericarp). The hilum may be elongated if the seed is attached for a considerable distance, or may be punctiform, and is characteristic in shape for some genera. There is often a furrow on this posterior side of the caryopsis in which will be found the hilum. Since the palea is often grown to the caryopsis this must be removed when searching for the hilum.

164. The embryo is straight or nearly so, the plumule directed upward and the young root downward. The corn grain illustrates the general features of all grass embryos. An important organ is the scutellum which is attached to the embryo at the middle and enfolds it, lying against the endosperm on its outer surface. This organ is thought to represent the first leaf or cotyledon. Its function is to absorb the nourishment from the stored food during germination. In large embryos like the corn there may be observed on the sides of the epicotyl, or first joint above the attachment of the scutellum, the beginnings of lateral or secondary roots. In other genera the rudimentary secondary roots usually appear on the hypocotyl.

165. The endosperm consists mainly of starch, although there is a considerable amount of oil, which, however, is mainly in the embryo. On the outside within the epidermis is a layer of cells containing aleurone, rich in protein. The stored food is also called albumen by some authors. The endosperm is hard and corneous or mealy according to the density of the starch-containing cells.

166. The rachilla is the axis of the spikelet. It may be jointed to the pedicel below the glumes (usual in Panicoideæ), or jointed above the glumes (usual in Poaoideæ). It may be continuous (Eragrostis, Fig. 51) or articulated between the florets at maturity (Festuca).

In genera with many-flowered spikelets the rachilla is of course elongated, while in 1-flowered spikelets it is reduced so that the floret seems to be terminal. It often extends beyond the insertion of the upper floret in many-flowered spikelets but is usually hidden by the upper lemmas. In 1-flowered spikelets the rachilla may extend beyond the base of the floret. It then appears as a slender sometimes plumose bristle or stalk pressed against the palea. This extension of the rachilla sometimes bears a rudimentary second floret. The first internode of the rachilla above the glumes is sometimes elongated, forming a stipe to the floret. This stipe may be developed into a sharp-pointed callus, which at maturity aids in seed-dispersal (Stipa, Aristida). Usually the internodes of the rachilla between the florets are short, the florets being closely imbricated; but, occasionally, they are elongated, the florets being rather distant, as in Senites.

A peculiar jointing of the rachilla is to be observed in *Festuca subuliflora* Scribn. in which there is an articulation midway between the distant florets. This is probably due to "a downward elongation of the callus, surrounding and becoming grown to the rachilla, which has likewise become elongated so that the joint is still at the base of the callus." *

* Piper, Contr. U. S. Nat. Herb. 10: 36. 1906.

CHAPTER XIII

ECOLOGY

ECOLOGY is that branch of botany which treats of the relation of plants to their environment. It is often considered to be a branch of physiology since it is a study of the response to stimuli. Plants are acted upon by external factors, either physical or biological. The response to these forces determines the plant's adaptation to its environment. The more important ways in which grasses are influenced by environment will be briefly discussed.

SEED DISPERSAL

167. The seeds of grasses are for the most part adapted to dispersal by means of the wind. Some kinds are so small that they are readily transported in this manner without any special adaptation. The fruit by itself (Eragrostis) or inclosed in the lemma and palea (Poa) is easily blown about by air currents. In Panicum and its allies the whole spikelet falls away by disarticulating below the glumes. Among the Andropogoneæ the axis of the spike usually disarticulates between the pairs of spikelets and the resulting joints are sufficiently small to allow of their being easily transported by the wind.

168. Dispersal by wind.—But the fruit is not infrequently modified in such manner as to make wind dispersal more effective. A common adaptation is the development of silky hairs on some part of the fruit. Such hairs are found on the lemmas in Arundo, on the rachilla joints in Phragmites, on the whole spikelet in Saccharum (Fig. 14), on the awns in *Stipa pennata* L. of Europe and *S. speciosa* Trin. & Rupr. of California, on the long pedicels of *S. elegantissima* Labill. of Australia. Awns and bristles often aid dispersal by increasing the surface. Clusters of spikelets, with their surrounding involucre of bristles, fall away from the rachis, the bristles catching air currents. Long-awned species of Hordeæ, with disarticulating rachis, are adapted to wind dispersal. Sitanion and Hordeum are good examples of this. The joints of Sitanion, with their numerous long awns spreading in all directions, are sent whirling across the open grassland in the western states. In many species of Aristida (Fig. 35) the 3 awns spread horizontally or are somewhat reflexed. On the Great Plains it is common to see, at the proper season, the fruits of these grasses being hurled along by the high winds, the sharp-pointed callus to the front ready to catch in the wool or hair of animals. From such fruits it is an easy transition to wing-fruits, in which the increased surface is furnished by wings, appendages or sterile parts. The inflated lemma of Briza, the winged crests on the lemmas of Phalaris, the group of sterile spikelets of *Phalaris paradoxa*, all aid in dispersal. In some grasses the whole inflorescence breaks away and becomes a "tumble-weed." The panicles of *Panicum capillare* L., *Agrostis hiemalis* (Walt.) B. S. P., *Chloris verticillata* Nutt. and *Eragrostis pectinacea* (Michx.) Nees, are familiar examples. At maturity the panicles separate from the plant and roll over the surface of the ground before the wind, the widely spreading branches making the whole very light. The small fruits are dropped here and there as the panicle travels. The inflorescence of *Schedonnardus panic-*

ulatus (Nutt.) Trel., a common grass in Texas, consists of several slender distant spikes arranged along a slender axis. After flowering, the central axis greatly elongates becoming at the same time somewhat spirally coiled. The lateral spikes also elongate. There results a loose cylindrical skeleton that can be easily rolled along by the wind after it disarticulates from the parent plant.

An indirect method of adaptation for wind dispersal is illustrated by the fruits of *Eleusine indica* (L.) Gaertn. and *Sporobolus indicus* (L.) R. Br. The pericarp of these, when wet, develops a mucilage by which the seeds are enabled to stick to leaves or other objects that may be blown about by the wind. In so far as they are able to stick to birds or other animals they are adapted also to this method of dispersal.

169. Dispersal by animals.—Some grasses are adapted to dispersal by the aid of animals. The species of Cenchrus (Fig. 27) produce burs made up of a group of connate branchlets armed with retrorsely barbed spines. The bur-like spikelet of Nazia produces hooks on the second glume. The callus of the fruits of Aristida (Fig. 35), Stipa (Fig. 36), Heteropogon, Chrysopogon and other needle-fruits of this kind, is sharp-pointed and armed with retrorse hairs. Such fruits readily bore into the coats of animals. The fruits of certain Hordeæ, with disarticulating rachises, have been mentioned above under adaptations for wind dispersal Usually in these fruits, the point of the rachis-joint is sharp and the awns are antrorsely scabrous (the teeth pointing forward). They thus are adapted to working their way into the coats of animals. In *Panicum glutinosum* of the American tropics the spikelets are viscid and readily attach themselves to a passing body.

GERMINATION

170. The situation of the embryo in the grass seed is such that by the enlargement and growth of the organs the plumule and root at once emerge in opposite directions. The seed remains in position, which is usually upon the surface of the ground. The primary root at first elongates but soon secondary roots appear which in a short time exceed the primary. The plumule pushes up somewhat later. The first leaf of the plumule acts as a protecting sheath and never develops into a foliage leaf. If the seed is below the surface of the soil this sheath, closed at the apex, elongates until the surface is reached, when the tip breaks and the bud pushes through. In many embryos there is a small scale-like organ (epiblast) at the base of the plumule opposite the scutellum. This is thought by some to represent a leaf, in which case the scutellum is the first leaf or cotyledon, and the protecting sheath of the plumule is the third leaf.

171. The germination of the maize is described at length by Collins. The protecting sheath he calls the coleoptyle. Between the coleoptyle and the seed is a more or less elongated axis to which the name mesocotyl is given. This portion is called by Hackel and others the epicotyl on the supposition that it is an internode above the cotyledon or scutellum. Collins and others consider the scutellum, epiblast and coleoptyle to be all parts of a highly specialized cotyledon. Collins also describes the germination of Hopi and Navajo varieties of maize in which the mesocotyl elongates greatly, reaching the enormous length of 25 or even 30 cm. The plumule is thus able to reach the surface from a corresponding depth. Such varieties are adapted to dry regions. The usual varieties of maize are unable to force the mesocotyl to a length greater than 10 cm. (Collins, Journ. Agr. Res. 1:293. 1914).

172. Impervious seed-conveyers.—At maturity all seeds are moderately dry within, that is, for the preservation of the endosperm during the dormant stage the moisture has been reduced to a minimum. To protect the contents against further loss of moisture which would injure or kill the embryo, the seed is enveloped by an impervious coating, which serves the double purpose of preventing the loss of moisture from within and the absorption of moisture from without. The protecting coating may be in immediate contact with the seed or it may be developed from some outer coating or organ. If an outer coating such as the glumes become hardened for this purpose, then the inner organs, lemma and pericarp are comparatively thin.

The protective coating is developed from the seed-coat (Sporobolus), pericarp (wheat), lemma and palea (Panicum), glumes (Andropogon), rachis and glume (Tripsacum), sheathing bract (Coix), involucre (Cenchrus), or various combinations of these. In some cases, as in Cenchrus, several seeds are protected by the same outer coating.

173. Self-burial.—The dormant stage continues through the season unfavorable for germination, that is, winter or a dry season. When the season for germination arrives, the seed, under the influence of moisture and higher temperature, gradually absorbs water, growth is started, the embryo swells and bursts through its surroundings, and germination has begun. Ordinarily the seeds are more or less covered with earth or debris by the action of the wind. But some seeds are aided in self-burial by the torsion of the awns they possess. The awns of Stipa (Fig. 36) have already been described (Par. 156). By the alternate drying and wetting they twist and untwist, bend and straighten. The fruits, being provided with a sharp callus, covered with retrorse hairs, gradually insinuate themselves into the porous covering of the soil and finally into the soil itself. As the fruit is heavier at the base, it tends to fall point down. Awns of this kind are found upon the fruits of a number of genera, the burial being brought about by the rotation of the twisted portion or by the bending and straightening of a geniculate portion or by a combination of these. Straight awns or bristles that are antrorsely scabrous undoubtedly act in the same manner.

Examples of tortion: Stipa, Aristida, Heretopogon, Chrysopogon, Sorghastrum, Arundinella, Avena, Danthonia. Examples of antrorsely scabrous awns: Hordeum, Sitanion.

174. Water grasses.—The seeds of water grasses fall into the water and remain moist until germination. It has been shown that the seeds of *Zizania palustris* are injured by exposure for any considerable length of time* to the drying influence of the air.

If the caryopsis at the time of germination is normally inclosed within outer envelopes, as lemmas or glumes, the embryo must be able to push its root and plumule through or around these parts. The usual method is for the root to break through the obstruction and for the plumule to push up between the parts.

Some of the grains (wheat, rye, corn and kafir) are naked caryopsides and the growth of the embryo is unhampered. The grain or caryopsis of the oat is permanently invested by the lemma and palea. The root breaks through the back of the lemma near the base and the shoot pushes up between the grain and the lemma, emerging at the apex. The fruit of barley also consists of the grain inclosed in the lemma and palea and more or less adherent to the

* For a full discussion of this subject, see Brown & Scofield, "Wild Rice: Its Uses and Propagation." U. S. Dept. Agric. Bur. Pl. Ind. Bulletin No. 50. 1903

former. Emmer differs from wheat in that the whole spikelet containing several seeds becomes a fruit and breaks away from the rachis entire. The seed-like fruit of foxtail millet (*Chætochloa italica*) and proso millet (*Panicum miliaceum*) consists of a coriaceous lemma and palea tightly inclosing the thin-walled caryopsis. In all these cases the root breaks through the back of the lemma near the base by splitting the tissue and the shoot pushes up through the space between the caryopsis and the lemma, emerging near the tip. In Johnson-grass (*Holcus halepensis*) the grain is enveloped by the hard glumes and delicate lemma, sterile lemma and palea. The tissue of the glume appears to be too firm to permit the root to penetrate, for it passes through between the glumes. The fruit of tall oat-grass (*Arrhenatherum elatius*) consists of 2 florets, only the second of which is fertile. The root passes through the back of the lemma of this floret. Rice germinates in a manner different from that of the other fruits described. The caryopsis is inclosed in the much-flattened and keeled lemma and palea. The shoot breaks through the back of the lemma at the base and appears first as a pointed organ at the base of which later emerge the roots.

175. Propagation by bulblets.—Some grasses of high latitudes and altitudes produce, in the inflorescence, bulblets in place of ordinary spikelets. Bulblets are spikelets or portions of spikelets, in which the floral bracts have been transformed into small leaves, the whole becoming a vegetative shoot. These bulblets, which may be provided with young roots, fall off and produce new plants. A number of species may, under certain conditions, produce bulblets, while a few do this uniformly in certain regions (*Poa bulbosa* L.). Certain species (as *Poa alpina* L.) are ordinarily sexual but in extremes of altitudes and latitudes are asexual.

PLANT SOCIETIES

176. So far as concerns their adaptation to environment based upon condition of moisture, grasses may be divided into four groups—mesophytes, xerophytes, halophytes and hydrophytes. It should be understood that there is no sharp line between these groups. There are transitions in all directions. It is impossible to define in exact terms the limits that circumscribe these groups. One cannot, except approximately, say that plants growing upon soil containing certain definite limits of moisture shall be classed as mesophytes and that between other limits the plants shall be called xerophytes. Many other conditions modify the effect. One must judge rather by the sum total of the effect upon the plant, that is, the reaction to environment. If the plant shows general adaptations that aid it in resisting loss of moisture, the plant is a xerophyte. However, it often happens that the soil may contain sufficient moisture a part of the time and a deficiency at other times. So far as the plant is concerned the critical period is the growing season. A beech tree is a mesophyte in summer and a xerophyte in winter. In the summer there is sufficient moisture for its broad thin leaf-blades. In winter the ground freezes, the branches and twigs may freeze, moisture can not be supplied to so great a surface, and the surface is reduced by casting off the leaves. Nevertheless the beech is classed as a mesophyte. On the other hand, desert regions are visited occasionally by heavy rains and for a short time the soil may be saturated. But the plants of these regions are called xerophytes, because these periods of abundance are not of sufficient length to effect the general adaptations of the plants.

177. Mesophytes.—As the name indicates, this group includes those grasses that thrive under medium conditions of moisture. They are not water plants on the one hand, and on the other hand are not especially adapted to resist evaporation. They include most grasses of swamps, bogs, moist land along water-courses, and the inhabitants of forest and woodland. Grasses that become weeds in cultivated and waste soil usually belong to the mesophytes. In general they have flat blades and will endure considerable alternation of conditions between a large amount of soil moisture and a moderate amount of drought.

Familiar examples of mesophytes are the common cultivated grasses, such as corn, the small grains, sorghum, sugar-cane, the meadow grasses, common annual weeds, such as crab-grass and foxtail, and the shade grasses of the tropical forests.

Certain areas of open grass land include a mesophytic flora. Natural meadow land contains too much moisture to be classed as prairie. Grass land which contains an excess of water, but not enough to support strictly water plants, may be classed as bog, swamp, marsh or slough. The tundra of northern regions includes a large grass element. It is open wet land—wet because the subsoil is frozen and there is poor drainage. At high altitudes are found mountain meadows that support a mesophytic flora, even though the soil be dry, the low temperature being the determining factor.

178. Xerophytes.—These are grasses that are fitted to endure soil conditions in which the moisture content is deficient. They are, in consequence of this deficiency provided with especial adaptations to resist evaporation. In xerophytes belonging to other families of plants, water-storing organs are common, but among grasses this adaptation is rare.

Panicum bulbosum H. B. K., of New Mexico, is provided with a corm which probably acts as a storehouse of moisture. The corms at the base of some species of Melica, and the chain of corms in

Arrhenatherum elatius bulbosum (Par. 241) may serve for storage, although the plant last mentioned is not a xerophyte.

In general, xerophytic grasses have become adapted to their surroundings by the production of impervious epidermis or of mechanical tissue in leaves and stems and by fine foliage. Roll-leaves, described in a preceding paragraph (Par. 139), are common. The foliage of xerophytic grasses is nearly always firm and hard from the excessive development of sclerenchyma fibers and other mechanical tissue and the relative lack of soft parenchymatous tissue. The stomata are in protected places, in the longitudinal furrows of the blades or on the inside of rolled blades. All these structures tend to retard evaporation and prevent the loss of water which cannot readily be obtained from the dry soil.

There are four chief habitats where xerophytic grasses may be found,—prairie, sandy soil, rocks and desert.

179. Prairie is open grass land where the soil is deficient in moisture. If open grass land occurs upon soil in which there is no deficiency of moisture it may be swamp, tundra or mountain meadow as indicated under a preceding paragraph (Par. 177). Prairies are found as isolated areas interspersed through regions that are chiefly occupied by a mesophytic flora, as the eastern united States. In Iowa and Missouri, they occupy large areas, with woodland interspersed. A vast prairie extending from Texas northward far into Canada is called the Great Plains. Similar regions in western Asia are called steppes and in South America are called pampas and llanos. In Central America and in some other countries, they are known as savannahs (or savannas). The dominant plants of these prairies and plains are grasses. In general, there are many species producing rhizomes or stolons so that much of the surface is covered by a sod. Stipas and various Andropogoneæ, especially Andropogon, are often dominant species. Over much of the Great Plains, a single species, *Bulbilis dactyloides* (buffalo-grass) or this combined with *Bouteloua gracilis* (grama-grass) gives a characteristic aspect to the vegetation. Those grasses often called "short grasses" may occupy vast areas almost to the exclusion of other species of plants. Farther south, the Bulbilis is replaced by *Hilaria cenchroides* (curly mesquite). This portion of the Great Plains is known locally as the "short-grass country" because the uniform compact curly growth is only a few inches high. The regions described above are known as semi-arid regions.

180. Sandy soil.—Plants characteristic of sandy soil are sometimes called psammophytes. The best illustration of this kind of xerophytes may be observed upon sand-dunes. These are found along sandy seacoasts of temperate regions, the sandy shores of lakes, along the banks of rivers, especially in arid regions, and in dry interior regions far removed from bodies of water. Such areas are found in the United States along the Atlantic seaboard, especially on Cape Cod, along the Great Lakes, especially the eastern and southern shore of Lake Michigan, and along certain large rivers, such as the Columbia east of the Cascades, and the Arkansas in western Kansas. Large areas of sand hills are found in interior regions such as central Nebraska.

181. Sand-dunes may be so far removed from water or in such rapid motion that no vegetation can be supported. Dunes near the sea, though completely dried out at the surface may be moist beneath on account of the drawing of water from below by capillary attraction. Many grasses of sand-dunes produce a well-developed system of rhizomes. These do not form a sod as the soil is too poor in plant-food to support plants sufficiently near together. Representative species are *Ammophila arenaria* and *Spartina patens* (Ait.) Muhl. along the seacoast, *Calamovilfa longifolia* (Hook.) Hack. in the Great Plains, *Elymus flavescens* Scribn. & Smith in the Columbia River basin and *Elymus arenarius* L. of the Alaskan seacoast. The first mentioned, *Ammophila arenaria*, called beach- or marram-grass, is a typical sand-binder. It not only produces widely extending rhizomes which may reach great depth, but the culms push upward as the sand drifts around them. (Par. 93).

182. Pine-barrens.—Sandy regions in which there is a sparse forest-cover represent xerophytic conditions, though less marked than those of dune areas. The pine-barrens of the Atlantic coastal plain are typical of these regions. They are mostly level areas covered with open pine woods. Southward they include the turpentine country, and in Florida they become the "high pine land" and the still more xerophytic "scrub." These regions are the home of the smaller species of Panicum and many other peculiar grasses.

183. Rocks.—On account of the impervious substratum, plants growing upon rocks are insufficiently provided with water unless near some source of supply, such as spray from a waterfall, springs, melting snow and the like. Hence xerophytic grasses may occur in a mesophytic region. Such grasses are bunch-grasses as rhizomes do not develop under these conditions.

184. Deserts.—Regions in which the deficiency in the water-content of the soil is greater than in prairie and in which the humidity of the atmosphere is very low, are called deserts, or arid regions. Deserts owe their aridity primarily to scanty rainfall rather than to soil conditions, as in the case of rocks and sand-dunes. They are so situated that the prevailing winds have been previously deprived of their moisture by passing over mountains. The chief desert region of the United States is found in the Great Basin from the plains of the Columbia in eastern Washington southward through Arizona to the Mexican plateau. The aridity increases southward and reaches its maximum in the Colorado Desert of southeastern California. The annual rainfall is less than 20 inches, often less than 10 inches. On account of the higher temperature and longer summers the aridity increases southward even though the rainfall may remain the same. Other desert regions are found along the Pacific slope in Peru and northern Chili, in the interior of Australia and Asia, and the Sahara Desert of north Africa.

The perennial grasses of deserts are for the most part bunch-grasses and on account of the scarcity of moisture the bunches are widely scattered. In contradistinction to the other xerophytic regions, deserts are inhabited by several species of annual grasses. Such grasses are adapted to the distribution of the rainfall. This usually comes in occasional heavy showers. Immediately after such a shower the seeds of annuals germinate, develop rapidly and mature seed before the effects of the shower have passed away. This adaptation to seasonal moisture is especially marked if the showers are concentrated within a certain period of the year forming a rainy season. In southern Arizona there are usually two such rainy seasons, one in winter and one in summer, with a corresponding growth of annuals, many of them grasses, after each period of rainfall. In all desert regions the grasses tend to collect in depressions or drainage basins where the water from showers remains longest.

185. Halophytic grasses are those that grow in soil containing an excess of mineral salts. In general they are known as salt-marsh plants. They are found in the salt-marshes of the seacoast and of interior alkali regions. The soil that supports halophytes may not be lacking in water, but the presence of soluble salts increases the density of the soil-water and hence renders it less easily absorbed by the root-system of the plant. Although growing in water or wet soil, the plants have difficulty in obtaining the necessary water-supply and consequently, to avoid injury from loss of water through evaporation, xerophytic characters have been developed. Among these characters may be mentioned harshness due to the presence of mechanical tissue, roll-leaves, and succulence. Familiar examples of halophytic grasses are *Spartina glabra* Muhl. of the Atlantic coast salt-marshes and *Distichlis spicata* (L.) Greene of the interior alkali plains.

186. Hydrophytes are water plants. They grow in the water, either submerged or from soil that is permanently saturated. Only a few grasses, such as *Hydrochloa caroliniensis* Beauv., are nearly or quite submerged. But there are many that inhabit permanent fresh-water or brackish marshes. To this group belong *Zizania palustris* L. (Indian rice), *Zizaniopsis miliacea* (Michx.) Döll & Asch., *Paspalum dissectum* L. and *P. repens* Berg. *Panicum elephantipes* Nees and *Echinochloa sabulicola* Nees of the American tropics are succulent hydrophytes, growing in several feet of water. *Paspalum repens,* of Panama, forms long runners that float upon the surface of the water, buoyed up by their inflated sheaths.

Swamp-grasses as distinguished from marsh-grasses are usually to be classed with mesophytes, because they are subject to much fluctuation in the water-supply. The soil may be saturated at one time and moderately dry at another time. Swamp-grasses often show xerophytic characters, especially roll-leaves. During the early part of the growing season, particularly in the North, the air at least during the day is warm while the roots are immersed in the cold substratum. There is thus danger of the loss of water by evaporation from the leaves faster than the cold sluggish root-system can supply it; hence the presence of roll-leaves.

GEOGRAPHICAL DISTRIBUTION

187. Geographical distribution of plants is their range or dissemination over the surface of the earth. The present distribution is the result of causes which have acted through an indefinitely long period of time and often over areas of continental extent. Every species of plant occupies its present area by virtue of its ability to adapt itself to its environment. If the environmental conditions change, the plants concerned must become adapted to the new conditions, or they are forced to migrate, or, failing in this, they become extinct. It is not the purpose here to discuss the causes that have brought about these changes, but merely to outline the present distribution of the grass family. For a further discussion the student is referred to the works dealing with the evolution of plants, especially those of Darwin, Wallace, Hooker and Gray.

Darwin: "Origin of Species." Wallace: "Darwinism," "Island Life," "The World of Life," and other works. Hooker: "Distribution of Arctic Plants." Gray: "Collected Essays."

188. Distribution of grasses.—As stated in a preceding paragraph (Par. 121), the grasses are represented in all parts of the earth's land-surface where the conditions are suitable for the growth of flowering plants, from sea-level to the snow-line on the high mountains, from Greenland to the antarctic continent, from swamp to desert, and from the deep forest to the clefts of the boldest cliff. The great tribes Andropogoneæ and Paniceæ predominate in the warmer regions, while the Agrostideæ and Festuceæ predominate in the cooler regions. Space will not permit of detailed references to the distribution of genera and species. Small genera are often much restricted in their area while large genera are usually distributed over a wide area. The great genera Andropogon, Panicum, Paspalum and Eragrostis are found throughout the tropics of both hemispheres. Muhlenbergia and Bouteloua, also large genera, are confined to the American continent and are especially well represented on the Mexican plateau. Poa and Festuca are found in all continents, but mostly in the cooler regions, extending to the northern and southern limit of vegetation, and well represented in alpine regions, even of the high mountains of the tropics.

189. Distribution of species.—Species also vary greatly as to the extent of the area in which they are found. Certain agressive species known as weeds are now widespread over extensive areas of both hemispheres. Crabgrass (*Syntherisma sanguinalis*) and goose-grass (*Eleusine indica* (L.) Gaertn.) are familiar examples. *Heteropogon contortus* (L.) Beauv. is an example of a similarly widespread species which is native throughout its area. Many species of the seashore and of marshes are likewise extensively distributed. *Spartina glabra* Muhl. and *Ammophila arenaria* are found on the seacoast of Europe and America, the one in salt-marshes the other upon sand-dunes. Many species have a circumpolar distribution* and often extend southward along the mountain ranges. *Poa alpina,* found at sea-level within the arctic circle, extends southward in the Rocky Mountains to Colorado where it is found on alpine summits.

190. Circumpolar distribution.—Those species that are indigenous to North America and Eurasia usually show evidence, by a present circumpolar distribution, such as that of *Poa alpina* and many others, of a common origin in polar regions; or they suggest the probability of such distribution in the past. During a preceding warm epoch, when vegetation zones lay farther north than now, many species were circumpolar that afterward were driven south by the succeeding ice period. These species survived only where they found conditions suited to their requirements. Some were driven along the mountain ranges; others were driven along the coastal regions. As the climates of the northeastern coasts of North America and Asia are similar, there are many cases where the same or similar species of plants inhabit both regions.† Among grasses one notes the genera Diarrhena and Zizania, each represented by similar species in the two regions and not found elsewhere.

191. Generic distribution.—Sometimes large genera show a special development in certain areas although there may be scattering species in regions remote from the areas of greatest development. The genera Bouteloua and Muhlenbergia, mentioned above, are represented by numerous species on the tableland of Mexico, although certain species of the former are found as far south as

*Hooker, "Distribution of Arctic Plants."

†Gray, "Analogy between the Flora of Japan and that of the United States."

Argentina, and of the latter as far north as New England, and west even to eastern Asia. The subgenus Dichanthelium of the immense genus Panicum is represented by nearly 100 species in southeastern United States, but there are a few species extending to the state of Washington, and others through the West Indies and Mexico to northern South America. Danthonia, with over 100 species, centers in South Africa, but several species are found in America and other countries.

CHAPTER XIV

TAXONOMY OR CLASSIFICATION

UNDERLYING all present systems of classification of living organisms is the doctrine of evolution, that all organisms are descended from other more or less dissimilar organisms and that in the course of such descent there is an inherent tendency to vary. Classification is an attempt to group organisms in a manner that shall represent, as nearly as our knowledge permits, actual genetic relationships.

192. Species.—The size and limits of the proposed groups are influenced by convenience. The unit of biological classification is the species, a term however which is difficult to define. A species includes all those individuals that show as much resemblance to each other as they might be expected to show if they were all known to be descended from a common and comparatively recent ancestor. As the genetic history of the individuals is not known, the grouping into species is an expression of the opinion of the biologist, and his opinion is based upon judgment and experience. It should be kept in mind that a species is a taxonomic idea* and is not an entity the existence of which can be proved. For this reason, taxonomists often disagree as to the limits of species. The more experience a botanist has had with plants, especially with living plants in their native habitat, the

* "The name itself is but the expression of a taxonomic idea." Greene, "Landmarks of Botanical History," p. 122.

more may his judgment be trusted when defining the limits of species with which he is familiar, and the more nearly should his taxonomic ideas approach the truth. The truth for which the taxonomist seeks is a knowledge of genetic relationships; the grouping of organisms into species, genera and other divisions is a convenience which is intended as nearly as may be to express this truth. In the ever-diverging lines of descent, certain groups of individuals have been cut off, as it were, from their allies, so that in these cases the species of the taxonomist probably does express the truth. In other cases the groups are in process of formation and separation, and are not actually distinct. It is here that the taxonomist meets his greatest difficulties. Even with complete knowledge, his taxonomic ideas can be no more distinct than are the groups as they exist in nature. In proportion to his lack of knowledge is the probability that his taxonomic ideas fail to represent the truth. It follows, then, that a classification submitted by a botanist is accepted by his co-workers in proportion to their faith in his judgment and their knowledge of his experience. The members of a complex group of allied species may have been defined and their limits placed with approximate accuracy and yet it may be impossible definitely to refer every individual to its proper species. According to the degree of divergence of allied species in their descent from a common origin, there are a greater or less number of intermediate individuals. The existence of individuals intermediate between two species should not invalidate those species; rather they emphasize the fact that species do not exist in nature, that they are ideas according to which most of the individuals may be classified.

193. Genera.—A genus is a group of species that are thought to be closely related genetically. The species of a genus will show similarity in fundamental characters, such as the structure of the flowers and fruit, and usually also a similarity in habit, or general aspect.

Familiar genera are the oaks, the pines, the asters, the goldenrods; or, among grasses, the blue-grasses and the wheat-grasses, the millets and the bromes.

As genera do not exist in nature, but represent the taxonomist's ideas as to groups of related species, botanists may not agree as to the limits of genera. The size of genera, that is, the number of species included, is sometimes a matter of convenience. Conservative botanists would probably not recognize Panicum and Paspalum as separate genera, when considering the generic characters only, but each group contains such a large number of species that the two have been kept distinct for convenience. Some species are so different from their nearest allies that they cannot be consistently grouped with other species. Such a species stands as the sole representative of its genus, and the genus to which it belongs is called a monotypic genus. It not infrequently happens that after a monotypic genus is established other species are discovered, which are assigned to it, and it ceases to be monotypic. In contrast with monotypic genera are others, such as Panicum, Andropogon and Poa, with hundreds of species. Large genera may sometimes be conveniently divided into smaller groups, such as subgenera and sections.

From a nomenclatorial standpoint the term monotypic is used to indicate genera with only one species at the original place of publication. Cook suggests the word haplotypic for such genera. (Amer. Nat. 48:311. 1914.)

194. The grass family and its subdivisions.—The genera of plants are grouped into families, and these into orders and higher divisions of the vegetable kingdom. The grass family is called Poaceæ or Gramineæ, and this with the Cyperaceæ (sedges) constitute the order Poales or Glumifloræ.

The term Poales is used for the order in the "North American Flora," the termination -ales being uniformly added to a generic stem to form the names of orders. Glumifloræ is used by Engler and Prantl in their "Pflanzenfamilien." Glumaceæ is used by Bentham and Hooker ("Genera Plantarum") as the name of the series that includes Eriocauleæ, Centrolepideæ, Restiaceæ, Cyperaceæ and Gramineæ. The classification here adopted is in the main that of Bentham and Hooker ("General Plantarum") and of Hackel ("Pflanzenfamilien"). The latter author will be followed in the enumeration of the tribes. Although Hackel's classification is in some respects artificial, it is on the whole the most natural arrangement yet proposed.

The family Poaceæ has been divided for convenience into 2 series and 13 tribes.

195. The 2 series of tribes.—Modern agrostologists usually divide the genera of grasses into 2 series. The first series Panicoideæ (or Panicaceæ), the more highly developed or modified, is characterized as follows: Spikelets with 1 terminal perfect floret and often a staminate or neutral floret below; an articulation below the spikelet, sometimes in the pedicel, sometimes in the rachis, sometimes at the base of a cluster of spikelets, the spikelets falling away at maturity singly or in groups, or with portions of the rachis; spikelets usually more or less dorsally compressed, rarely laterally compressed. The second series, Poæoideæ, is characterized as follows: Spikelets with 1 to many florets, the imperfect ones when present usually being above; rachilla often articulated above the glumes; spikelets usually laterally compressed.

There are exceptions to all these characters. In some cases the exceptional genera are clearly related to others that conform to the above definitions. Other genera are more or less anomalous and are tentatively placed in the category to which they seem most nearly related. In Isachne the lower floret is perfect and similar to the upper, but it is evidently allied to Panicum and hence is placed near that genus in the first series. Several genera, such as Sphenopholis, Spartina and Alopecurus, have an articulation below the spikelet so that the latter falls from the pedicel, in which respect they agree with the first series, but in most characters they agree with the second series, in which they are placed. In Phalarideæ of Series II the imperfect florets are below the terminal perfect one.

196. The tribes of grasses.—There are 6 tribes in the first series and 7 in the second. The following key to these tribes is not made to cover exceptional genera, since to do this for the sake of a comparatively few genera would make the keys unnecessarily complex.

SERIES I

A. Spikelets round or dorsally compressed; hilum short.

B. Lemmas and palea very thin and hyaline, the glumes much thicker.

C. Inflorescences monœcious, the staminate and pistillate flowers in different parts of the same plant............Tribe 1. MAYDEÆ (Chap. 15).

CC. Inflorescences not monœcious, usually a mixture of perfect and staminate or neutral spikelets............Tribe 2. ANDROPOGONEÆ (Chap. 16).

BB. Lemmas and paleas membranaceous or thicker, not thin and hyaline.

C. Lemmas thinner than the glumes.

D. Spikelets falling off singly or in groups from a continuous rachis; the first glume usually larger than the second. Tribe 3. NAZIEÆ (Par. 212).

DD. Spikelets falling off singly from the ultimate branches of a panicle; first glume smaller than the second. Tribe 4. MELINIDEÆ (Par. 213).

CC. Lemmas thicker than the glumes, hardened........................Tribe 5. PANICEÆ (Chap. 17).

AA. Spikelets laterally compressed; hilum linear* Tribe 6. ORYZEÆ (Chap. 18).

SERIES II

A. Culms woody.......................Tribe 13. BAMBUSEÆ (Par. 270).

AA. Culms herbaceous.

B. Spikelets in spikes or spike-like racemes.

C. Spikelets crowded on one side of the rachis......................Tribe 10. CHLORIDEÆ (Chap. 22).

CC. Spikelets on opposite sides of the rachis. Tribe 12. HORDEÆ (Chap. 24).

BB. Spikelets in contracted or open panicles.

C. Spikelets with 1 perfect floret.

D. Perfect floret with 2 sterile lemmas below....................Tribe 7. PHALARIDEÆ (Chap. 19).

DD. Perfect floret solitary, no sterile lemmas below....................Tribe 8. AGROSTIDEÆ (Chap. 20).

CC. Spikelets with 2 or more florets.

D. Lemmas awned from the back; glumes usually longer than the first lemma. Tribe 9. AVENEÆ (Chap. 21).

DD. Lemmas awned from the tip or awnless.......................Tribe 11. FESTUCEÆ (Chap. 23).

THE MORE IMPORTANT GENERA OF GRASSES

197. Hackel recognizes over 300 genera of grasses, and some writers, including the author, recognize many more, probably 400 in all. Only a few of the more important genera are described in the present work, the selection being based upon the size of the genus, or the

* In Gray's "Manual" this tribe is placed in Series II (Gray, Man. ed. 7, p. 88. 1908).

economic value of included species. Keys are given to all genera native or commonly cultivated in the United States.

198. Characters used in classification.—The consensus of botanical opinion is that genetic relationships among phanerogams are best shown by the structure of the flowers. Grasses are no exception to this rule and hence the classification is based upon the structure of the spikelets. The preceding key indicates the characters used in classifying the tribes. The classification appears to be somewhat artificial, but nevertheless it brings together in the same tribe genera that are evidently related. But it also in some cases, separates into different tribes genera that are closely related. Reference will be made to some of these cases again in the appropriate place.

199. Phylogeny.—As to the phylogeny of the grasses, it is probable that the most primitive existing forms are those in which the spikelet consists of a series of flowers in the axils of herbaceous bracts. The simpler genera of Bambuseæ, such as Arundinaria, probably represent the lower or more primitive forms. It must not be understood that this tribe is, as a whole, less developed than the other tribes. Some genera are highly developed. There is good ground for believing, however, that the Bambuseæ arose from forms more primitive than those that gave rise to the other tribes. The Festuceæ and Hordeæ probably come next in phylogenetic development, while the Andropogoneæ and Paniceæ are highly developed. The exact relationship of the various tribes and the smaller groups is, of course, for the present largely a matter of conjecture and individual opinion. Phylogenetic ideas are expressed by the grouping of forms rather than by attempting to trace lines of descent. We may group allied species into genera and allied genera into higher groups without committing ourselves as to how the various groups came to be what they are. The modern tendency is toward a grouping of species in all large genera. Some of these groups are recognized under the formal titles of subgenera, sections and subsections. But it is often convenient to form smaller groups centering around well-known or widespread species.

Ascherson and Gräbner bring together closely allied species under the heading Gesammtart (Syn. Mit.-Eur. Fl.). In our recent revision of the North American Species of Panicum (Contr. U. S. Nat. Herb. 15) these minor groups or species were indicated by the plural of the leading species, e.g., the allies of *Panicum dichotomum* were grouped under Dichotoma.

CHAPTER XV

TRIBE I. MAYDEÆ

This tribe is scarcely more than a division of the next tribe, Andropogoneæ, from which it differs in the separation of the staminate and pistillate inflorescences. The structure of the spikelets in the 2 tribes is similar.

KEY TO THE GENERA OF MAYDEÆ

A. Staminate and pistillate spikelets in separate inflorescences, the former in a terminal tassel, the latter in the axils of the leaves.
  B. Pistillate spikes distinct, articulated........EUCHLÆNA (Par. 201).
  BB. Pistillate spikes grown together forming an "ear"..............................ZEA (Par. 202).
AA. Staminate and pistillate spikelets in separate portions of the same spike, the pistillate below.
  B. Spikes short, the 1- to 2-flowered pistillate portion inclosed in a bead-like sheathing bract..................................COIX (Par. 203).
  BB. Spikes many-flowered, the pistillate portion breaking up into several 1-seeded joints; no bead-like sheathing bract.............TRIPSACUM (Par. 200).

200. Tripsacum *L.*—The terminal inflorescence consists usually of a cluster of spikes the lower portions of which are pistillate and the upper portions staminate. The pistillate portion consists of a series of joints which disarticulate at maturity forming bony cylindrical or angled seed-like parts made up of the thick axis and an imbedded spikelet. The spikelet consists of a hard first glume which closes the spikelet within the joint of the rachis, a thinner second glume, a sterile lemma with a palea, and a fertile floret, the latter all hyaline. The staminate spikelets are in pairs on a slender rachis. The spikelet consists of 2 coriaceous glumes and 2 florets with stamens, the lemmas and paleas being hyaline. Besides the terminal inflorescence there are usually in the axils of the leaves others that may be reduced to a single spike. One species, *T. dactyloides* L., a coarse perennial found through eastern and southern United States, is an excellent forage grass, sometimes called gama-grass. A few other species are found in Mexico.

FIG. 11. Euchlæna mexicana. Portion of plant reduced; a pistillate inflorescence, ×½, and 4 fertile spikelets ×1 (U. S. Dept. Agr. Div. Agrost. Bull. No. 20).

201. Euchlæna *Schrad.*—Teosinte. The staminate flowers are in a terminal panicle while the pistillate are in spikes in the axils of the leaves. The staminate spikelets are similar to those of Tripsacum. The spike of pistillate spikelets breaks up at maturity into rhomboidal seed-like joints. The styles are very long and protrude from the top of the inclosing leaf-sheath. The best known species is *E. mexicana* Schrad. (Fig. 11), a native of Mexico. This is a coarse annual resembling corn, cultivated in the southern United States as a forage plant, chiefly for green fodder. There are 1 or 2 other species in Mexico and Central America. A hybrid between Euchlæna and Tripsacum is described by Collins and Kempton. The pollen was furnished by a variety of Euchlæna from Durango, Mexico (Journ. Wash. Acad. Sci. 4: 114. 1914).

202. Zea *L.*—Indian corn, maize. This genus is represented only by the cultivated maize (*Z. mays* L.), and is not known in the wild state. There are several well-marked varieties, such as dent, pop and sweet, which are thought by some to be distinct species. Like the preceding genus, the staminate inflorescence is separate from the pistillate. The former is a terminal panicle called the tassel and the latter, a thick spike surrounded by leafy bracts or husks, is called the ear. The staminate spikelets are in pairs on the rachis, 1 sessile and the other pediceled, each 2-flowered, the thin lemmas and paleas being shorter than the firm glumes. The ear consists of several close rows of pistillate spikelets upon a greatly thickened axis, the cob. The spikelet consists of 2 glumes, a sterile lemma with a small palea, and a fertile lemma and palea. All these bracts remain at the base of the mature grain as coriaceous chaff on the cob. The numerous single styles protrude from the ear and form the "silk." There is a potential ear in every leaf-axil but usually only one develops into a perfect ear. In one variety, called pod-corn, each kernel is enveloped in the elongated floral bracts.

There has been much speculation as to the origin of corn. Some have thought that it has been developed from Teosinte, others that the original wild form has become extinct. It is more likely that it is a hybrid between Teosinte and an unknown or extinct species resembling pod-corn. (Collins "The Origin of Maize," Journ. Wash. Acad. Sci. 2:520. 1912.)

Corn has been cultivated from prehistoric times by the early races of American aborigines, from Peru to middle North America, and is now cultivated throughout the world in warmer regions for food for man and domestic animals. The chief varieties are dent, the common commercial field variety, flint, formerly common in the northern states, sweet and pop. A starchy variety called flour corn is grown in South America and pod-corn is occasionally cultivated as a curiosity. A form with variegated leaves is cultivated in gardens for ornament. (For further notes on classification see Montgomery, "The Corn Crops" 15. 1913.)

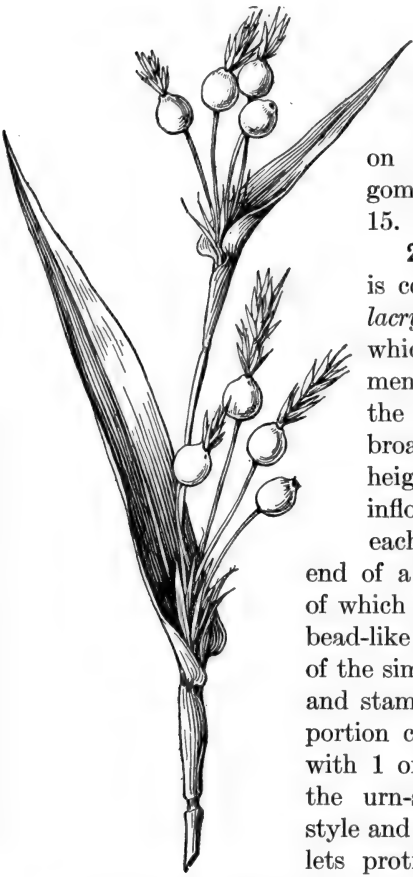


Fig. 12. Coix lacryma-Jobi. Inflorescence showing several pistillate beads, the staminate spikes protruding, ×⅔.

203. Coix *L.*—Only 1 species is common, the Job's-tears (*C. lacryma-Jobi* L.) (Fig. 12), which is cultivated for ornament and escaped as a weed in the tropics. It is a handsome broad-leaved species, reaching a height of 4 to 6 feet. The inflorescences are several on each plant, each being at the end of a long peduncle on the end of which is an urn-shaped indurated bead-like bract, supporting the base of the simple spike, pistillate at base and staminate above. The pistillate portion consists of 1 fertile spikelet with 1 or 2 sterile ones, inclosed in the urn-shaped bract, the 2-cleft style and the tips of the sterile spikelets protruding through the opening at the top. The glumes of the fertile spikelet are broad, hyaline with membranaceous tips, the lemmas and palea delicately hyaline. The staminate upper portion of the inflorescence also protrudes from the opening for an inch or two. This consists of a few spikelets in pairs, the structure being similar to that described above for the other genera. At maturity the staminate portion of the inflorescence disarticulates, the sheathing bract containing the seed forms an ivory-like ovoid fruit, from white to bluish gray in color, that separates by a joint from the peduncle. These fruits are used as beads for ornament.

CHAPTER XVI

Tribe II. ANDROPOGONEÆ

This great tribe is represented in the warmer regions of both hemispheres but is absent from the arctic and alpine regions and is poorly represented in the cooler temperate regions. The spikelets are usually arranged in pairs at each joint of a spike-like raceme, 1 sessile, the other pedicelled. The rachis of the raceme is usually articulated and breaks up at maturity into joints. The racemes are often woolly with long hairs and may be arranged in a compound inflorescence. Sometimes the racemes are reduced to the terminal joint of 3 spikelets, in which case the compound inflorescence is a panicle, as in Johnson-grass. The spikelets nearly always consist of 2 glumes, at least 1 of which is firm or indurated, a sterile lemma, and a terminal fertile floret. The bracts above the glumes are usually thin and hyaline. The fertile lemma often bears a bent or twisted awn. Grasses of this kind are commonly abundant on savannas and plains in the tropics and in prairie regions of the United States, and many species are useful forage grasses. There are about 50 genera in the tribe but only a few contain species of interest to Americans. Of the 5 sub-tribes, only 2 will be mentioned here.

Key to the Genera of Andropogoneæ

A. Axis of the spike glabrous, much thickened, with excavations holding the spikelets; fertile lemma awnless.

B. First glume flattened or somewhat convex. Florida.................................MANISURIS.

BB. First glume hard and globular, pitted. Florida to Arizona.......................RYTILIX.

AA. Axis of the spike or raceme hairy, not excavated nor greatly thickened; fertile lemma usually awned.

B. Spikelets all alike.

C. Axis of racemes continuous.

D. Racemes in a narrow spike-like panicle; spikelets awnless. Florida............IMPERATA.

DD. Racemes in a broad fan-shaped panicle; spikelets awned.....................MISCANTHUS (Par. 204).

CC. Axis of racemes breaking up into joints; racemes in a much-branched panicle on a main axis.

D. Spikelets awned.....................ERIANTHUS (Par. 206).

DD. Spikelets awnless.....................SACCHARUM (Par. 205).

BB. Spikelets not all alike, one of the pair perfect, the other staminate, neutral or reduced to a pedicel.

C. Fertile spikelet pedicelled, with a long plumose awn; sterile spikelet nearly sessile, awnless.......................TRACHYPOGON.

CC. Fertile spikelet sessile; sterile spikelet pedicelled; axis articulate.

D. Spikelets awnless; raceme solitary, terminating the culm..................ELIONURUS.

DD. Spikelets awned; racemes 1 or more from each sheathing bract but not solitary on the culms; sometimes reduced to the terminal joint of 3 spikelets and borne in panicles.

E. Sessile spikelets all alike in the same raceme.

F. Racemes several-flowered.........ANDROPOGON (Par. 208).

FF. Racemes reduced to 1 or 2 joints, these in panicles.

G Awn several inches long........CHRYSOPOGON.

GG. Awn short.

H. Plants perennial, without rhizomes; sterile spikelet reduced to a pedicel..........SORGHASTRUM.

HH. Plants perennial, with rhizomes, or annual; sterile spikelets staminate.........HOLCUS (Par. 210).

EE. Sessile spikelets at the base of the spike different from the others.

F. Racemes solitary at the ends of the branches. . . . . .HETEROPOGON.
FF. Racemes in pairs from a sheathing bract, these in panicles. . . . . .CYMBOPOGON (Par. 209).

SUBTRIBE SACCHAREÆ

Spikelets perfect, all alike. The genera here mentioned have large compound inflorescences of woolly racemes.

204. Miscanthus *Anderss.*—Tall coarse perennials with large panicles, axis of the racemes not articulated. One species, *M. sinensis* Anderss. (*Eulalia japonica* Trin.) (Fig. 13), a native of eastern Asia, is cultivated for ornament. This grass grows in large bunches, with numerous narrow leaves, 2 to 4 feet long, tapering to a slender point, slender upright flower-stalks 4 to 6 feet high bearing a fan-shaped cluster of woolly spikes 6 to 12 inches long. There are 3 varieties in cultivation: var. *variegatus*, with striped leaves; var. *zebrinus*, with banded leaves; and var. *gracillimus* with leaves much narrower than in the other forms. Two other species are occasionally cultivated,—*M. saccharifer* Benth., with nearly or quite awnless spikelets, and *M. nepalensis* Hack. (Himalaya fairy-grass), with spikelets one-fourth as long as the brown involucral hairs.

FIG. 13. Miscanthus sinensis. Plant much reduced, spikelet, ×3. (U. S. Dept. Agr., Div. Agrost., Bull. 20.)

205. Saccharum *L.*—The best-known species is the sugar-cane (*S. officinarum* L.) (Fig. 14), a tall coarse grass with broad blades and a large woolly plume-like panicle as much as 2 feet long. The unawned spikelets are similar to those of the preceding genus, but the axis of the racemes is articulated. The native country of sugar-cane is not known, but it is now cultivated in all tropical countries. Although it produces seed occasionally it is propagated by cuttings of the stem.

FIG. 14. Saccharum officinarum. Plant much reduced; three joints of the rachis (*a*), a spikelet (*b*), and a flower (*c*), ×3. (U. S. Dept. Agr., Div. Agrost., Bull. 20.)

206. Erianthus *Michx.*—The inflorescence resembles that of the preceding genus, but the spikelets are awned. One species (*E. Ravennæ* Beauv.), a native of the Mediterranean region, is cultivated for ornament under the name of plume-grass, wool-grass, Ravenna-grass, or hardy pampas-grass. It is a tall perennial with narrow blades and a plume-like panicle, as much as 2 feet long.

SUBTRIBE EUANDROPOGONEÆ

207. Spikelets not all alike, the sessile one of each pair fertile, the pedicelled sterile, sometimes reduced to the pedicel. The genera described below are included by some authors as sub-genera of the large genus Andropogon. The axis of the raceme is articulated. The awn is very large and strong in some genera (Heteropogon, Chrysopogon), is geniculate and twisted, and bears at the base of the spikelet a strong sharp hairy

Fig. 15. Erianthus divaricatus. Plant reduced; spikelet, the two glumes, and the fertile lemma with lower portion of awn, ×3; flower, ×5.

callus, the whole much resembling the awned fruit of *Stipa spartea.*

208. Andropogon *L.*—Sessile spikelets all alike in more or less elongated racemes. The racemes may be single or in pairs, or rarely 3 or 4 from a sheathing bract, or they may be in naked panicles. The species are usually coarse perennials that inhabit prairies, hills, pine-barrens and other dry places. Some species are important native forage grasses. Two of these are common on the prairies of the Mississippi Valley, the little bluestem (*A. scoparius* Michx.) and the big bluestem (*A. furcatus* Muhl.) (Fig. 16). The first species has solitary racemes from each bract or spathe, and is a representative of the subgenus Schizachyrium. The other has 3 or 4 racemes in a naked digitate cluster. A common but less valuable species, the broom-sedge (*A. virginicus* L.), is found in the Atlantic states on sterile soil. This large genus of hundreds of species is spread over the warmer regions of both hemispheres.

FIG. 16. Andropogon furcatus. Inflorescence, $\times \frac{1}{2}$. A joint of the rachis with a fertile spikelet below and a staminate spikelet above, $\times 5$.

209. Cymbopogon *Spreng.*—This genus resembles Andropogon in having racemes in pairs from sheathing bracts, but differs in that 1 or 2 of the lowermost pairs of spikelets of at least 1 of the racemes, are both staminate. In the economic species the pairs of racemes are arranged in a large compound panicle. Several species of this genus* furnish volatile essential oils and some are cultivated for this purpose. The most common cultivated species, both from India, are citronella-grass, *C. Nardus* (L.) Rendle, and lemon-grass, *C. citratus* (DC.) Stapf.

210. Holcus *L.*—Racemes reduced to the terminal joint which consists of a fertile spikelet and a pair of staminate spikelets, these racemes or groups arranged in panicles. One species, *H. halepensis* L. (Fig. 17), the well-known Johnson-grass, a native of the Old World, is now naturalized in America. This is a valuable forage-grass but on account of its tendency to spread in cultivated fields and the difficulty with which it is eradicated it cannot be recommended. It is a coarse perennial with creeping rhizomes. The other important species of this genus is sorghum (*H. Sorghum* L.), a tall coarse annual, not found in the wild state but thought to be derived from the preceding species. There are many varieties cultivated for various purposes,† the sugar sorghum, or saccharine sorghum, for its juice, from which sugar and syrup are obtained, the forage sorghum, often called "cane" on the Great Plains, grown for forage, kafir, grown for forage and the seed, broom-corn for the stiff branches of the inflorescence, and durra, milo, Egyptian corn, etc., for forage and seed. Many other varieties are cultivated in Africa and Asia. In some countries it is called millet.

The genus Holcus has been known as *Sorghum* and has been included by many under Andropogon. The names of the 2 species mentioned appear in books as *Sorghum halepense* (L.) Pers. or *Andropogon halepensis* (L.)

*For a discussion of this subject, see O. Stapf, "Oil Grasses of India and Ceylon" (Kew Bull. Misc. Inf. 8: 297. 1906).

†See Ball, "History and Distribution of Sorghum" (U. S. Dept. Agric. Bur. Pl. Ind. Bulletin No. 175. 1910).

Brot. for the first and *Sorghum vulgare* Pers. or *Andropogon Sorghum* (L.) Brot. for the second.

H. halepensis L. Johnson-grass. Culms usually 3 to 5 feet tall, erect, smooth, often glaucous, producing strong creeping rhizomes; sheaths smooth; ligule membranaceous, about 2 mm. long, the upper half a ciliate fringe; blades smooth or nearly so, somewhat scabrous on the margins, 1 to 3 feet long, mostly ¼ to ½ inch wide, tapering to a fine point, the white midrib conspicuous; panicle open and spreading, 6 inches to 2 feet long, usually more or less reddish or purple, the branches 2 to 4 together, naked below, pubescent at the base; spikelets somewhat crowded along the upper part of the branches, in pairs or the terminal in 3's, 1 sessile and fertile and 1 or 2 pediceled and staminate; fertile spikelet about 5 mm. long, flattened dorsally, elliptical or ovate-lanceolate, indistinctly nerved, firm and coriaceous, at first pubescent but later becoming smooth

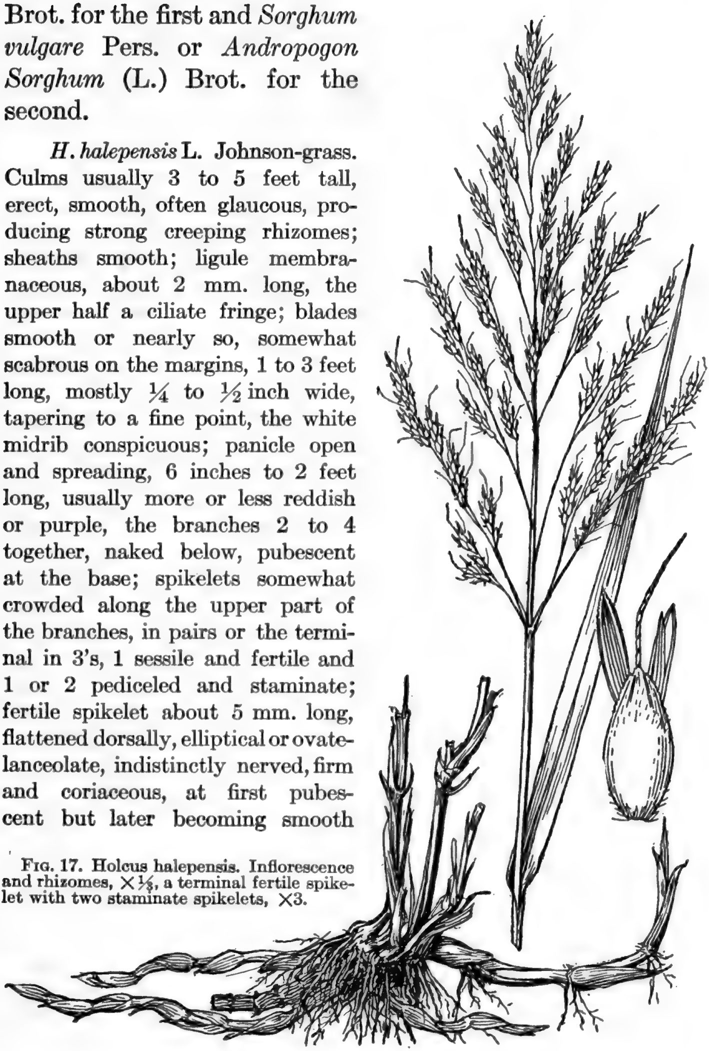


FIG. 17. Holcus halepensis. Inflorescence and rhizomes, $\times\frac{1}{8}$, a terminal fertile spikelet with two staminate spikelets, $\times 3$.

and shining on the exposed parts; staminate spikelets more slender, and slightly longer than the sessile, distinctly nerved, membranaceous, the pedicel about half as long as the sessile spikelet, ciliate. The staminate spikelets disarticulate early so that the mature fertile spikelets show only the 1 or 2 ciliate pedicels at the back. The whole plant is frequently subject to a disease which produces purple spots on the stem and leaves. This is also observed in *Holcus Sorghum.*

211. Classification of the sorghums.—Ball (loc. cit.) classifies the sorghums as follows:

A. Pith juicy.
  B. Juice abundant and very sweet............SORGO.
  BB. Juice scanty, slightly sweet to subacid.
    C. Panicles cylindrical; peduncles erect; spikelets 3 to 4 mm. wide; lemmas awnless..KAFIR.
    CC. Panicles ovate; peduncle mostly inclined, often recurved; spikelets 4.5 to 6 mm. wide; lemmas awned..................MILO.
AA. Pith dry.
  B. Panicle lax, 25 to 70 cm. long...
    C. Rachis less than one-fifth as long as the panicle; panicle umbelliform, the branches greatly elongated............BROOM-CORN.
    CC. Rachis more than two-thirds as long as the panicle.
      D. Panicle conical, the branches strongly drooping..........................SHALLU.
      DD. Panicle oval or obovate, the branches spreading.........................KOWLIANG.
  BB. Panicle compact, 10 to 25 cm. long.
    C. Spikelets elliptic-oval or obovate, 2.5 to 3.5 mm. wide........................KOWLIANG.
    CC. Spikelets broadly obovate, 4.5 to 6 mm. wide.
      D. Glumes gray or greenish, not wrinkled, densely pubescent; seeds strongly flattened..........................DURRA.
      DD. Glumes deep brown or black, transversely wrinkled, thinly pubescent; seeds slightly flattened..............MILO.

Sudan-grass resembles Johnson-grass in habit but is an annual, entirely devoid of rootstocks. By Piper it is referred to Sorghum as a variety. Sudan-grass promises to be of value as a forage crop in the southern states. Tunis-grass, resembling Sudan-grass, is another variety of the sorghum. (See, "Some New Grasses for the South," Yearbook U. S. Dept. Agr. 1912.)

Sorghastrum nutans (L.) Nash, a species of a related genus, is a common constituent of native meadows over the same region that *Andropogon furcatus* is found. It is a tall slender perennial with bronze-colored panicles with brilliant yellow anthers.

TRIBE III. NAZIEÆ (ZOYSIEÆ)

212. This is an unimportant tribe of about a dozen small genera. The spikelets are similar to those of Andropogoneæ but having membranaceous awnless instead of hyaline usually awned lemmas, are single or in groups and fall entire from the continuous rachis. In the genera found in the United States the spikelets are in groups.

KEY TO GENERA OF NAZIEÆ

A. Second glume beset with hooked spines.......NAZIA.
AA. Second glume without hooked spines.
B. Groups of spikelets spreading or drooping along one side of the main axis...........ÆGOPOGON.
BB. Groups of spikelets erect, not secund.
C. Plants stoloniferous....................HILARIA.
CC. Plants not stoloniferous.................PLEURAPHIS.

The most important genus is Hilaria, with the species *H. cenchroides* H.B.K. (Fig. 18), curly mesquite. This grass is common on the uplands of Texas and Mexico where it is an important range-grass. It resembles buffalo-grass in being short, in producing stolons and in forming a sod, and by stockmen is often confused with that grass. In curly mesquite, the spikelets are in clusters of 3, the groups borne on the upright axis forming

FIG. 18. Hilaria cenchroides. Plant reduced; group of spikelets, a staminate spikelet, a pistillate spikelet, ×5. (U. S. Dept. Agr., Div. Agrost., Bull. 20.)

a short spike. The allied genus Pleuraphis furnishes a few important forage grasses in the Southwest. *Pleuraphis Jamesi* Torr., is called galleta in New Mexico, a name which is applied in California to *P. rigida* Thurb.

Other grasses of interest belonging to this tribe are Nazia, one species of which, *N. aliena* (Spreng.) Scribn. extends from the tropics into Arizona, and Osterdamia (Zoysia), one species of which *O. matrella* (L.) Kuntze (*Zoysia pungens* Willd.), the Japanese or Korean lawn-grass is occasionally cultivated in California, and along the seacoast of the south Atlantic states. The first mentioned genus is peculiar in that the fascicles of 3 to 5 spikelets form a bur, the second glume of each spikelet being provided with hooked spines. In Osterdamia the spikelets are single instead of in groups.

Tribe IV. MELINIDEÆ (TRISTEGINEÆ)

213. This is a small tribe of about 8 genera, none of which is represented in the United States. The spikelets are borne singly in panicled racemes with a continuous axis. The most important genus is Arundinella, reed-like grasses, several species of which are found in tropical America.

CHAPTER XVII

Tribe V. PANICEÆ

Spikelets with 1 terminal perfect floret and a staminate or neutral floret below; fertile lemma firmer than the glumes, often chartaceous; spikelets jointed on the pedicel below the glumes. This large and important tribe is, like Andropogoneæ, found mostly in the tropics and warm regions, but is well represented throughout the United States, especially in the southern portion. The first glume is usually absent in the large genus Paspalum and in a few other genera, and in Reimarochloa and in certain species of Paspalum the second glume also is absent. In Eriochloa the first glume is reduced to a minute ridge about the swollen ring-like lower joint of the rachilla. In Isachne the lower flower is perfect like the upper. In this tribe the spikelets are usually unawned but the glumes are awned in Echinochloa, Oplismenus and Chætium, and the lemma in Tricholæna. What appear in some genera to be awns are bristle-like branchlets. In Chætochloa there are 1 or more of these below all or some of the spikelets, the bristles remaining after the fall of the spikelets. In Pennisetum there is an involucre of bristles (branchlets) surrounding the base of a cluster of spikelets, the bristles being deciduous with the cluster. In Cenchrus the bristles are retrorsely barbed and fused into a mass, forming a bur around the spikelets. An Australian genus, Spinifex, is diœcious and Olyra is monœcious. The fruit of Panicum and of several other genera is a seed-like body consisting of the chartaceous fertile lemma and palea inclosing a caryopsis the covering of which is thin. The genus Amphicarpon is peculiar in having 2 kinds of spikelets, ordinary spikelets in a terminal panicle, and underground cleistogamous spikelets borne on short subterranean branches that appear like rhizomes. Only the latter bear seed.

Key to the Genera of Paniceæ

A. Spikelets not all alike.
  B. Spikelets all perfect, but those of the aërial panicle not perfecting grains; the fruitful spikelets cleistogamous, borne on subterranean branches. Florida to New Jersey. AMPHICARPON.
  BB. Spikelets not all perfect, the inflorescence bearing pistillate spikelets above and staminate spikelets below; panicles terminating the branches; blades broad, elliptical. Florida ...... OLYRA.
AA. Spikelets all alike.
  B. Spikelets sunken in the cavities of the flattened corky axis ...... STENOTAPHRUM (Par. 223).
  BB. Spikelets not sunken in the rachis.
    C. Spikelets subtended or surrounded by 1 to many bristles (sterile branchlets), these distinct or more or less connate, forming an involucre.
      D. Bristles persistent, spikelets deciduous.. CHÆTOCHLOA (Par. 220).
      DD. Bristles falling with the spikelets at maturity.
        E. Bristles not united at base, usually slender, often plumose ...... PENNISETUM (Par. 221).
        EE. Bristles more or less united into a bur-like involucre ...... CENCHRUS (Par. 222).
    CC. Spikelets not subtended by bristles.
      D. Fruit cartilaginous-indurated, not rigid, papillose, usually dark-colored, the lemma with more or less prominent white hyaline margins not inrolled.
        E. Fruiting lemma boat-shaped, the hyaline margins narrow. Florida to Louisiana ...... ANTHÆNANTIA
        EE. Fruiting lemma convex, the hyaline margins broad.
          F. Fruit lanceolate-acuminate; second glume and sterile lemma long-silky. Florida to Arizona ...... VALOTA.

L

FF. Fruit elliptic; pubescence short or none.
G. Inflorescence of slender racemes, more or less digitately arranged........................SYNTHERISMA (Par. 216).
GG. Inflorescence a capillary panicle..LEPTOLOMA.
DD. Fruit indurated, rigid (or if thin, not hyaline-margined).
E. Spikelets (or the primary one of a pair) placed with the back of the fruit turned away from the rachis, usually solitary (not in pairs).
F. First glume and the rachilla joint forming a swollen ring-like callus below the spikelet..............ERIOCHLOA.
FF. First glume present or wanting but no ring-like callus below the spikelet.
G. First glume present; racemes racemose along the main axis..BRACHIARIA.
GG. First glume wanting; racemes digitate or subdigitate.........AXONOPUS (Par. 215).
EE. Spikelets placed with the back of the fruit turned toward the rachis of of the spike-like racemes, or pedicellate in panicles.
F. Fruit long-acuminate, scarcely indurated; both glumes wanting; spikelets sessile, solitary in spike-like racemes, these reflexed or verticillate at maturity. Florida, rare.........................REIMAROCHLOA.
FF. Fruit not long-acuminate, indurated.
G. First glume typically wanting; spikelets plano-convex, subsessile in spike-like racemes......PASPALUM (Par. 214).
GG. First glume present; spikelets usually in panicles.
H. Glumes and lemmas unawned.
I. Second glume inflated-saccate, this and the sterile lemma much exceeding the stipitate fruit............SACCIOLEPIS.
II. Second glume not inflated-saccate.
J. Culms (in our species) woody; fruit with a tuft of down at apex. Florida.LASIACIS.

JJ. Culms herbaceous. PANICUM (Par. 217).

HH. Glumes or lemmas awned (or awn-tipped in *Echinochloa colonum*).

I. Inflorescence paniculate; spikelets silky. Introduced in Florida........TRICHOLÆNA (Par. 219).

II. Inflorescence of unilateral racemes along a common axis.

J. Glumes 2-lobed, awned from between the lobes; blades broad and thin, lanceolate. Florida........OPLISMENUS.

JJ. Glumes awned from the tip...ECHINOCHLOA (Par. 218).

FIG. 19. Paspalum dilatatum. Inflorescence, ×½, spikelet, ×5.

214. Paspalum *L.*—A large genus of probably 200 species, well represented in the Gulf and south Atlantic states. It can be easily distinguished by the plano-convex spikelets in spike-like racemes. There are comparatively few species of economic importance. They are almost entirely absent from the grazing regions of the central and western United States, and in the southeastern states do not form an important constituent of grazing areas, being mostly inhabitants of wet or sandy soil and not often gregarious. An attempt was made, but with little success, to introduce into cultivation *P. dilatatum* Poir. (Fig. 19), under the name of water-grass. In the savannas of Central America certain species, such as *P. notatum* Flügge and *P. minus* Vasey, are important.

215. Axonopus *Beauv.*—By many authorities this group has been included in the genus Paspalum, but it forms a distinct natural group. Several species are found in tropical America but only 2 extend as far north as the United States. One of these, *A. compressus* (Swartz) Beauv., is the carpet-grass of the Gulf States, where it is an important grazing-grass and also a lawn-grass. It is a stoloniferous perennial with flattened stems, comparatively short, broadly linear, abruptly pointed blades, and slender spikes more or less digitate or clustered at the summit of the stem. (*Anastrophus* Schrad.)

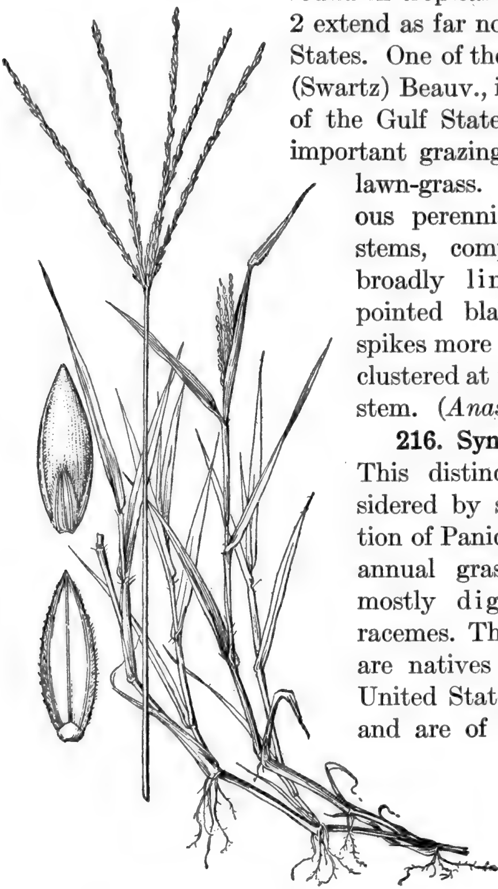


Fig. 20. Syntherisma sanguinalis. Plant, ×½; two views of spikelet, ×5.

216. Syntherisma *Walt.*—This distinct group is considered by some to be a section of Panicum. Perennial or annual grasses with slender mostly digitate spike-like racemes. The perennial species are natives of the southern United States and southward and are of little importance. Most of the annuals are introduced from Europe and are troublesome weeds. One species in particular, *S. sanguinalis,* is a well-known weed under the name of crab-grass. This and *S. ischæmum* are troublesome weeds in lawns. Being annuals, they die out and leave unsightly brown patches. Crab-grass is often utilized for hay in the southern states. (*Digitaria* Hall.)

Syntherisma sanguinalis (L.) Dulac. (Fig. 20). Crab-grass. Crop-grass. Annual; culms becoming much branched at base, decumbent or prostrate and rooting at the nodes, the flowering branches ascending, sometimes as much as 3 or 4 feet long; sheaths hirsute, with hairs arising from papillæ, sometimes nearly glabrous except near the nodes; ligule about 1 mm. long, thin and membranaceous, blades flat and thin, more or less hirsute like the sheaths, 2 to 6 inches long and as much as ½ inch wide; panicle consisting of few to several slender spikes, 3 to 6 inches long, a few digitate at the summit of the culm, with usually several others below in a more or less distinct whorl; rachis flat, winged on the margins, about 1 mm. wide, bearing on one side the appressed crowded spikelets, these in pairs, one nearly sessile, the other with a sharply triangular pedicel about half as long as the spikelet; spikelets flattened dorsally, elliptical-lanceolate, about 3 mm. long, the first glume small, nerveless, about ⅓ mm. long, the second glume lying next to the axis, narrow, about half as long as the spikelet, appressed-villous, the sterile lemma distinctly 3-nerved, as long as the spikelet, the lateral nerves more or less ciliate-fringed. The plant is often purplish tinged, and the species is variable in size and habit accordingly as it grows in rich or poor soil, in the open or among other plants.

A related species, *S. ischæmum* (Schreb.) Nash (*Digitaria humifusa* Pers.; *Syntherisma linearis* Nash; *S. glabrum* Schrad.), is common in the eastern United States. This species can be distinguished from the preceding by its being glabrous or nearly so, by the smaller spikelets, and by the absence of the first glume.

217. Panicum *L.*—This large genus of probably 400 species is distributed throughout all warm regions. The spikelets are usually arranged in panicles. They consist of

2 glumes and a sterile lemma, all herbaceous, and 1 indurated fertile lemma and palea. The sterile lemma may contain a staminate flower. The subgenus Dichanthelium, confined to America, with its center of distribution in the southeastern states, includes over 100 species. This group is peculiar in having simple vernal culms with terminal spreading panicles, the vernal phase usually very distinct from the later branched or autumnal phase in which the panicles are much reduced and often included in the sheaths. The autumnal spikelets are cleistogamous and fertile while the vernal spikelets appear to be usually unfruitful. Despite the great number of species in the genus Panicum, few are of ecomonic importance. One species, *P. miliaceum* L. (Fig. 21), proso millet or broom-corn millet, is cultivated in Europe for the grain which is used for food, and is sparingly cultivated in this country for fodder. It is an

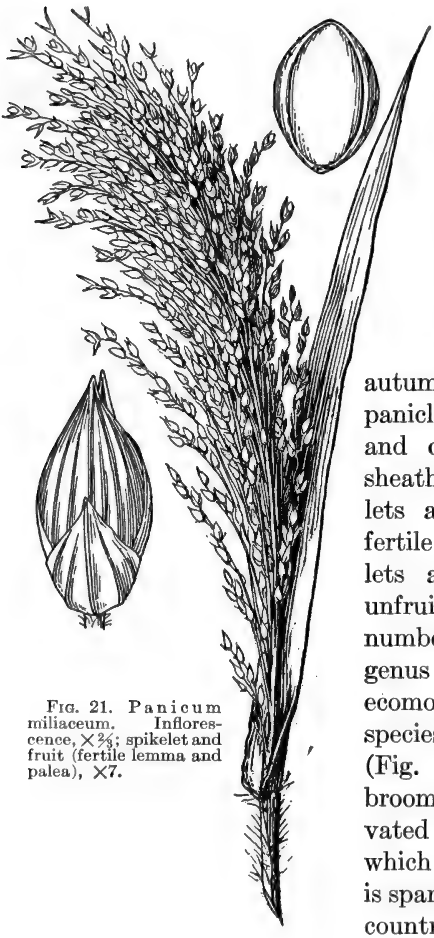


FIG. 21. Panicum miliaceum. Inflorescence, $\times \frac{2}{3}$; spikelet and fruit (fertile lemma and palea), $\times 7$.

annual with a drooping panicle. Pará-grass (*P. barbinode* Trin.), a Brazilian grass much cultivated for forage in the American tropics, is sparingly grown in the southern parts of Florida and Texas. It is a coarse grass, with stolons several feet in length, strongly bearded nodes, and an inflorescence of several spike-like racemes racemosely arranged. Guinea-grass (*P. maximum* Jacq.) is an African grass, also much grown in the tropics for forage. It is an erect bunch-grass, as much as 8 feet high, with a large spreading panicle. Guinea-grass is too susceptible to frost for cultivation in the United States except in southern Florida. Texas millet, or Colorado-grass, is *P. texanum* Buckl., a native of the Colorado River valley in Texas (Par. 62). *Panicum bulbosum* H. B. K., of the Southwest, produces well-marked corms.

218. Echinochloa *Beauv.*—A small genus that is included by some as a section of Panicum. The spikelets are as in Panicum, but the sterile lemma and usually the second glume are awned, often conspicuously so. The fruit is pointed and the palea is free at the summit. The spikelets are in short racemes, these racemosely arranged. All the species are annuals. One species, barnyard-grass, *E. Crus-galli* (L.) Beauv., is a common weed in waste places and cultivated soil. A

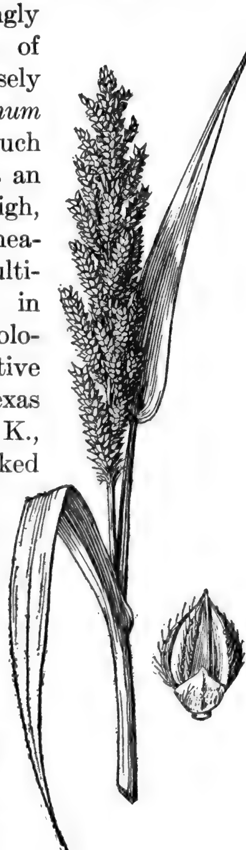


FIG. 22. Echinochloa frumentacea. Inflorescence, ×½, spikelet, ×5.

closely allied species, *E. frumentacea* (Roxb.) Link (Fig. 22), is cultivated for forage under the name billion-dollar-grass. This and *E. colonum* (L.) Link are cultivated in India for the seed, which is used for food.

FIG. 23. Chætochloa lutescens. Inflorescence, ×¾; spikelet with subtending bristles, ×5.

219. Tricholæna *Schrad.*—A small genus of African grasses, one of which has been introduced into the American tropics. Spikelets in panicles, very hairy. *Tricholæna rosea* Nees has given promise of value as a meadow-grass on the dry pine lands of Florida. It is there called Natal-grass and, incorrectly, redtop. Natal-grass is an erect perennial, 2 to 3 feet high, with a loose panicle of pink or rosy silky spikelets. It is said to furnish 4 or 5 cuttings of hay in a season. This grass may be grown from seed or by setting out divisions of the root or crown.

220. Chætochloa *Scribn.*—A small genus of annuals or perennials, the spikelets in narrow often spike-like panicles, interspersed with bristles. Two annual European species with cylindrical spike-like panicles are common weeds in the eastern half of the United States. One of them, yellow foxtail, *C. lutescens* (Weigel) Stuntz (Fig. 23), has yellow spikes and 5 or more bristles below each spikelet; the other, green foxtail, *C. viridis* (L.) Scribn., has green spikes and only 1 to 3 bristles below each spikelet. Another species, *C. italica*, closely allied to the latter, is commonly cultivated as millet or Hungarian grass. This has large heads, or spikes, which in some varieties are compound and more or less lobed. In this country millet is grown for forage but in some parts of the Old World the seed is used for human food. (*Setaria* Beauv.)

Fig. 24. Chætochloa italica, Hungarian grass. Inflorescence, ×¾.

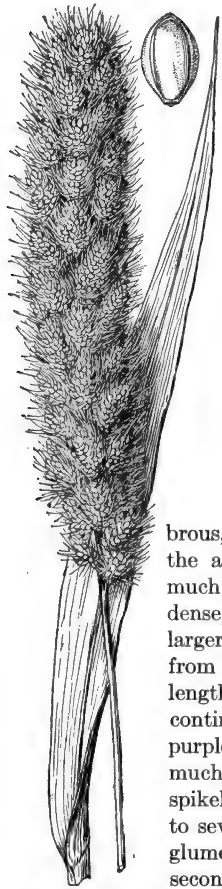


Fig. 25. Chætochloa italica, common millet. Inflorescence, ×½, fruit, ×5.

Chætochloa italica (L.) Scribn. (*Setaria italica* Beauv.; *Panicum italicum* L.) (Figs. 24 and 25). Millet. Foxtail millet. Hungarian grass. Annual; culms erect, simple or nearly so, 2 to 4 feet high, or sometimes larger, glabrous or scabrous below the panicle; sheaths glabrous, ciliate on the margins and pubescent at the collar; ligule a densely ciliate ring 1 to 2 mm. long; blades flat, scabrous, narrowed below and toward the apex, 6 to 18 inches long, as much as an inch wide; panicle dense, cylindrical, erect or in the larger forms drooping at the apex, from an inch or two to as much as a foot in length and from ½ inch to 2 inches in diameter, continuous or lobed and interrupted, yellow or purple, bearing bristles as long as the spikelets or much exceeding them; rachis and branches villous; spikelets about 3 mm. long, the bristles from 1 to several times the length of the spikelet, the first glume ovate, 3-nerved, about 1 mm. long, the second glume a little shorter than the spikelet, 7-nerved, the sterile lemma similar to the second glume, as long as the spikelet; fruit easily disarticulating above the sterile lemma, round on one side, flattened on the other, straw-colored, red or brown, smooth, very minutely and rather faintly cross-wrinkled.

There are many varieties differing in the length and color of the bristles, in the color of the seed or fruit and in the size and lobing of the panicle or head. The name Hungarian grass is given to the form with small purple heads.

221. Pennisetum *Pers.*—In this genus the spikelets, single or in groups, are surrounded by bristles as in Cenchrus but the bristles are distinct, and are often unequal in length or plumose. The inflorescence is a spike or raceme. The most important species of the genus is the pearl millet, *P. glaucum* (L.) R. Br. (Fig. 26); *P. americanum* (L.) Schum.; *Penicillaria spicata* Willd.; *P. typhoideum* Rich.). This is a tall coarse annual with broad blades like sorghum and a close cylindrical spike about a foot long and an inch or less in thickness. At maturity the smooth and shining ripened caryopsis bursts through the lemma and palea. Pearl millet is grown in Africa for food and to a limited extent in our southern states for forage. Two species of Pennisetum are commonly cultivated for ornament, *P. villosum* R. Br., with short broad heads and long plumose bristles, and *P. Ruppellii* Steud., with more slender rose-colored spikes tapering at the apex. (*Penicillaria* Willd.; *Gymnothrix* Beauv.)

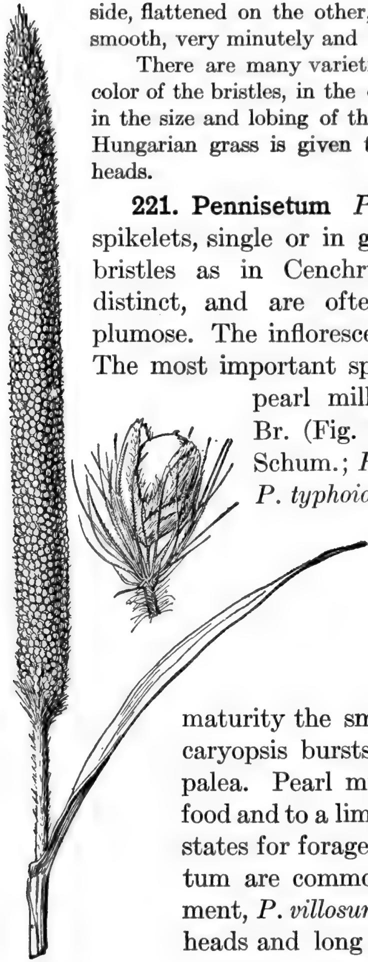


FIG. 26. Pennisetum glaucum. Inflorescence, ×¼; spikelet with involucre of bristles, ×5.

222. Cenchrus *L.*—Sand-bur. Bur-grass. Low often weedy grasses, usually annuals, the spikelets, singly or 2 or 3 together, inclosed by a bur formed of coalesced bristles or branchlets, these usually retrorsely barbed. The burs are borne in a spike or raceme, and, detaching easily at maturity, are transported by animals. The spikelets remain permanently inclosed in the bur, germination of the seed taking place within it. The first glume is much reduced, sometimes wanting. The common sand-bur of the United States is *Cenchrus carolinianus* Walt. (Fig. 27). The one with larger burs found among the sand-dunes of the Atlantic seacoast is *C. tribuloides* L.

Fig. 27. Cenchrus carolinianus. Upper portion of plant with inflorescence, ×⅔; spikelet, ×7.

223. Stenotaphrum *Trin.*—The best-known species of this genus is the St.

Augustine grass, *S. secundatum* (Walt.) Kuntze (Fig. 28), a stoloniferous perennial with flat stems and spikes, the spikelets partly immersed in the thickened rachis. This species is grown as a lawn-grass near the seacoast from North Carolina to Florida and Louisiana.

FIG. 28. Stenotaphrum secundatum. Upper portion of culms with inflorescence, ×½, spikelet, ×5.

CHAPTER XVIII

Tribe VI. ORYZEÆ

This is one of the smaller tribes, the place of which among the other tribes is not evident. Neither is it in itself a natural group, but is made up of genera of diverse affinities. Certain anomalous genera, such as Pharus (Fig. 29) Streptochæta and Reynaudia, included by Hackel and by Baillon in Oryzeæ are referred by Bentham and Hooker, the first two to Paniceæ and the third to Tristegineæ. The articulation of the spikelets below the glumes indicates an alliance with the first series of tribes, Panicoideæ; the laterally compressed or terete spikelets indicate an

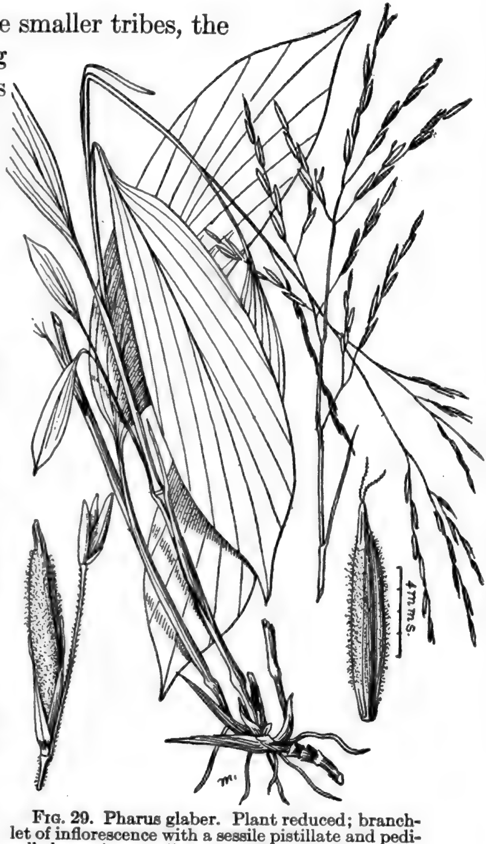


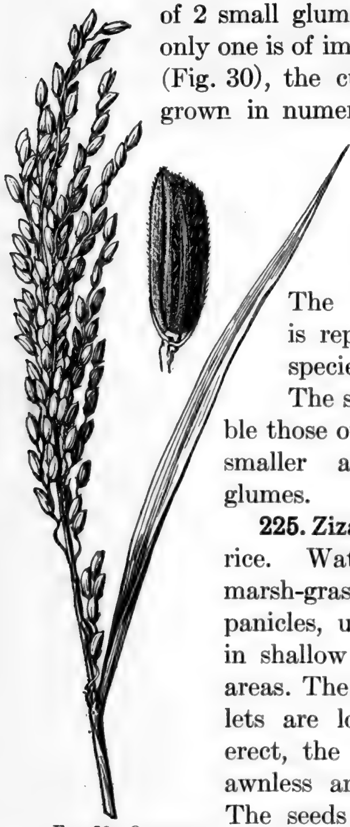
Fig. 29. Pharus glaber. Plant reduced; branchlet of inflorescence with a sessile pistillate and pedicelled staminate spikelet, and a fertile floret, ×3. (U. S. Dept. Agr., Div. Agrost., Bull. 20).

alliance with the second series, Poæoideæ. The spikelets are 1-flowered, perfect or unisexual, and usually disposed in panicles. There are usually 6 stamens and the hilum is linear instead of punctiform, in which two respects the structure is somewhat anomalous. The palea is usually described as 1-nerved, but an examination of *Oryza sativa* shows a palea with the 2 nerves close to the margin, the region between convex instead of concave as is usual in the palea of other grasses. In several genera, glumes are rudimentary or wanting. The tribe includes about 16 genera, mostly inhabitants of tropical America, 6 extending into the United States.

Key to the Genera of Oryzeæ

A. Spikelets perfect, strongly compressed laterally.
  B. Glumes 2; lemma often awned ....ORYZA (Par. 224)
  BB. Glumes wanting; lemma awnless...........HOMALOCENCHRUS.
AA. Spikelets unisexual, terete; plants monœcious.
  B. Plants slender, creeping in the mud or floating in the water.
    C. Inflorescence a few-flowered spike; plants not stoloniferous. Southeastern United States.............................HYDROCHLOA.
    CC. Inflorescence a panicle; plants stoloniferous. Alabama.......................LUZIOLA.
  BB. Plants erect, stout; marsh plants or terrestrial.
    C. Blades elliptical or oblanceolate, petiolate; fruit cylindrical, beset with hooked hairs; plants terrestrial. Florida.......PHARUS.
    CC. Blades elongated, linear, not petiolate; marsh plants.
      D. Pistillate spikelets in the usually narrow upper part of the panicle; staminate spikelets in the spreading lower part..ZIZANIA (Par. 225).
      DD. Pistillate and staminate spikelets mixed in the panicle, the former below and the latter above on each branch. Gulf States.......................ZIZANIOPSIS.

224. Oryza *L.*—Rice. Characterized by the perfect flowers, strongly compressed spikelets and the presence



of 2 small glumes. Of the half-dozen species only one is of importance. This is *O. sativa* L. (Fig. 30), the cultivated rice, an annual now grown in numerous varieties throughout the warmer regions of the world. Rice is the most important of the cereals in the sense that it furnishes food to more people than any other one grain. The allied genus Homalocenchrus is represented by several perennial species in the eastern United States. The spikelets resemble those of Oryza but are smaller and lack the glumes.

Fig. 30. Oryza sativa. Inflorescence, ×½, spikelet, ×3.

225. Zizania *L.*—Indian rice. Water-rice. Tall marsh-grasses, with large panicles, usually growing in shallow water in large areas. The pistillate spikelets are long-awned and erect, the staminate are awnless and drooping. The seeds were formerly gathered by the American Indians and used for food. There are 3 species, *Zizania palustris* L. (Fig. 31), the common Indian rice of the United States, *Z. aquatica* L., a less common species of Canada, and *Z. latifolia* (Turcz.) Stapf, of eastern Asia.

Fig. 31. Zizania palustris. Inflorescence, much reduced. (U. S. Dept. Agr., Div. Agrost., Bull. 14.)

CHAPTER XIX

Tribe VII. PHALARIDEÆ

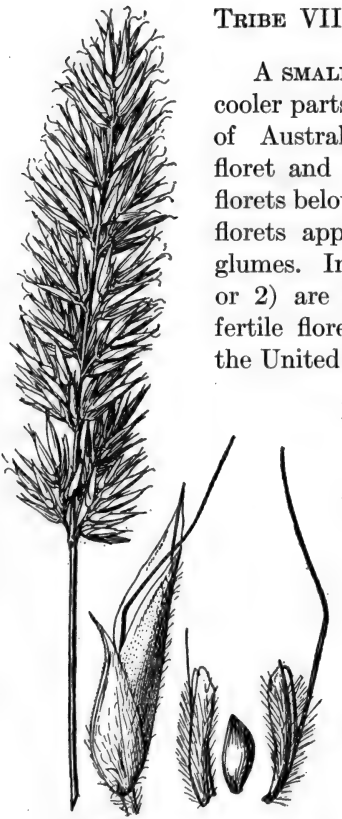


Fig. 32. Anthoxanthum odoratum. Inflorescence, 1; spikelet, the two sterile lemmas and the fertile floret, ×5.

A small tribe of about 6 genera in the cooler parts of the northern hemisphere and of Australasia. Spikelets with 1 fertile floret and a pair of staminate or neutral florets below. In Phalaris, the pair of sterile florets appear as small scales within the glumes. In Savastana the lateral florets (1 or 2) are staminate and as large as the fertile floret. Only 3 genera are found in the United States.

Key to the Genera of Phalarideæ

A. Lateral florets staminate.............. Savastana (Par. 226).

AA. Lateral florets neutral.

B. Lateral florets reduced to small awnless scales; spikelets much compressed laterally.......... Phalaris (Par. 228).

BB. Lateral florets consisting of awned hairy sterile lemmas about as long as the fertile floret; spikelets terete......... Anthoxanthum (Par. 227).

226. Savastana *Schrank.*—Inflorescence an open or contracted but not spike-like panicle; spikelets brown and shining; lateral florets (often awned) with 3 stamens, the central perfect floret with 2 stamens. The best known species is *S. odorata* (L.) Scribn., or vanilla-grass, a native of northern Europe and America. The name vanilla-grass refers to the fragrant odor of the foliage. Fragrant baskets, boxes and mats are woven of the long leaves of the sterile shoots, by the American Indians. Commonly called holy-grass in Europe. (*Hierochloë* R. Br.)

227. Anthoxanthum *L.*—Inflorescence a bronze-green spike-like panicle. One species, *A. odoratum* (Fig. 32), sweet vernal grass, a native of Europe, introduced in the cooler parts of the United States. Like vanilla-grass, it is fragrant, for which reason it is sometimes cultivated as a constituent of meadow-grasses to impart a pleasant odor to the hay. Sweet vernal grass is useless as a forage-grass.

A. aristatum Boiss. (*A. Puelii* Lecoq & Lamotte), an annual species is sometimes cultivated in the west and southwest.

Anthoxanthum odoratum L. Sweet vernal grass. Perennial; culms in tufts, without rhizomes, erect, slender, smooth, 1 to 2 feet high; sheaths smooth or somewhat pubescent; ligule membranaceous, 2 to 5 mm. long; blades flat, thin, scabrous, 1 to 3 inches long,

FIG. 33. Phalaris arundinacea. Inflorescence, $\times \frac{1}{2}$; spikelet and fertile floret, $\times 5$.

M

mostly basal, one about the middle of the culm, the upper portion of the culm naked; panicle dense, spike-like, bronze-green, 1 to 3 inches long, narrowed above and below, the short branches spreading in flower; spikelets 8 to 10 mm. long, lanceolate, acuminate, the glumes sparsely pilose, acuminate, the first membranaceous, about half as long as the somewhat indurated second glume, the first sterile lemma short-awned below the apex, the second bearing a strong bent scarcely exserted awn near its base, both exceeding the chestnut-brown, smooth and shining fertile lemma and palea. Common in grassland in the northeastern states.

FIG. 34. Phalaris canariensis. Inflorescence, ×½; glumes and fertile floret with the pair of sterile lemmas, ×5.

228. Phalaris *L.*—Inflorescence a short or long usually dense spike-like panicle. The spike is often white or variegated with green from the green nerves of the spikelets, and is usually papery at maturity. One of our native species, *P. arundinacea* L. (Fig. 33), reed canary-grass, is a perennial found in the northern portion of the United States, where it furnishes an excellent quality of wild hay. In this species the sterile lemmas are much reduced and are closely appressed to the fertile lemma and palea. A variety of this (var. *picta* L.) with leaves striped with white is cultivated for ornament under the name of ribbon-grass or gardener's garters. *P. carolinianus* Walt., a perennial of the southern United States, is cultivated to a limited extent for winter forage. Another species, *P. canariensis* L., canary-grass, an annual with ovate heads, is an occasional weed introduced from Europe. This is grown in Europe for the seed which furnishes the canary seed of commerce.

Canary seed usually contains also the seed of *Panicum miliaceum*. The seed of *Phalaris canariensis* (Fig. 34) is pale yellow, 5 mm. long, elliptical-lanceolate, laterally somewhat flattened but equally convex on both sides, hard and shining and more or less pubescent. The fruit of *Panicum miliaceum* is pale, brownish or reddish, about as long as canary-grass seed but much more plump, dorsally flattened on one side, the palea being inclosed or overlapped by the lemma, the whole smooth, hard, shining, and faintly nerved. The seed, when removed from the inclosing lemma and palea is nearly white, somewhat globular with a notch in one side, pearly in appearance. The fruit of common or foxtail millet (*Chætochloa italica*) differs from that of *Panicum miliaceum* in being somewhat smaller and faintly cross-wrinkled, and in the appearance of the palea, which presents 2 ridges near the margin representing the 2 keels. (See Figs. 21 and 25.)

CHAPTER XX

Tribe VIII. AGROSTIDEÆ

A large tribe of about 50 genera inhabiting more especially the temperate and cooler regions of the world. Spikelets 1-flowered (the rachilla prolonged as a stipe behind the palea in a few genera) usually perfect, arranged in open, contracted or spike-like panicles, but not in 1-sided spikes or racemes. The spikelets are jointed with the pedicel in a few genera, and fall off entire (Alopecurus, Cinna, Polypogon, Lycurus, Limnodea). The palea is usually 2-nerved but in Cinna it appears to be 1-nerved, the 2 nerves lying close together. In some species of Agrostis the palea is a small nerveless scale or is wanting. In some genera the floret is raised slightly from the glumes on a hard stipe, the short internode of the rachilla. This remains attached to the floret at maturity as a hard point and is called the callus. This callus is pronounced in Stipa and Aristida and less so in Oryzopsis, Muhlenbergia and a few other genera. In some species of Calamagrostis the short callus bears numerous silky hairs as long as the floret.

Key to the Genera of Agrostideæ

A. Lemma indurated at maturity, firmer than the glumes, closely enveloping the caryopsis and usually the palea, awned (except in Milium) from the tip, or mucronate (some species of Muhlenbergia).

B. Awn trifid (the lateral awns sometimes short, rarely wanting).................. Aristida (Par. 229).

BB. Awn simple.

c. Spikelets in pairs in a spike-like panicle; one perfect, the other staminate or neutral, the pair deciduous together.......LYCURUS.

cc. Spikelets all alike.

d. Rachilla prolonged behind the palea as a pedicel; glumes very short; inflorescence a narrow few-flowered panicle.BRACHYELYTRUM.

dd. Rachilla not prolonged.

e. Lemma awnless; fruit short, ovoid; inflorescence an open panicle.......MILIUM.

ee. Lemma awned or mucronate.

f. Awn slender, straight or flexuous, not twisted nor bent; spikelets small; glumes shorter than the lemma........................MUHLENBERGIA.

ff. Awn usually stout, bent or twisted.

g. Awn stout, twisted and bent, persistent; callus pointed, long; lemma narrow...............STIPA (Par. 231).

gg. Awn bent but not twisted, deciduous; callus short; obtuse; lemma broad, elliptical or ovate........................ORYZOPSIS. (Par. 230).

aa. Lemma not indurated at maturity, membranaceous or hyaline, like the glumes or more delicate.

b. Glumes none; low annual. Oregon and Washington..........................SCHMIDTIA.

bb. Glumes present.

c. Glumes falling with the spikelet, sometimes with a portion of the pedicel or branchlet, the articulation being below the glumes (compare Cinna).

d. Glumes long-awned..................POLYPOGON.

dd. Glumes awnless.

e. Inflorescence a dense spike-like panicle; lemma awned from the lower part of the back..................ALOPECURUS (Par. 233).

ee. Inflorescence a narrow loose panicle; lemma awned from the bifid apex..LIMNODEA.

cc. Glumes persistent, not articulated on the pedicel.

d. Glumes longer than the lemma.

e. Glumes plumose; an annual with woolly ovoid heads...............LAGURUS (Par. 237).

ee. Glumes not plumose.

f. Inflorescence a dense cylindrical spike-like panicle; glumes compressed-carinate, ciliate on the keels; lemma awnless...........PHLEUM (Par. 232).

FF. Inflorescence an open or contracted but not densely cylindrical panicle; glumes not compressed-carinate and ciliate.

G. Glumes saccate at base; lemma long-awned; inflorescence contracted, shining; annuals.....GASTRIDIUM.

GG. Glumes not saccate at base.

H. Lemma bearing an awn several times its length; annuals with open panicles..........APERA.

HH. Lemma short-awned, or awnless, the palea often reduced or wanting................AGROSTIS (Par. 234).

DD. Glumes as long as, or shorter than the lemma.

E. Lemma bearing a tuft of hairs at base from the short callus.

F. Lemma and palea thin............CALAMAGROSTIS (Par. 235).

FF. Lemma and palea chartaceous.

G. Panicles spike-like; rachilla prolonged......................AMMOPHILA (Par. 236).

GG. Panicles open; rachilla not prolonged......................CALAMOVILFA.

EE. Lemma without hairs at base.

F. Palea apparently 1-nerved, the 2 nerves close together; rachilla prolonged; panicle open.........CINNA.

FF. Palea distinctly 2-nerved; rachilla not prolonged.

G. Nerves of lemma densely silky..BLEPHARONEURON.

GG. Nerves of lemma not silky.

H Fruit not inclosed in the lemma and palea, seed usually also loose in the pericarp, this opening at maturity....SPOROBOLUS.

HH. Fruit inclosed in the lemma and palea; the seed also inclosed in the pericarp at maturity and grown to it; panicles spike-like in our species.

I. Panicles short, partly inclosed in the upper sheath; sparingly introduced from the Old World...........HELEOCHLOA.

II. Panicles elongated; tall perennials of Arizona and southward..............EPICAMPES.

229. Aristida *L.*—Needle-grass. A large genus, mostly tufted perennials of the warmer parts of the world, especially abundant in America. They are easily distinguished by the narrow terete lemma bearing a pointed hairy callus below and a trifid awn above. The 2 lateral awns are sometimes shorter than the others or may be absent altogether (*A. scabra* (H. B. K.) Kunth and its allies). The species not only have little forage value but on the contrary are often troublesome to ranchmen because of the sharp fruits which penetrate the skin of grazing animals. Several low perennial species are found in the new soil around the burrows of prairie dogs, hence the name dog-town grass.

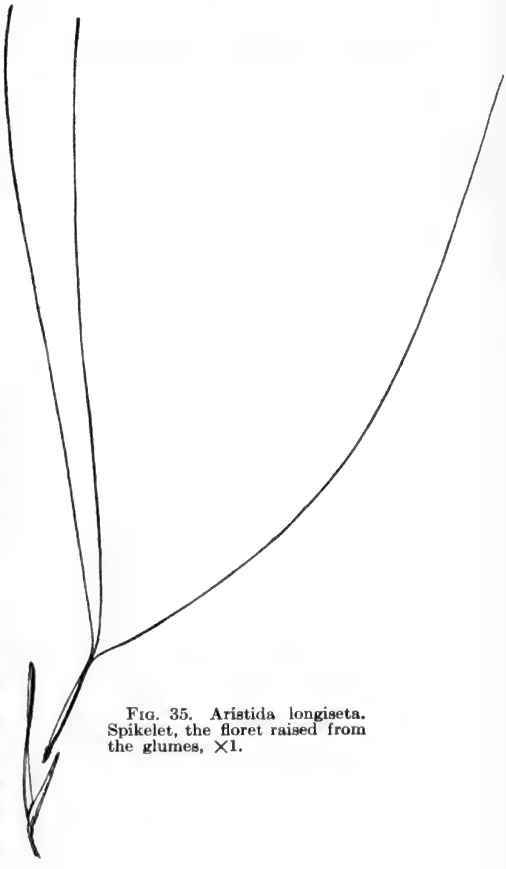


Fig. 35. Aristida longiseta. Spikelet, the floret raised from the glumes, ×1.

230. Stipa *L.*—Spear-grass. A large genus of tufted perennials found on the plains and steppes of both hemispheres. The fruit resembles that of Aristida but terminates in a single awn. This awn is usually tightly twisted below, the upper part being once or twice bent. In some species (*S. spartea* Trin.) (Fig. 36) the awn is stout and several inches long; in others it is beautifully plumose with silky hairs (*S. pennata* L. of the Russian steppes and *S. speciosa* Trin. & Rupr. of California). The various species form an important part of the forage on the plains and foothills of the southwestern states and Mexico. The esparto- or alfa-grass of Spain and Algeria (*S. tenacissima* L.) furnishes a fiber that is used for paper and for cordage. The sleepy-grass (*S. Vaseyi* Scribn.) of Colorado and New Mexico because of narcotic qualities is injurious to horses. Two species of the Old World are said to be poisonous (*S. inebrians* Hance and *S. sibirica* Lam.).

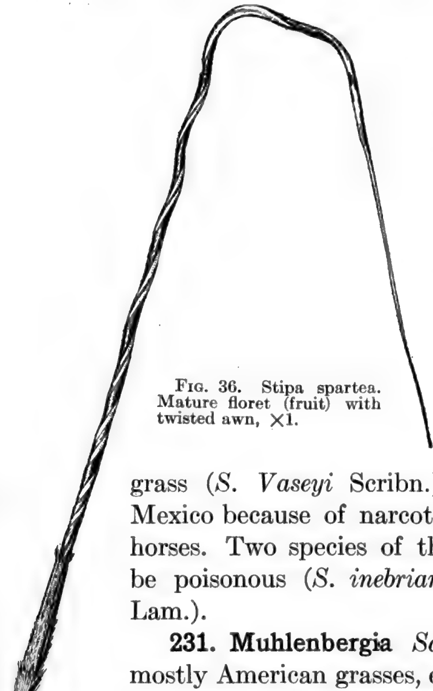


FIG. 36. Stipa spartea. Mature floret (fruit) with twisted awn, ×1.

231. Muhlenbergia *Schreb.*—A large genus of mostly American grasses, especially abundant on the dry uplands of the southwestern states and Mexico. It grades on the one hand into Sporobolus, from which it differs in having an awned or mucronate lemma, and on the other into Epicampes, from which it differs in having a relatively firmer lemma. Many species are important constituents of the forage upon grazing areas in the Southwest. One species of the allied genus

FIG. 37. Muhlenbergia gracilis. Plant, ×½; spikelet, the floret raised from the glumes, glumes and floret, ×5. (U. S. Dept. Agr., Div. Bot., Bull. 26.)

Epicampes (*E. rigens* Benth.) is of some economic importance in Mexico, whence it is exported, the strong fibrous roots being used to make coarse brushes.

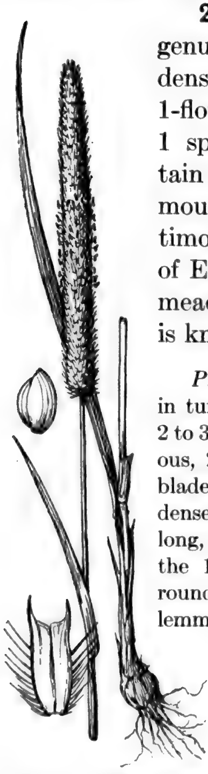


Fig. 38. Phleum pratense. Inflorescence, × ½; glumes and mature floret, ×7.

232. Phleum *L.*—Timothy. A small genus of cold regions, recognized by the densely cylindrical spike-like panicles, and 1-flowered much-compressed spikelets. Only 1 species is native in America, the mountain timothy (*P. alpinum* L.) of the higher mountains and arctic regions. Common timothy (*P. pratense* L.) (Fig. 38), a native of Europe, is our most important cultivated meadow-grass. In some localities this grass is known as herd's-grass.

Phleum pratense L. Timothy. Perennial; culms in tufts, somewhat bulbous at base, erect, smooth, 2 to 3 feet high; sheaths smooth; ligule membranaceous, 2 to 3 mm. long or the uppermost longer; blades flat, a few inches to a foot long; panicle densely cylindrical and spike-like, 2 to 5 inches long, obtuse; glumes about 3 mm. long, excluding the 1 to 2 mm. long awn, compressed, abruptly rounded to the awn, long-ciliate on the keel, the lemma and palea about equal, thin, half as long as the glumes.

233. Alopecurus *L.*—A small genus of wide distribution, in cold temperate regions and in high altitudes, one species of which, meadow foxtail (*A. pratensis*), a native of Europe, is occasionally cultivated as a meadow-grass. This species may be recognized by its resemblance to timothy in having densely cylindrical spike-like panicles, but differing in having awns on the back of the lemmas that protrude from the spikelets giving the spike a soft furry appearance.

Alopecurus pratensis L. (Fig. 39). Meadow foxtail. Perennial; culms erect from a short creeping base, smooth, 1 to 3 feet high; sheaths smooth, the uppermost somewhat inflated; ligule membranaceous, truncate, 2 to 4 mm. long; blades flat, smooth beneath, rough above, 2 to 6 inches long; panicle dense, cylindrical, 1½ to 3 inches long, ⅓ inch thick; glumes 5 mm. long, equal, awnless, 3-nerved, ciliate on the keel, connate at base, the broad, obtuse 5-nerved lemma nearly as long, bearing from near the base a slender dorsal slightly bent awn, exserted about 5 mm.

FIG. 39. Alopecurus pratensis. Plant reduced; spikelet and floret, ×3. (U. S. Dept. Agr., Div. Agrost., Bull. 20.)

234. Agrostis *L.*—Bent-grass. A large genus found all over the world but sparsely represented in tropical America. The North American species are nearly all perennials and are especially abundant in the western mountains. Spikelets 1-flowered; lemma delicate, shorter than the nearly equal glumes, often awned from the back; palea small or wanting; inflorescence an open or contracted panicle. The wild species are mostly important constituents of grazing areas in the mountains. Redtop (*A. alba*), cultivated as a meadow-grass, is a perennial 1 to 4 feet tall, with rootstocks, flat blades and an erect open often reddish panicle usually 4 to 8 inches long, with verticillate lower branches. A smaller form, Rhode Island bent (*A. alba vulgaris*), with finer foliage and a smaller more open panicle, is often used for lawns. Another form of *Agrostis alba* with creeping stems and narrow panicle is used for lawns under the name of creeping bent.

Agrostis alba L. (Fig. 40) Redtop. Perennial; culms erect from a more or less decumbent base bearing rhizomes, smooth, 1 to 4 feet high; sheaths smooth; ligule membranaceous, pointed, more or less lacerate, as much as 6 mm. long; blades flat, 2 inches to as much as a foot long, scabrous on both surfaces, strongly nerved, acuminate, usually rather stiffly upright; panicle 2 to 12 inches long, open at anthesis but usually more or less contracted in fruit, the branches in whorls, some naked below, others short and spikelet-bearing at base; glumes 2 to 3 mm. long, lanceolate, pointed, scabrous on the keel, the lemma thin, a little shorter than the glumes, the palea half to two-thirds as long as the lemma. The color of the panicle varies from greenish to purple or brown. This grass has escaped from cultivation or has been introduced over a large part of the United States. In the western mountains the species is doubtfully native. This grass is known by the name of herd's-grass in some localities, especially in Pennsylvania. In England it is called fiorin.

Agrostis alba vulgaris (With.) Thurb. Rhode Island bent. Differs from the preceding in the smaller size, more delicate culms and foliage, smaller and especially more open and fewer-flowered panicle, this not contracted in

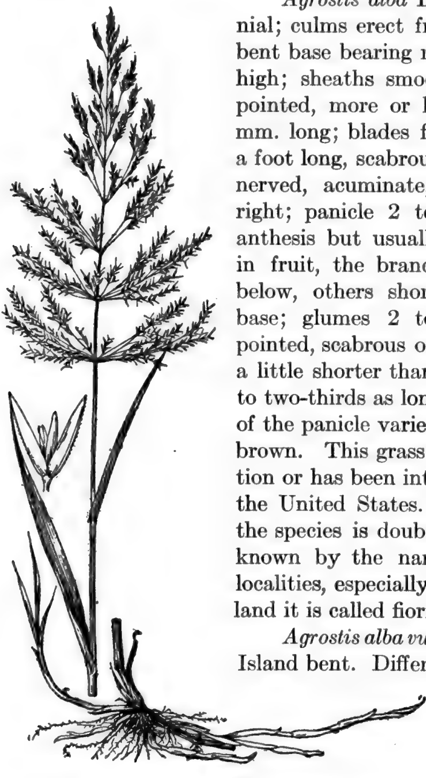


FIG. 40. Agrostis alba. Inflorescence and rhizomes, ×½; spikelet, ×5.

fruit. The ligule is often shorter and usually truncate. This form is common in grass land in the northeastern states, where it is introduced or escaped from cultivation.

Agrostis alba maritima (Lam.) G. F. W. Mey. Creeping bent. Differs from redtop in its creeping or stoloniferous stems and narrow panicles, the blades mostly short and appressed. Native along the North Atlantic coast of America and Europe, and the Pacific coast from central California to British Columbia. The form cultivated for lawns appears to have been derived from this.

Rhode Island bent. In botanical literature this name has been applied to *Agrostis canina* L., a grass similar in appearance to *A. alba vulgaris*, but usually more delicate, the glumes about 2 mm. long, the lemma about three-fourths as long as the glumes, bearing a little below the middle a bent exserted awn, the palea wanting. This is a native of Europe and is rare in America. There is no evidence that this species has been cultivated in Europe or America. The seed sold under the name Rhode Island bent is imported from Europe, and consists for the most part of some form of *Agrostis alba*, usually of creeping bent, or the form described above under *A. alba vulgaris*.

FIG. 41. Calamagrostis scabra. Plant reduced; spikelet, the floret raised from the glumes, ×3. (U. S. Dept. Agr., Div. Agrost., Bull. 20.)

235. Calamagrostis *Adans.*—A large genus of perennials growing in the cooler regions of all continents.

Spikelets 1-flowered, the rachilla prolonged; lemma awned from the back, surrounded by a tuft of callus hairs; inflorescence an open or contracted panicle. A common constituent of native meadows in the northern temperate and arctic regions of America. Bluejoint, *C. canadensis* (Michx.) Beauv., is commonly cut for hay from Montana to Minnesota. This is a perennial with creeping rhizomes, erect culms 3 to 5 feet high and a rather open panicle resembling that of redtop. Another species, pine-grass *C. rubescens* Buckl. (*C. Suksdorfii* Scribn.), is an excellent range-grass in the mountains of eastern Oregon and Washington. *Calamagrostis scabra* Presl (erroneously referred to *C. Langsdorfii*) (Fig. 41) is a common grass along the coast of Alaska and in open grass lands of British Columbia.

FIG. 42. Ammophila arenaria. Inflorescence and lower portion of plant, × ½. (U. S. Dept. Agr., Div. Agrost., Bull. No. 14.)

236. Ammophila *Host.*—Beach-grass. Marram-grass. A genus of 1 or 2 species, allied to Calamagrostis from which it differs in its strongly compressed spikelets and chartaceous lemma and palea, the lemma awnless. The common species is *A. arenaria* (L.) Link (Fig. 42), which grows in sand-dunes of the north Atlantic coast of Europe and America. It is found also on the sand-dunes along the east and south shores of Lake Michigan. It produces extensively creeping rootstocks because of which, and because the culms are able to push upward when buried, it can grow in drifting sand. It has been utilized as a sand-binder in Europe and more recently in America, especially on Cape Cod and in Golden Gate Park, San Francisco. In Europe marram-grass is used also for paper-making.

237. Lagurus *L.*—The one species, *L. ovatus* L., a native of Europe, is cultivated as an ornamental grass for dry bouquets. It is an annual with ovoid woolly heads, and narrow pointed plumose glumes.

CHAPTER XXI

TRIBE IX. AVENEÆ

A MODERATELY large tribe of about 30 genera, found in the cooler parts of the world. Spikelets 2- to several-flowered, in open or contracted panicles or sometimes in racemes; lemmas usually shorter than the glumes, usually awned on the back or from between the teeth of a bifid apex, the awn bent and often twisted, the callus and usually the rachilla-joints hairy. Only a few of the genera are found in America. In all these except Aira, an introduced genus, there is a prolongation of the rachilla behind the uppermost floret; and except in some species of Sphenopholis and in the American species of Kœleria the lemma is awned. These genera are usually placed in Festuceæ, but in all characters except the absence of the awn they show affinity with the genera of Aveneæ.

KEY TO GENERA OF AVENEÆ

A. Articulation below the glumes, these deciduous with the whole or a part of the spikelet.
  B. Glumes longer than the 2 florets, pubescent..NOTHOLCUS (Par. 238).
  BB. Glumes shorter than the 2 or 3 florets, glabrous or scabrous, the second widened above.................................SPHENOPHOLIS.
AA. Articulation above the glumes and between the florets.
  B. Lemma awnless or mucronate; inflorescence a spike-like panicle; an erect perennial....KŒLERIA.
  BB. Lemma awned.
    C. Rachilla not prolonged; spikelets 2-flowered; delicate introduced annuals.......AIRA.
    CC. Rachilla prolonged behind the uppermost floret.

D. Awn arising from between the teeth of the bifid apex, flattened, twisted; inflorescence a simple panicle or reduced to a raceme or even to a single spikelet. DANTHONIA.
DD. Awn dorsal.
E. Lower floret of the 2-flowered spikelet staminate.................... ARRHENATHERUM (Par. 241).
EE. Lower floret perfect.
F. Spikelets large, the glumes over 1 cm. long...................... AVENA (Par. 239).
FF. Spikelets less than 1 cm. long.
G. Lemma keeled, bidentate; awn arising from above the middle.. TRISETUM.
GG. Lemma convex; awn from below the middle.................. DESCHAMPSIA.

238. Notholcus *Nash.*—A genus of several species of Europe and Africa, one of which, velvet-grass (*N. lanatus*), is introduced in America. This is sometimes cultivated as a meadow-grass but has little forage value. As it thrives better than other meadow-grasses upon poor soil it is utilized for sterile ground. It has escaped in many parts of the United States especially on the Pacific coast. Velvet-grass is an erect perennial with velvety foliage and a narrow panicle, expanded in flower. (*Holcus* L. in part.)

Notholcus lanatus (L.) Nash. (Fig. 43). Velvet-grass. Perennial; culms erect, 1 to 3 feet high, pubescent; sheaths velvety especially near the node; ligule pubescent, membranaceous, about 2 mm. long, more or less toothed and ciliate; blades flat, velvety, mostly 2 to 4 inches long; panicle oblong, 2 to 4 inches long, pale or purplish, in flower spreading and rather open, in fruit contracted; spikelets 4 to 5 mm. long, the glumes pubescent, longer than the florets, ciliate on the nerves, the upper broader, 3-nerved, the awn of the second floret hooked. A common weed from Puget Sound to San Francisco, in moist and dry soil.

239. Avena *L.*—Oats. Mostly annuals with large spikelets, of which the common cultivated oat (*A. sativa*) is the most familiar example. The drooping spikelets are in open panicles. The large and papery glumes are longer than the lemmas, the latter being awnless or bearing a straight awn. A wild species (*A. fatua*) differs in having the lemma covered with brown hairs and in having a stout geniculate twisted dorsal awn attached near the base. This species is a native of Europe but is introduced on the Pacific coast where it is a common weed known as wild oats and where it is often used for hay.

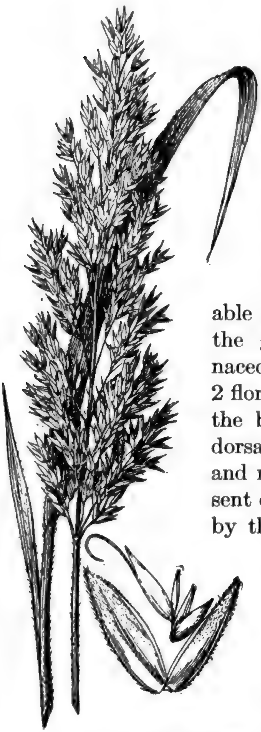


FIG. 43. Notholcus lanatus. Inflorescence, $\times \frac{2}{3}$; spikelet, the two florets raised from the glumes, $\times 7$.

Avena sativa L. Cultivated oat. Annual; culms erect, tufted, smooth, 2 to 4 feet high; sheaths smooth, striate, the lower rather papery; ligule membranaceous, truncate, 1 to 3 mm. long, toothed or serrate, decurrent along the margin of the sheath; blades flat, as much as 1 foot long and ½ inch wide, scabrous especially on the margins; panicle open or more or less contracted, erect or nodding, sometimes 1-sided, the pedicels thickened at the apex; spikelets large, drooping, variable in size but usually about ¾ to 1 inch long, the glumes strongly several-nerved, membranaceous, acuminate, scabrous, containing usually 2 florets, the lemmas smooth or slightly hairy at the base, the teeth acute but not awned, the dorsal awn absent or, if present, usually straight and not much exceeding the glumes, often present only on the lower floret, the palea inclosed by the inrolled margin of the lemma, densely short-ciliate on the 2 keels. The florets do not easily disarticulate, a condition probably due to cultivation. Commonly cultivated and often escaped from fields and in the vicinity of elevators, mills, railroads and in waste places, but rarely established permanently. There are several races or possibly species in cultivation. The naked oat (*A. nuda* L.) differs in having more than 2 florets and in having the caryopsis loosely and not permanently inclosed in the nerved lemma.

Avena fatua L. (Fig. 44). Wild oats. Differs from *A. sativa* chiefly in the spikelet characters. Florets easily disarticulating, the lemma beset with stiff usually brown hairs, these more abundant at base, the teeth acute as in *A. sativa*, the dorsal awn well developed, over an inch long, geniculate, twisted at base, usually brown. A common weed on the Pacific coast and occasional elsewhere.

Avena fatua glabrata Peterm. Differs from *A. fatua* in having nearly or quite glabrous lemmas. This form can be distinguished from the usual forms of *A. sativa* by the strong awn and by the easily disarticulating spikelets.

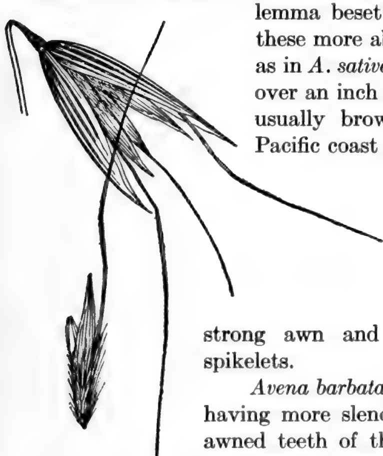


FIG. 44. Avena fatua. Spikelet and a lower floret, ×1.

Avena barbata Brot. Differs from *A. fatua* in having more slender panicle branches and in the awned teeth of the lemma. A common weed on the Pacific coast, and a constituent of the wild oats of that region.

Avena sterilis L. Animated oats. Differs from *A. fatua* in having larger spikelets, the glumes nearly 2 inches long, and awns about 2 inches long. An occasional weed and sometimes cultivated as a curiosity, the "seeds" moving about as the awns twist and untwist. This motion is due to the absorption or loss of moisture.

240. Origin of the cultivated oats.—Trabut has shown that our cultivated oats are derived from at least three wild species. *Avena fatua* is the parent of most of the varieties cultivated in America, and in general the varieties of temperate and mountain regions. The Algerian oat grown in North Africa and Italy is derived from *Avena sterilis.* A few varieties such as *Avena strigosa,* adapted to dry countries, are descended from *Avena* *barbata.* (See Translation of Trabut's article in Journal of Heredity 5: 56. 1914.)

241. Arrhenatherum *Beauv.*—To this small genus belongs the tall oat-grass (*A. elatius*), a tall perennial with narrow panicles of spikelets similar to those of the oat but smaller, about 8 mm. long, 2-flowered, the first floret staminate and awned, the second perfect and nearly awnless. This is a native of Europe and now cultivated occasionally in this country as a meadow-grass, especially in mixtures. It is also called Randall-grass.

Arrhenatherum elatius (L.) Beauv. (Fig. 45.) Tall oat-grass. Perennial; culms erect, smooth, 3 to 4 feet high, sheaths smooth; ligule membranaceous, truncate, about 1 mm. long; blades narrow, usually not over ¼ inch wide, scabrous on both surfaces; panicle long and narrow, rather loose, 6 to 10 inches long, pale or purplish, shining, the short branches verticillate, usually spikelet-bearing from the base; spikelets 7 to 8 mm. long, the glumes minutely scabrous, unequal, the second nearly as long as the florets; lemmas scabrous, the awn of the staminate floret about twice the length of its lemma, geniculate, scabrous. Often escaped from cultivation and a weed in waste places in the humid region.

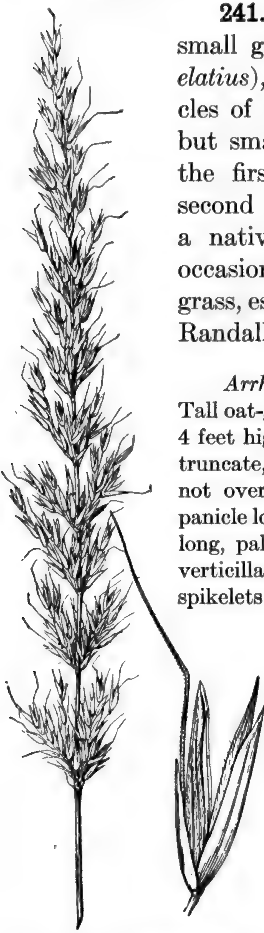


Fig. 45. Arrhenatherum elatius. Inflorescence, ×½; spikelet, ×4.

Arrhenatherum elatius bulbosum (Presl) Koch. Differs from the preceding in producing corms at the base of the stems. These corms are 5 to 10 mm. in diameter in clusters of usually 2 to 5 in moniliform strings. An occasional introduction, from Virginia southward.

CHAPTER XXII

TRIBE X. CHLORIDEÆ

A MODERATELY large tribe of about 30 genera, mostly of warm regions. It can be recognized by its 1-sided spikes or spike-like racemes, the spikelets borne in 2 rows on one side of a continuous rachis. Spikelets 1- to many-flowered, usually articulated above the glumes. The spike is reduced to 2 or 3 spikelets or even to 1 spikelet in some species of Bouteloua and allied genera. In the diœcious genus Bulbilis the pistillate spikelets are in a small cluster among the leaves, but the staminate inflorescence is characteristic of the tribe. Some species of Leptochloa approach the tribe Festuceæ, the spikes not being strictly 1-sided. In some species of Bouteloua the small spikes are deciduous from the main axis, thus resembling Nazieæ.

KEY TO THE GENERA OF CHLORIDEÆ

A. Plants diœcious or monœcious; low stoloniferous perennials.......................BULBILIS (Par. 245).
AA. Plants with perfect flowers.
  B. Spikelets with more than 1 perfect floret.
    C. Spikes solitary, the spikelets distant, appressed, several-flowered; a low perennial..............................TRIPOGON.
    CC. Spikes more than 1 (exceptionally 1 in Eleusine).
      D. Spikes numerous, slender, along an elongated axis.....................LEPTOCHLOA.
      DD. Spikes few, digitate or nearly so; annual weeds.
        E. Rachis of spike extending beyond the spikelets.......................DACTYLOCTENIUM.

EE. Rachis not prolonged .... ELEUSINE.
BB. Spikelets with only 1 perfect floret, often with additional imperfect or modified florets above, sometimes also below.
C. Spikelets without additional modified florets, the rachilla sometimes prolonged.
D. Rachilla articulated below the glumes.
E. Glumes narrow, unequal .... SPARTINA.
EE. Glumes equal, broad and boat-shaped .... BECKMANNIA.
DD. Rachilla articulated above the glumes.
E. Spikes digitate; plants extensively creeping .... CAPRIOLA (Par. 242).
EE. Spikes racemose; plants cespitose.... SCHEDONNARDUS
CC. Spikelets with 1 or more modified florets above the perfect one.
D. Spikelets with 2 sterile florets below the perfect one .... CAMPULOSUS.
DD. Spikelets with no sterile florets below the perfect one.
E. Spikes digitate.
F. Fertile lemma 1-awned or awnless.. CHLORIS (Par. 243).
FF. Fertile lemma 3-awned .... TRICHLORIS.
EE. Spikes racemose.
F. Spikelets distant; spikes slender.... GYMNOPOGON.
FF. Spikelets approximate, often imbricated.
G. Spikes usually short and rather stout, sometimes with only 1 to few spikelets .... BOUTELOUA (Par. 244).

242. Capriola *Adans.*—A small genus of Old World grasses, one of which, Bermuda-grass (*C. Dactylon*), has been introduced in America and is now common in the tropics and warmer regions as far north as Maryland and southern Kansas. This is a low perennial, producing extensively creeping stolons and rhizomes and erect flower-culms, a few inches to a foot or more in height, ending in 3 to 6 slender digitate spikes. It is an excellent grass for lawns and pastures in the southern states but in cultivated fields often becomes a troublesome weed. In soft soil it forms large rhizomes and coarse foliage but in lawns the foliage is fine and the plants are stoloniferous. Although called Bermuda-grass it is not a native of Bermuda. (*Cynodon* Rich.)

Capriola Dactylon (L.) Kuntze (*Cynodon Dactylon* (L.) Pers.). (Fig. 46.) Bermuda-grass. A gray-green perennial; culms extensively creeping, either below the surface of the soil forming rhizomes, or above ground forming stolons, the fertile shoots ascending, smooth, a few inches to as much as 2 feet in height; sheaths smooth, flattened and keeled, villous on each side at the throat; ligule a very short ciliate-fringed membrane; blades flat, 2 to 4 mm. wide, ½ to 2 inches long or on sterile shoots sometimes much longer, more or less scabrous, at least on the margin, sharp-pointed; inflorescence consisting of 3 to 6 slender ascending spikes 1 to 2 inches long, digitate at the summit of the culms, pubescent at the base, the rachis ⅓ to ½ mm. wide; spikelets much compressed, often purplish, ovate, about 2½ mm. long; glumes narrow, pointed, scabrous on the keel, shorter than the spikelet, the lemma pubescent on the margin and often also on the keel.

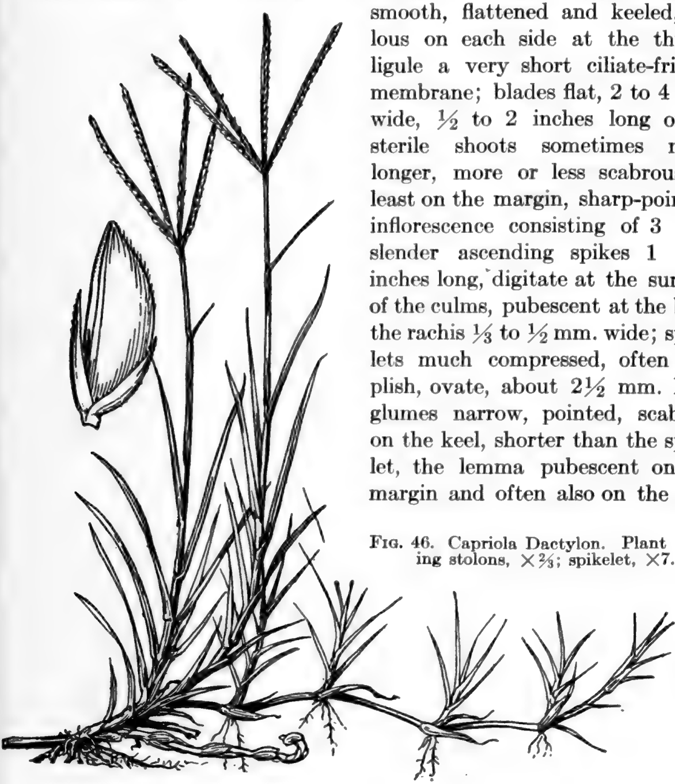


FIG. 46. Capriola Dactylon. Plant showing stolons, ×⅔; spikelet, ×7.

The spikelets face alternately to the right and left, often apparently in a single row. In Europe this grass is called dog's-tooth, referring to the tooth-shaped old sheaths on the runners, and cock's-foot, referring to the digitate inflorescence. In the British West Indies it is called Bahama-grass.

FIG. 47. Bouteloua gracilis. Inflorescence, × 1; spikelet, ×10.

243. Chloris *Swartz.*—A moderate-sized genus, many annual species of which are weeds in the tropics. On account of the silky spikes they are usually handsome grasses. One species, *C. Gayana* Kunth, has been introduced in the southern states as a meadow-grass under the name of Rhodes-grass. (See "Some New Grasses for the South," Yearbook, U. S. Dept. Agr. 1912.)

244. Bouteloua *Lag.*—Grama-grasses. A genus of about 30 species, all American, especially abundant in southwestern United States and on the Mexican plateau. They are important grazing-grasses.

Bouteloua gracilis (H.B.K.) Lag. (*B. oligostachya* Torr.). (Fig. 47.) Perennial; culms smooth, tufted, erect, 6 to 18 inches high; sheaths smooth, or the lower somewhat villous, bearing at the throat a tuft of long hairs on each side; ligule very short; blades mostly basal, flat or usually involute, flexuous or curly, 1 to 2 mm. wide, 2 to 4 inches long, scabrous on the margin; spikes usually 2, 1 terminal, the other a short distance below, both nearly sessile and more or less ascending, about an inch long, somewhat curved; spikelets sessile, about 5 mm. long, densely crowded on one side of the pubescent rachis; glumes narrow, the upper villous and more or less beset with dark papillæ, the lemma pubescent; rudiment rounded, 3-awned. The end of the rachis does not project beyond the spikelets. The spikes turn with the wind like vanes. In the less arid portions of the Great Plains this species forms a rather compact sod; in drier regions the tufts are isolated. This is sometimes called blue grama but to stockmen it is usually known merely as grama. It is the most important economic species of the genus, ranging on the Great Plains from Manitoba to South America and westward into New Mexico, Arizona and southern California.

Bouteloua hirsuta Lag. Black grama. Resembles the preceding but differs in the prolongation of the rachis as a naked point 5 to 8 mm. beyond the spikelets, and in the more hairy second glumes with prominent black papillæ. The range is about the same as that of the preceding but does not extend so far north.

Bouteloua curtipendula (Michx.) Torr. Tall or Side-oat grama. Culms 2 to 3 feet high, the spikes numerous, 30 to 50, arranged, by twisting of the peduncles, along one side of the upper part of the culm for 6 to 10 inches, about ½ inch long, the spikelets appressed, 5 to 8 in each spike. Prairies and plains, from Ontario to Montana and south through Mexico to South America.

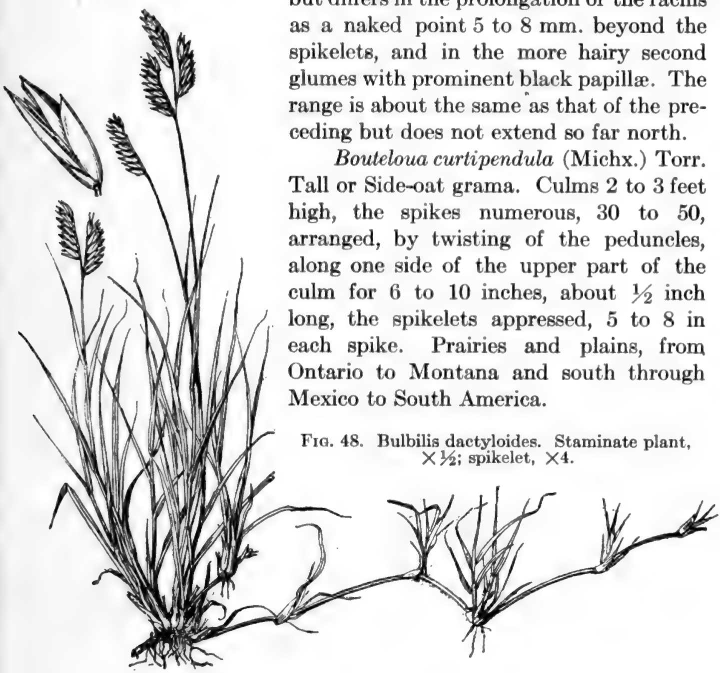


FIG. 48. Bulbilis dactyloides. Staminate plant, ×½; spikelet, ×4.

There are many other species in the southwestern states and in Mexico, but the 3 described above are the best-known economic species.

245. Bulbilis *Raf.*—Buffalo-grass. The single species, *B. dactyloides* (Nutt.) Raf. (*Buchloë dactyloides* (Nutt.) Engelm.) (Figs. 48 and 49), a common and often the dominant grass on the Great Plains, is a low stoloniferous perennial that forms a firm sod. The staminate inflorescence consists of 2 or 3 short 1-sided spikes on a culm a few inches high; the pistillate spikes are hidden among the leaves near the ground.

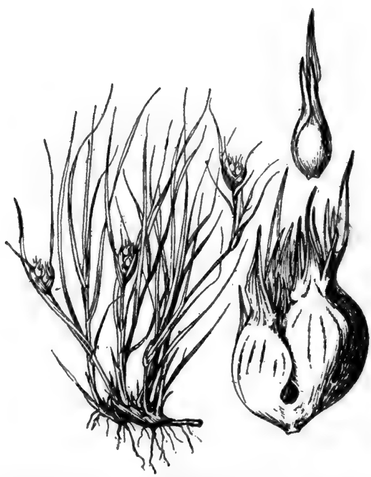


Fig. 49. Bulbilis dactyloides. Pistillate plant, ×½; cluster of spikelets and floret, ×4.

CHAPTER XXIII

TRIBE XI. FESTUCEÆ

A LARGE tribe of about 80 genera, mainly inhabitants of the cooler regions. Spikelets more than 1-flowered, usually several-flowered; inflorescence an open, narrow or sometimes spike-like panicle. If the lemmas are awned, the awn is straight and terminal or rarely from between the teeth of a bifid apex (some species of Bromus and a few species of Festuca). The lemma is divided into several awns at the summit in Pappophorum and Cottea and a few other genera. In some species of Eragrostis the palea is persistent on the inarticulate rachilla. In most of the genera the spikelet breaks up at maturity, each floret falling with a joint of the rachilla, the glumes being persistent on the pedicel. Scleropogon, Monanthochloë, Distichlis and a few species of Poa are diœcious. The blades are broad and petioled in a few tropical genera. Gynerium, Cortaderia, Arundo and Phragmites are tall reeds.

KEY TO THE GENERA OF FESTUCEÆ

A. Lemmas divided at summit into 3 to several awns or awn-like lobes (only the pistillate in Scleropogon; lemmas more or less 3-toothed in Tridens of the next division).

B. Awns 9 or more.

C. Divisions of lemma awn-like, plumose; panicle spike-like. Arizona. . . . . PAPPOPHORUM.

CC. Divisions membranaceous, awn-pointed; panicle open. Texas to Arizona. . . . . COTTEA.

BB. Awns less than 9.

c. Plants diœcious; sexes unlike, the pistillate lemmas long-awned, the staminate awnless or nearly so; southwestern states (burro-grass) .... SCLEROPOGON.

cc. Plants perfect; lemmas broad, 5-lobed; spikelets in racemes; annuals. California .... ORCUTTIA.

AA. Lemmas awnless or with 1 terminal awn, this sometimes from between 2 teeth (more or less 3-toothed in Tridens).

B. Rachilla or lemma with hairs as long as the lemma (only the pistillate in Cortaderia); tall reeds with large terminal plume-like panicles.

c. Plants diœcious, the staminate spikelets naked; blades narrow .... CORTADERIA (Par. 246).

cc. Plants perfect; blades broad.

D. Lemmas hairy; rachilla naked .... ARUNDO (Par. 247).

DD. Lemmas naked; rachilla hairy .... PHRAGMITES.

BB. Rachilla and lemmas naked or pubescent, not with long hairs.

c. Plants diœcious.

D. Plants low and creeping; spikelets obscure, scarcely differentiated from the short crowded rigid leaves; mud flats along coast. Florida and California .... MONANTHOCHLOË.

DD. Plants erect from creeping rhizomes; inflorescence a narrow simple exserted panicle .... DISTICHLIS (Par. 249).

cc. Plants not diœcious (except a few species of Poa).

D. Spikelets of 2 forms, sterile and fertile intermixed.

E. Fertile spikelets 2- to 3-flowered; sterile spikelets with numerous awned glumes; our species perennial (*C. cristatus* L., crested dog's-tail, occasionally sown in mixtures for meadows) .... CYNOSURUS.

EE Fertile spikelets 1-flowered, long-awned; sterile spikelets with many obtuse glumes; annual (*A. aureum* (L.) Kuntze, *Lamarckia aurea* Moench, golden top, occasionally cultivated for ornament, commonly introduced on the Pacific coast).... ACHYRODES.

DD. Spikelets all alike.

E. Callus and nerves of lemma densely bearded; lemma 3-nerved, the nerves ending in teeth or lobes.
  F. Empty lemmas 2 below the fertile floret; spikelets with 1 fertile floret and a 3-awned rudiment above; low desert perennials..... BLEPHARIDACHNE.
  FF. Empty lemmas none at base of spikelets.
    G. Hairs not extending along the 3 conspicuous nerves of the lemma; panicle large and open. REDFIELDIA.
    GG. Hairs extending from the callus along the nerves of the lemma.
      H. Palea ciliate-fringed; midnerve excurrent between the lobes of the lemma.............. TRIPLASIS.
      HH. Palea not ciliate-fringed; the 3 nerves of the lemma often extending into teeth, the apex sometimes 2-lobed..... TRIDENS.
EE. Callus and nerves of lemma glabrous or pubescent, sometimes cobwebby but not bearded.
  F. Plants tufted and creeping, annual; spikelets hidden among the short sharp-pointed leaves. Western... MUNROA.
  FF. Plants with distinct inflorescence.
    G. Lemmas coriaceous, rounded on the back, smooth and shining, the margin not scarious.
      H. Empty lemmas 1 to 4 at base of spikelets; spikelets strongly compressed .... UNIOLA.
      HH. Empty lemmas 2 to 4 at summit of spikelet; spikelets not compressed .... DIARRHENA.
    GG. Lemmas membranaceous, or if somewhat coriaceous, the margins scarious.
      H. Lemmas 3-nerved (Sphenopholis might be sought here).
        I. Glumes longer than the lemmas. California....... DISSANTHELIUM.
        II. Glumes shorter than the lemmas.
          J. Spikelets subterete. Sparingly introduced from Europe.............. MOLINIA.

JJ. Spikelets compressed.
K. Spikelets 2-flowered; rachilla articulate ....CATABROSA.
KK. Spikelets 3- to many-flowered; rachilla usually continuous, the palea persistent after the fall of the lemma...........ERAGROSTIS (Par. 248).
HH. Lemmas 5- to several-nerved.
I. Lemmas flabellate, many-nerved; spikelets in close spike-like panicles; annual. California.................ANTHOCHLOA.
II. Lemmas not flabellate.
J. Spikelets in 1-sided fascicles, these in a panicle, the branches spreading in anthesis, appressed at maturity.................DACTYLIS (Par. 250).
JJ. Spikelets not in 1-sided fascicles.
K. Palea wing-margined or appendaged on the keels; spikelets long and slender, in racemes. California...PLEUROPOGON.
KK. Palea not wing-margined nor appendaged.
L. Callus bearded (base of lemma cobwebby in species of Poa) spikelets 2- to 4-flowered.
M. Rachilla pilose, prolonged above the upper floret; lemma with a short awn just below the tip..............GRAPHEPHORUM.
MM. Rachilla naked, not prolonged; lemma awnless but 1 or more of the nerves projecting beyond the apex......SCOLOCHLOA.
LL. Callus not bearded.
M. Spikelets as broad as long, somewhat heart-shaped; lemmas broad, closely imbricated, horizontally spreading.BRIZA.
MM. Spikelets longer than broad.

N. Lemmas papery, scarious-margined, narrow and awned or acuminate, or broad and obtuse (the upper lemmas then reduced to a club-shaped rudiment enfolded by the upper broad lemmas); spikelets tawny or purplish, not green . . MELICA.

NN. Lemmas not scarious-margined, or if slightly so, only at the tip, the lemma green (Poa).

O. Lemma obscurely nerved, rounded on back, obtuse, awnless; glumes small, much shorter than lemmas. Low plants of the seashore and of alkaline soil . . . . PUCCINELLIA.

OO. Lemma distinctly nerved; glumes nearly as long as the first lemma.

P. Nerves of lemma prominent, parallel; lemma broad, obtuse, awnless, 8- to 9-nerved . . . . . . PANICULARIA.

PP. Nerves of lemma evident but not prominent.

Q. Lemmas obtuse or acutish, awnless, somewhat scarious at tip, 5-nerved, sometimes cobwebby at base . . . . POA (Par. 251).

QQ. Lemmas acute or awned.

R. Lemmas entire, often awned, rounded below. FESTUCA (Par. 254).

RR. Lemmas bifid at apex, often awned from between the teeth; spikelets large, sometimes compressed and keeled........Bromus (Par. 258).

246. Cortaderia *Stapf.*—Pampas-grass. The ornamental species, *C. argentea* (Nees) Stapf (Fig. 50), is a large reed growing in clumps, the blades numerous, long and narrow, drooping, the flower-stalk tall and slender, bearing a large silvery white or rosy plume 1 to 2 feet long. A native of Argentina, cultivated for ornament and, in California, on a commercial scale for the plumes.

Another species, *C. jubata* (Lem.) Stapf, with smaller and more lax lavender-colored plume, is occasionally cultivated. A related plant, the uva-grass *Gynerium sagittatum* (Aubl.) Beauv. (*G. saccharoides* Humb. & Bonpl.), sometimes cultivated, is a tall coarse leafy reed, 12 to 30 feet high, with creeping rootstocks, the lower leaves soon dropping, leaving the stem naked below. Tropical America; not hardy.

Fig. 50. Cortaderia argentea. A group of inflorescences greatly reduced; glumes of pistillate spikelet (*a*), florets of pistillate spikelet (*b*), glumes (*c*), and florets (*d*) of staminate spikelet, ×1. (U. S. Dept. Agr., Div. Agrost., Bull. 20.)

247. Arundo *L.*—Giant-reed. The species found in the United States, *A. Donax* L., is a tall stout reed, 5 to 10 feet high, with somewhat woody finally much-branched stem, broad clasping blades and large plumes or panicles. A native of the Mediterranean region, cultivated in the southern states for ornament. It has escaped along irrigation ditches from Texas to California.

248. Eragrostis *Host.*—A large genus of over 100 species, found throughout the warmer regions of the world. Annuals or perennials with open, narrow or spike-like panicles; spikelets many-flowered, awnless; rachilla usually continuous, the paleas often persistent after the fall of the lemmas and fruits. Several species are weeds introduced from the Old World. One of these, *E. cilianensis* (All.) Link (*E. megastachya* (Koel.) Link) (Fig. 51), called snake-grass or stink-grass, emits a disagreeable odor from glands along the keels of the lemmas. Teff, *E. abyssinica* (Jacq.) Link, is an important food-plant in Abyssinia and has been tried in other countries as a forage plant. Several species are occasionally cultivated for ornament, the panicles being used for dry bouquets.

FIG. 51. Eragrostis cilianensis. Plant reduced; 2 spikelets, showing variable number of florets; portion of rachilla from which some of the florets have fallen, ×3. (U. S. Dept. Agr., Div. Agrost., Bull. 17.)

249. Distichlis *Raf.*—Salt-grass. Low diœcious perennials of seacoasts and alkaline flats. Only 1 species, *D. spicata* (L.) Greene (Fig. 52), is found in the United States. This is common in salt-marshes throughout the country. The culms are erect fom extensively creeping rhizomes, with short distichous blades and narrow few-flowered panicles of many-flowered spikelets. In regions where it is abundant, salt-grass is utilized for forage, but on account of the excess of mineral constituents it is of inferior quality.

FIG. 52. Distichlis spicata. Staminate plant (at left) and pistillate plant (at right) reduced; pistillate and staminate spikelets.

250. Dactylis *L.*—The single species, *D. glomerata*, a native of Europe, is commonly cultivated as a forage grass under the name of orchard-grass. It is a tussock-forming perennial, 2 to 4 feet high, with flat blades and narrow panicles. The spikelets are in 1-sided fascicles or small heads at the ends of the few principal branches of the panicle. These branches spread at the time of flowering but close at maturity. The lemmas are fringed or ciliate on the sharp keel.

Dactylis glomerata L. (Fig. 53.) Orchard-grass. Perennial, in large tufts without creeping rootstocks; culms erect, smooth, 2 to 4 feet high; sheaths compressed and keeled, more or less retrorsely scabrous, closed for a portion of their length, sometimes nearly to the throat; ligule prominent, thin and papery, pointed, usually lacerate, the uppermost as much as ⅓ inch long; blades flat, usually scabrous on both surfaces, elongated, as much as ⅓ inch wide, tapering into a slender point; panicle 3 to 6 inches long, the branches few and stiff, singly disposed, naked below, bearing a few 1-sided clusters of spikelets, the clusters being about ½ inch wide, green or purplish; spikelets compressed, about ⅓ inch long usually 3- or 4-flowered; first glume 1-nerved, acute; second glume longer than the first, 3-nerved, acuminate, ciliate on the keel; lemmas rather indistinctly 5-nerved, ciliate on the keel, short-awned. During the flowering period the branches are spread open by the turgidity of prominent cushions of tissue in the basal angle. Later these cushions shrink and the branches become appressed so that in fruit the panicle is narrow and almost spike-like. The tufts of orchard-grass soon develop at the base into large tussocks. In England this grass is known as cock's-foot.

Fig. 53. Dactylis glomerata. Inflorescence, ×⅔, spikelet, ×7.

251. Poa *L.*—Blue-grass. A large genus of over 100 species, found throughout the world in the cooler parts and in the high mountains of the tropics. Annuals or mostly perennials often with creeping rhizomes. Spikelets in narrow or open panicles, 2- to 6-flowered; lemmas 5-nerved, awnless, somewhat scarious at tip, smooth or hairy on the nerves, sometimes cobwebby at base. This is one of the most important genera of forage grasses. The species are abundant in the grazing areas of our western mountains and several species are cultivated.

252. Kentucky blue-grass.—Culms from a few inches to 2 feet or more in height from slender creeping rhizomes; sheaths smooth; ligule short; blades flat or somewhat folded, ending like most species of the genus, in a boat-shaped blunt point, panicle 2 to 4 inches long or sometimes larger, pyramidal, open, the lower branches in groups of about 5; spikelets 3- to 5-flowered, 4 to 5 mm. long; lemmas pubescent on the keel and marginal nerves, bearing a tuft of cobwebby hairs at base. Commonly cultivated as a lawn- and pasture-grass.

Poa pratensis L. (Fig. 54.) Kentucky blue-grass. Perennial, in tufts but producing slender creeping rootstocks; culms slender, erect, smooth, terete or slightly flattened, 1 to 3 feet high; sheaths smooth, sometimes slightly keeled; ligule membranaceous, short, truncate, about 1 mm. long; blades, especially the basal, long and narrow, flat or usually partly folded or conduplicate, usually not over 4 mm. wide, the uppermost 1 to 3 inches long, appressed, slightly roughened on the margins and keel, especially toward the boat-shaped tip; panicle open, pyramidal or oblong, 3 to 6 inches long, the scabrous branches naked below, the lower in whorls of usually 5, one being stronger; spikelets ovate or lanceolate, flattened, 4 to 6 mm. long, usually 3- to 5-flowered, the ultimate pedicels about 1 mm. long; glumes narrow, acute, the first 1-nerved, the second 3-nerved; lemma 5-nerved, acute, hyaline or papery and often purple-tinged at apex, about 4 mm. long, the keel and marginal nerves pubescent, the base bearing a tuft of cobwebby hairs. The boat-shaped apex of the blades is characteristic of the genus. Blue-grass is a native of Europe and may also be native in the northern parts of North America. In open dry or sterile soil the flowering culm may be only a few inches in height. In color the foliage is a dark green and does not have a blue color as the name would indicate. As it flowers in June, the name June-grass is applied to this species in parts of the northern United States.

253. Other economic species of Poa.—Compared with Kentucky blue-grass, the other species of Poa are of slight importance, although Canada blue-grass attains some importance locally (Par. 35). Of the other species 2 are advertised by seedsmen and are occasionally used in mixtures.

Canada blue-grass (*Poa compressa* L.).—Culms wiry, flattened, with numerous creeping rhizomes, not tufted; panicles narrow, the branches in pairs. This resembles *P. pratensis* but is bluish green rather than dark green. Cultivated as a pasture-grass. Called also wire-grass and flat-stem.

Rough-stalked meadow-grass (*Poa trivialis* L.).—This resembles *P. pratensis* but differs in the absence of rhizomes and in having scabrous sheaths and a long ligule. Sometimes cultivated as a meadow-grass.

Fowl meadow-grass (*Poa triflora* Gilib.; *P. serotina* Ehrh.).—Culms 1 to 4 feet high, tufted but without rhizomes; sheaths smooth;

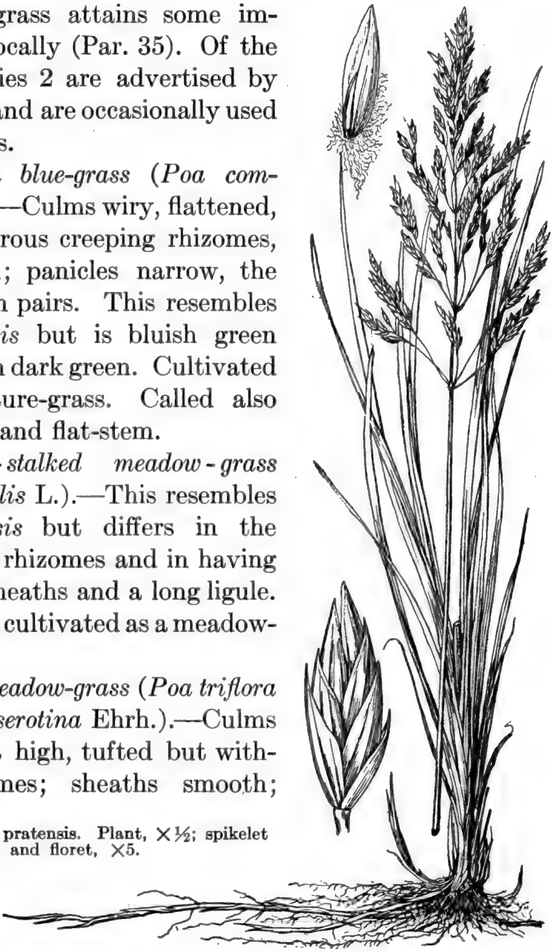


FIG. 54. Poa pratensis. Plant, ×½; spikelet and floret, ×5.

panicles large and open, 4 to 12 inches long. Sometimes cultivated as a meadow-grass.

Annual blue-grass (*Poa annua* L.).—A low-spreading tufted annual with soft light green foliage and small panicles resembling those of *P. pratensis*. A native of Europe, now a common weed throughout the warmer portions of the United States. In the eastern states, it is a troublesome weed in lawns, because, though it makes a good showing in the spring, it dies out later, leaving bare spots.

Poa arachnifera Torr. Texas blue-grass. A smooth rhizome-bearing, diœcious perennial 1 to 2 feet high, with contracted panicles 2 to 4 inches long; the staminate spikelets glabrous, the lemmas of the pistillate spikelets villous on the keel and marginal nerves, provided at base with a copious tuft of woolly hairs. A native of Texas, where it is a good but rather local range-grass. This species has been recommended as a winter pasture-grass for the South.

Many native species of Poa are important constituents of mountain ranges.

254. Festuca *L.*—Fescue-grass. A large genus found in all the cooler and arctic regions of the world. Annuals or perennials with narrow or open panicles of several-flowered spikelets; lemmas rounded on back, rather firm in texture, 5-nerved, acute or tapering into an awn. The annual species are weedy but the perennial species are excellent forage grasses, several species being cultivated as pasture-grasses.

255. Meadow fescue.—A tufted smooth perennial 1 to 4 feet high, with narrow panicle, 4 to 8 inches long, the branches spreading while in flower but contracting later. Commonly cultivated as a meadow- and pasture-grass. A form with lower culms and more simple panicle has been called *F. pratensis* Huds. In some localities meadow fescue is called English blue-grass.

Festuca elatior L. (Fig. 55). Meadow fescue. Perennial, sometimes with short rootstocks; culms erect, smooth, 1 to 4 feet high; sheaths smooth, or slightly scabrous toward the apex; ligule a membrane ½ mm. or less long; blades elongated, 2 to 5 mm. wide, scabrous on the upper surface, the base bearing on each side a more or less well-developed auricle; panicle erect or nodding at the apex, 4 to 8 inches long, rather loose, contracted, but spreading in flower, the branches mostly singly disposed, bearing few spikelets; spikelets oblong or lanceolate, about ½ inch long, smooth, green, usually 7- or 8-flowered; glumes lanceolate, about half as long as the first floret; lemma rounded on the back, faintly nerved, the scarious apex acute.

256. Sheep's fescue (*F. ovina* L.).—A densely tufted erect perennial 6 inches to 2 feet high with numerous slender firm involute basal leaves and narrow panicles 2 to 4 inches long, spreading in flower; spikelets short-awned. Common in Europe in many forms or closely allied species. Used in this country in pasture mixtures for sterile soil. Var. *capillata* (Lam.) Hack. has long slender rather soft blades. Var. *duriuscula* (L.) Koch, hard fescue, has harsh blades about 1 mm. thick.

257. Red fescue (*F. rubra* L.).—This differs from *F. ovina* in having less closely tufted culms, the bases somewhat decumbent or creeping. This species is also cultivated in meadows. Var. *heterophylla* (Lam.) Hack., various-leaved fescue, has

FIG. 55. Festuca elatior. Inflorescence, ×½; spikelet, ×4.

slender soft leaves and is more densely tufted than red fescue. It is used for shaded places in lawns where other grasses will not thrive.

Several native species of Festuca are important range grasses. *Festuca idahoensis* Elmer (*F. ingrata* (Hack.) Rydb.) is common in Oregon, Washington and Idaho. It is related to *F. ovina* and has numerous involute, stiff, scabrous blades and a rather large, spreading panicle, the lemmas awned. *F. viridula* Vasey is a green erect species with creeping rootstocks and awnless lemmas. It is a valuable range grass of the mountain meadows.

One section of the genus includes several species of small annuals. One species, *F. octoflora* Walt., is common in dry open ground throughout the United States. In the western states there are several other species, some of which are sufficiently abundant in the desert regions to produce forage after the rainy season.

258. Bromus *L.*—Brome-grass. A large genus, found mostly in the north temperate zone. Annuals or perennials with closed sheaths, and open or contracted panicles of comparatively large spikelets; lemmas keeled or rounded on the back, bifid at apex, usually awned from between the teeth. Several annual species have been introduced from Europe and have become troublesome weeds, especially on the Pacific coast. One species is called cheat or chess (*B. secalinus*) and is a weed in grain-fields in the eastern states. This species is cultivated for hay in Oregon and Washington. This has an open panicle of plump short-awned spikelets. The species of Bromus, even the annuals, are good forage grasses, at least when young.

259. Awnless brome-grass.—An erect perennial with creeping rhizomes, flat blades and open panicles of slightly flattened spikelets, the lemmas awnless or nearly so. A native of Europe and cultivated in the northwestern states as a forage grass.

Bromus inermis Leyss. (Fig. 56). Awnless brome-grass. Perennial with numerous creeping rootstocks; culms 1 to 3 feet high, smooth, leafy; sheaths smooth, closed nearly to the summit, bearing on each side at apex a point or auricle; ligule membranaceous, 1 to 2 mm. long, ciliate and more or less toothed; blades flat, 5 to 8 mm. wide, somewhat scabrous; panicle 4 to 6 inches long, somewhat open and spreading, the branches naked below, the lower in fascicles; spikelets about an inch long, brown or purplish, 8- to 10-flowered, slightly flattened; first glume narrow, acute, 1-nerved, 5 mm. long, the second broader and longer, obtuse, 3-nerved; lemma 5- to 7-nerved, the nerves scabrous, the apex awnless or short-awned.

Fig. 56. Bromus inermis. Inflorescence, ×½; spikelet, ×3.

260. Rescue-grass (*B. unioloides* Kunth).—Schrader's brome-grass. An erect annual or biennial, with pubescent sheaths and a narrow panicle of compressed spikelets, the lemmas keeled, acuminate, awnless. A native of South America, cultivated in our southern states for winter forage.

The annual weedy species of Bromus are numerous and conspicuous on the Pacific slope. The seeds germinate in the spring and the young plants cover the plains and foothills with green. By midsummer the plants have matured and the green mantle has turned to brown. The fruiting florets of some species with their antrorsely scabrous awns are sharp-pointed so they readily penetrate clothing and the wool of sheep, because of which these species are considered a great pest. The following key will distinguish the common species:

A. Panicle contracted, dense.
  B. Awn ⅔ inch long.
    C. Culm pubescent below panicle........... *B. rubens* L.
    CC. Culm glabrous below panicle............ *B. madritensis* L.
  BB. Awn about ¼ inch long.................... *B. hordeaceus* L.
AA. Panicle open, the branches spreading.
  B. Awn twisted and bent..................... *B. trinii* Desv.
  BB. Awn not twisted and bent.
    C. Sheaths smooth......................... *B. secalinus* L.
    CC. Sheaths pubescent.
      D. Awn 1½ to 2 inches long.............. *B. villosus* [Forsk.
      DD. Awn not over ⅔ inch long.
        E. First glume 1-nerved............... *B. tectorum* L.
        EE. First glume 3-nerved.
          F. Lemmas pubescent................. *B. arenarius* [Labill.
          FF. Lemmas glabrous................. *B. pratensis* [Ehrh.

CHAPTER XXIV

TRIBE XII. HORDEÆ

A SMALL tribe of about 25 genera in the temperate regions of both hemispheres. Spikelets 1- to several-flowered, sessile in spikes. The rachis is flattened or concave next to the spikelets, or in some genera it is hollowed out so that the spikelets are embedded or inclosed. The spike is 1-sided in Nardus (of Eurasia), but symmetrical in all other genera. In Triticum and its allies there is 1 spikelet at each node of the rachis, and in Hordeum and its allies there are 2 or more. The spikelets are usually placed sidewise to the rachis but in Lolium and its allies they are placed edgewise. In these genera the outer glume is fully developed, but the inner (second) glume is reduced or wanting except in the terminal spikelet, where the glumes are equal. The rachis of the spike disarticulates in Sitanion, Scribneria, Lepturus and a few species of Elymus and Agropyron. In some species of Elymus the glumes, except in the terminal spikelet, stand in front of the spikelet instead of at the 2 sides. According to some these 2 organs are the 2 portions of a single deeply cleft glume (Par. 153) or represent branchlets. In some species of Elymus and especially in Sitanion the glumes are very slender, extending into long awns. In Sitanion the glumes are commonly split into 2-several slender awns. The blades of this tribe usually bear on each side at the base an appendage or auricle. To this tribe belong our most important cereals.

Key to the Genera of Hordeæ

A. Spikelets more than 1 at each node of the rachis.
  B. Spikelets 3 at each node of the rachis, 1-flowered, the lateral pair pedicelled, usually reduced .... Hordeum (Par. 268).
  BB. Spikelets 2 at each node of the rachis, 2- to 6-flowered, all alike.
    C. Glumes none or reduced to short bristles; spikes very loose .... Hystrix.
    CC. Glumes usually equaling the florets; spikes dense.
      D. Rachis continuous; glumes broad or narrow, entire .... Elymus (Par. 269).
      DD. Rachis disarticulating at maturity, glumes slender, extended into long awns, these and the awns of the lemmas making the spike very bristly. Sitanion.
AA. Spikelets solitary at each node of the rachis.
  B. Spikelets placed edgewise to the rachis; glume 1 except in the terminal spikelet.
    C. Spikelets several-flowered .... Lolium (Par. 261).
    CC. Spikelets 1-flowered. Introduced on the Pacific coast .... Monerma.
  BB. Spikelets placed flatwise to the rachis; glumes in pairs.
    C. Spikelets 1-flowered; spikes slender, terete.
      D. Lemmas awnless .... Lepturus.
      DD. Lemmas awned. Pacific coast .... Scribneria.
    CC. Spikelets 2- to several-flowered.
      D. Plants perennial (as to species of the United States) .... Agropyron (Par. 262).
      DD. Plants annual.
        E. Glumes ovate, 3-nerved .... Triticum (Par. 263).
        EE. Glumes subulate, 1-nerved .... Secale (Par. 267).

261. Lolium *L.*—Rye-grass. A small genus of temperate Eurasia. Spikelets several-flowered, somewhat resembling those of Festuca, the lemma often awned. The genus can be easily distinguished by the position of the spikelets, edgewise to the rachis. The second glume being next the rachis is usually suppressed but is present and equal to the first in the terminal spikelet. Two closely related species are used for lawns, meadows and pastures.

These are perennial rye-grass, *L. perenne,* and Italian rye-grass, *L. multiflorum* (*L. italicum*).

Lolium perenne L. Perennial rye-grass. Perennial; culms tufted, erect, smooth, 1 to 2 feet high; sheaths smooth; ligule a short membrane, less than 1 mm. long; blades flat, narrow, mostly less than 4 mm. wide, smooth, or scabrous above, the base extended on each side into an auricle; spike slender, as much as a foot long; spikelets usually 8- to 10-flowered somewhat longer than the 5 to 8 mm. long glume, the lemmas awnless.

Lolium multiflorum Lam. (*L. italicum* A. Br.). (Fig. 57.) Differs from the preceding in having awned lemmas and usually a greater number of florets to the spikelet. This species is now common in grass land and waste places on the Pacific coast, where it is sometimes called Australian rye-grass. These species are both used in lawn mixtures in the East. The young plants resemble blue-grass but may be distinguished by the darker green color, the usually larger size and especially by the glossy surface of the blades, and by the absence of the boat-shaped tip. The auricles are characteristic when the shoots are sufficiently developed.

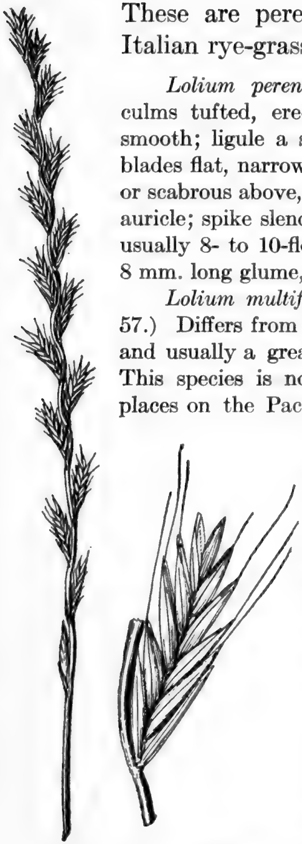


FIG. 57. Lolium multiflorum. Inflorescence, × ½; spikelet with portion of rachis, ×3.

Lolium temulentum L. Darnel. An annual with glumes as much as an inch long, longer than the 5- to 7-flowered spikelets. Introduced from Europe. Not common, but of interest because of the presence in the fruit of a narcotic poison said to be due to a fungus. This plant is said to be the one referred to in scripture in the parable of the tares (Henslow, "Plants of the Bible," p. 119).

262. Agropyron *Gærtn.*—Wheat-grass. A genus of about 50 species of the temperate regions. Spikelets several-flowered, 1 at each node of the rachis. Distinguished from Triticum by the narrow pointed or awned glumes. The American species are perennials. Couch-grass, *A. repens* (L.) Beauv. (Fig. 58), is a troublesome weed introduced from Europe. It propagates by creeping rhizomes. A similar native species, *A. Smithii* Rydb., is found in alkali soil in the western states and furnishes a fair quality of hay. Another species, *A. tenereum* Vasey, is a bunch-grass of the same region. This species has been introduced into cultivation and is sold by seedsmen under the name of slender wheat-grass. This has erect stems 2 to 4 feet high, with slender spikes 2 to 6 inches long, or even longer, broad-nerved awn-pointed glumes nearly as long as the spikelet, and short-awned or awnless lemmas.

263. Triticum *L.*—Wheat. A small genus of annuals distinguished from Agropyron by the broad several-toothed or awned glumes. The best known species is the common wheat (*T. vulgaris*; *T. sativum*) of which there are numerous varieties. Those varieties bearing long awns are called bearded wheats; those in which the awn is short or none are called beardless

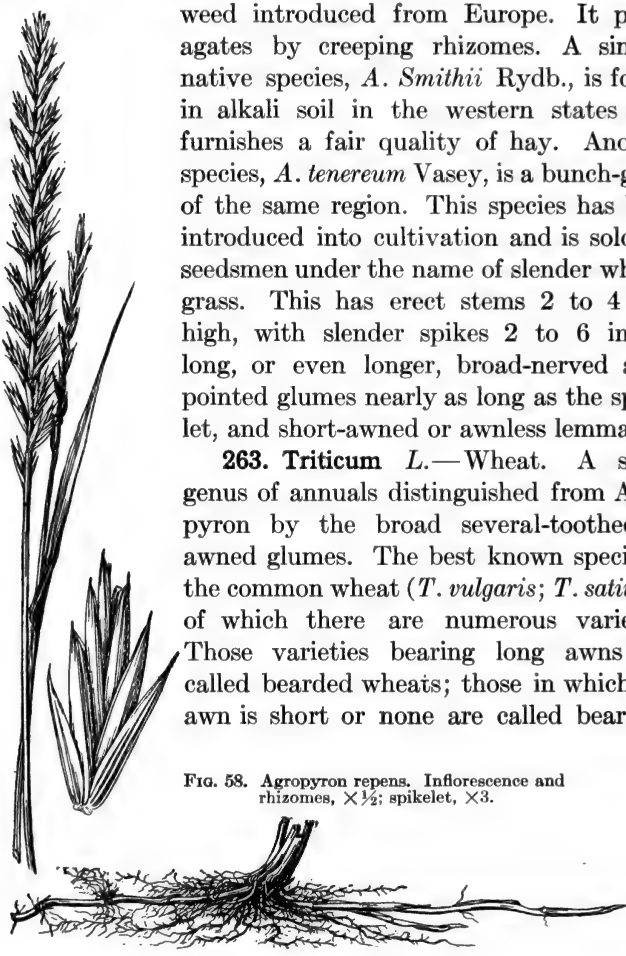


FIG. 58. Agropyron repens. Inflorescence and rhizomes, ×½; spikelet, ×3.

or smooth wheats. In all the true wheats, the grain is free from the lemma and palea (the chaff).

264. Spelt and emmer are considered by some as varieties of wheat, by others as distinct species, the first being *T. spelta,* the second *T. dicoccum* (Fig. 59). They differ from wheat in having an articulated rachis, and grains permanently inclosed in the glumes and lemmas. When threshed, the spike breaks up into the internodes of the rachis, each with a spikelet attached. In wheat, the threshing process removes the grains from the spikelets and leaves the rachis entire. The head or spike of emmer is compact, resembling that of bearded wheat. The spike of spelt is more slender and loose.

Fig. 59. Triticum dicoccum. Inflorescence (head), ×½, spikelet with a disarticulated joint of the rachis, ×2.

Emmer has been introduced into cultivation in recent years as a dry-land product in the Great Plains region, the grain being used in the same manner as barley for feeding stock. The statistics for this crop are given in the census report under "emmer and spelt." Since the amount of spelt cultivated is insignificant, the figures apply mostly to emmer. The production of this crop is given in Table XI (Par. 9).

265. Origin of wheat.—None of the cultivated wheats is now found growing spontaneously, that is, as a native plant. Various theories have been advanced as to their origin. Some botanists have supposed them to be derived from wild species now extinct or possibly existing in unexplored regions. Others have thought them to be the greatly changed descendants from common wild species such as *Triticum ovatum* Rasp. (*Ægilops ovata* L.). (See Fabre, Journ. Roy. Agr. Soc. 15: 167. 1854.) Schulz has recently suggested the probable origin of the cultivated forms. He considers the cultivated wheats to be culture-form groups rather than species, subspecies or races. Nomenclatorially he recognizes the following: *T. monococcum, T. spelta, T. dicoccum, T. vulgare, T. compactum, T. turgidum, T. durum, T. polonicum.* The first-mentioned, *T. monococcum,* he believes is derived from the wild *T. œgilopoides* Bal., and the third, *T. dicoccum,* from the wild *T. dicoccoides* Körn., recently discovered by Aaronsohn in the region of Mount Hermon, Palestine. (See Cook, U. S. Dept. Agr. Bur. Pl. Ind. Bull. 274. 1913. Aaronsohn, Op. cit. 180: 38. 1910. Verh. Zoöl.-bot. Ges. Wien. 59: 485. 1909. Altneuland Monatschr. Wirtsch. Erschl. Palästinas 213. 1906. Bull. Soc. Bot. France 56: 237. 1909. Schweinfurth, Ber. Deutsch. Bot. Ges. 26*a*: 309. 1908.) The second, *T. spelta,* he considers to have been derived from an as yet undiscovered wild species. Furthermore he thinks that *T. vulgare* and *T. compactum* were derived from *T. spelta,* and that *T. turgidum, T. durum* and *T. polonicum* were derived from *T. dicoccum.* (Schulz, Mitt. Natf. Ges. Halle 1: 14. 1911.) Aaronsohn considers *T. dicoccum* to be the prototype of true wheat and the former to be derived from *T. dicoccoides* (U. S. Dept. Agr. Bur. Pl. Ind. Bull. 180: 41. 1910).

Triticum æstivum L. (*T. vulgare* Vill.; *T. sativum* Lam.). (Fig. 60). Wheat. Annual; culms tufted, erect, smooth or pubescent at the nodes, 2 to 3 feet high; sheaths smooth or slightly scabrous, or the lowermost pubescent; ligule membranaceous, about 1 mm. long; blades flat, about ½ inch wide, more or less scabrous on the upper surface, the base extended on either side into points or auricles, these, at least in the young leaves, ciliate; spike dense, more or less 4-sided, 1 to 4 inches long; spikelets overlapping, single at the nodes, in 2 rows alternating on the zigzag continuous rachis, usually 3- to 5-flowered, ovate, somewhat compressed; glumes coriaceous, shorter than the spikelets, unsymmetrical or 1-sided, the outer side being broader, and bearing an obtuse or rounded shoulder or tooth, the sharp keel ending in a point or awn; lemmas similar to the glumes but nearly symmetrical, more or less 3-toothed, the central tooth sometimes extending into a long awn or beard. This includes all the forms that are grown in America under the name of wheat. There are numerous varieties differing in length of awn, color of the head and of the grain, in pubescence of the spikelets, in the shape of the head, and many other characters. The only other species of the genus grown commercially in America is emmer (*T. dicoccum* Schrank). Durum wheat is considered to be a variety of *T. æstivum*.

FIG. 60. Triticum æstivum. Inflorescence (head), ×½; spikelet with portion of attached rachis, ×2.

Two other species are grown to a limited extent in southeastern Europe. These are Polish wheat (*T. polonicum* L.) in which the glumes are papery in texture and longer than the spikelet; and einkorn (*T. monococcum* L.) with disarticulating rachis and slender long-awned heads, the lateral tooth of the glumes pointed, the palea splitting into 2 parts, the spikelets much compressed, 2-flowered but usually 1-seeded.

266. Classification of the wheats.—The cultivated forms of the genus Triticum may be divided into 2 series: (1) The spelt wheats, in which the axis disarticulates and the grains are permanently inclosed in the spikelets. This group includes spelt (*T. spelta* L.), emmer (*T. dicoccum* Schrank) and einkorn (*T. monococcum* L.), the latter, grown to a limited extent in certain parts of Europe, being distinguished by the 1-awned spikelets with usually only 1 grain. (2) The naked wheats, in which the axis is entire and the grains not permanently inclosed by the spikelets. In these the grain can be separated from the chaff by threshing. The group includes Polish wheat (*T. polonicum* L.), durum wheat (*T. durum* Desf.), English wheat (*T. turgidum* L.) and the numerous varieties of wheat grown in America, *T. æstivum* L., *T. vulgare* Vill., and *T. sativum* Lam. (See Jessen, Deutschlands Gräser 191. 1863.)

Hackel's classification.—Hackel divides the cultivated wheats into 3 species on more technical botanical characters:

A. Terminal spikelet aborted, often scarcely visible. Palea falling into 2 parts at maturity. Lateral teeth of glumes acute.............. 1. *T. monococcum.*
AA. Terminal spikelets developed; palea remaining entire; lateral teeth of the glumes obtuse.
  B. Glumes shorter than any of the lemmas, chartaceous; palea as long as lemmas..... 2. *T. sativum.*
  BB. Glumes as long as or longer than any of the lemmas, papery, lanceolate; palea of the lowest flower half as long as its lemma.... 3. *T. polonicum.*

Triticum sativum (the equivalent of *T. æstivum*) he divides as follows into 3 groups which he calls races:

A. Rachis articulate at maturity; grain entirely inclosed by the glumes, not falling out when threshed (however it is not grown to the glumes).
B. Spikes loose, almost 4-sided when seen from above; glumes broadly truncate in front, with a very short, obtuse middle tooth, obtusely keeled........................1. *T. sativum* [*spelta* Hack.
BB. Spikes very dense, laterally compressed; glumes tapering, with an acute middle tooth; sharply keeled...................2. *T. sativum dicoccum* Hack.
AA. Rachis not articulated at maturity; grain visible between the somewhat open fruiting lemma and palea, easily falling out.........3. *T. sativum* [*tenax* Hack.

The third race, which includes the common wheats, he divides in four subraces:

A. Glumes distinctly keeled only in the upper half, rounded or only slightly keeled in the lower half.
B. Spikes long, more or less loose, somewhat dorsally compressed.....................1. *T. sativum* [*vulgare* Hack.
BB. Spikes short, dense, distinctly 4-sided.......2. *T. sativum* [*compactum* Hack.
AA. Glumes sharply keeled at the base.
B. Grain short, thick, not compressed, broadly truncate above........................3. *T. sativum turgidum* Hack.
BB. Grain oblong, narrower, somewhat laterally compressed, and somewhat acuminate.....4. *T. sativum* [*durum* Hack.

The first includes most of the common wheats, of which there are numerous varieties. The second includes the club wheats grown in the Palouse country of Washington and the adjacent regions. The third includes English wheat, especially grown in Mediterranean countries. The fourth includes the durum wheat, recently introduced and now successfully grown in the Great Plains region. (See Hackel in Engl. & Prantl, Pflanzenfam. II. 2:80. 1887. True Grasses, 180. 1890.)

Körnicke's classification is similar to that of Hackel, but he recognizes the races and subraces as species. (Körnicke, Handb. Getreidebaues, 1:40. 1885)

267. Secale *L.*—Rye. A small genus of southern Europe and southwestern Asia including 2 wild species and the cultivated rye. Rachis continuous in the cultivated species, disarticulating in the wild species; spikelets mostly 2-flowered, single at the nodes, awned, the glumes narrow. One wild species is an annual, the other, *S. montanum* Guss., is a perennial. From the latter has been developed, according to some botanists, the cultivated rye.

FIG. 61. Secale cereale. Inflorescence (head), ×½; spikelet, ×2.

Secale cereale L. Rye. (Fig. 61). Annual; culms usually pubescent below the spike, otherwise smooth, usually glaucous, erect, tufted, 3 to 5 feet high; sheaths smooth; ligule membranaceous, short, about 1 mm. long, toothed, often lacerate; blades flat, ¼ to ½ inch wide, scabrous, bearing on each side at base a small point or auricle; spike 3 to 5 inches long, somewhat nodding; the rachis-joints pubescent on the edges; spikelets 2-flowered, or with a third rudimentary floret; glumes narrow, 1-nerved, almost subulate, scabrous on the keel; lemma lanceolate, much-compressed, 5-nerved, ciliate with stiff hairs on the keel and exposed margin, unsymmetrical, the outer half broader and more distinctly nerved, the apex tapering into a straight awn about an inch long.

268. Hordeum *L.*—Barley. A small genus of temperate regions. Glumes narrow or subulate, standing in front of the spikelet, the 3 pairs forming a sort of involucre at each node of the rachis; lemmas awned. The most important species is the cultivated barley (*H. vulgare*), an annual with close spikes like those of wheat, the spikelets long-awned. When all 3 spikelets of each group are fertile the barley is 6-rowed; when only the central spikelet is fertile the barley is 2-rowed. In 4-rowed, or common barley, all the spikelets are fertile but the lateral rows of the opposite sides of the head overlap or intermingle to form a single row. Several species of Hordeum are troublesome weeds. Of these may be mentioned *H. pusillum* Nutt., an annual, and *H. nodosum* L., a perennial, low short-awned species found widely distributed in the United States, and *H. jubatum* L. (squirrel-tail grass) with long-awned soft spikes, a perennial found especially westward, all 3 native species. Two species introduced from Europe, *H. murinum* L. and *H. Gussoneanum* Parl., variously known as fox-tail and wild barley, are common and troublesome on the Pacific coast. These are low spreading annuals, the first with flattened spikes and ciliate glumes, the second

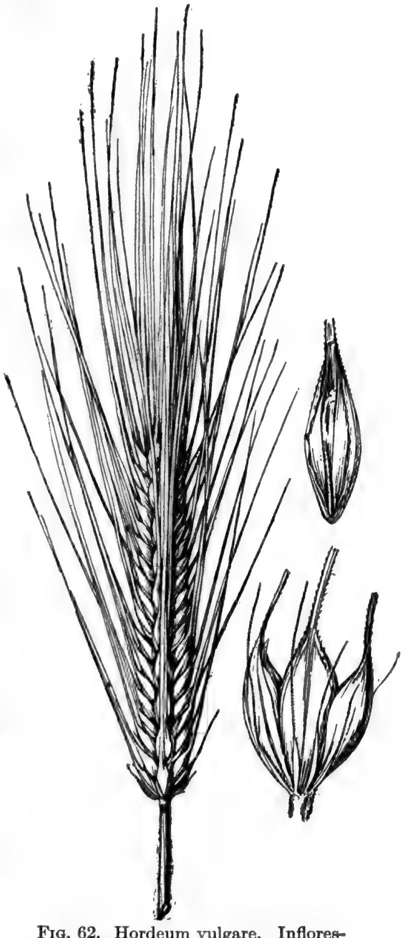


FIG. 62. Hordeum vulgare. Inflorescence (head), $\times \frac{1}{2}$; cluster of 3 spikelets, and a single floret from the back showing the stipiform rachilla, $\times 2$.

with cylindrical spikes and several setaceous glumes. All the species mentioned except cultivated barley have an articulated rachis that breaks up at maturity.

Hordeum vulgare L. (*H. sativum* Jessen). (Fig. 62.) Cultivated barley. Annual; culms and leaves similar to those of wheat; auricles prominent, as much as 5 mm. long, glabrous; spike densely flowered, usually 3 to 4 inches long, excluding the long awns or beards, the rachis not disarticulating at maturity; spikelets in 3's at each joint of the rachis; glumes about ⅓ inch long, narrow, the upper half narrowed into an awn; lemma fusiform, about ⅖ inch long, the upper portion narrowed into a very scabrous flat awn as much as 6 inches long, the rachilla of the spikelet extended behind the floret as a short hairy or scabrous pedicel lying in the furrow of the palea. In most of the forms of barley the grain is tightly inclosed in the lemma and palea.

Beardless barley is a variety in which the awns are suppressed and converted into irregular short lobes or teeth (*H. vulgare trifurcatum* Wenderoth).

Schulz divides the cultivated barleys into 2 groups: (1) *Hordeum distichum*, the 2-rowed barleys, which he refers to *H. spontaneum* Koch as the wild prototype. (2) *H. polystichum*, the many-rowed barleys, which he refers to *H. ischnatherum* (Coss.) Schulz, as the wild prototype. (Mitt. Natf. Ges. Halle 1: 18. 1911.)

269. Elymus *L.*—Wild rye. A moderate-sized genus of temperate regions. Rachis continuous; spikelets usually 2 at each node; glumes in pairs in front of the spikelets (the terminal spikelet having 2 opposite glumes) usually subulate or awned.

The related genus Sitanion differs in having an articulated rachis. The glumes are usually subulate and extended into long awns. Several species are found in the western states. The mature joints of the disarticulated rachis with the attached spikelets are injurious to grazing animals, penetrating the ears, eyes and nostrils.

Tribe XIII. BAMBUSEÆ

270. This tribe includes the bamboos. These are nearly all perennial, woody, often tree-like grasses, mostly of wet tropical regions. The culms in the larger species are as much as a foot in diameter and over 100 feet in height. The common economic species of the tropics, such as *Bambos Bambos* (L.) Wight (*Bambusa vulgaris* Wendl.), have large hollow culms, with hard partitions at each node. The wood is exceedingly hard and dense. The hollow joints are used as utensils and the culms for a great variety of purposes. There are, especially in the American tropics, several climbing species. The young shoots of the large erect species of bamboos are covered with large deciduous scales. The shoots grow to a considerable height before branching and producing the ordinary foliage. Several species of bamboos are cultivated in the United States (Par. 89). The commonest are *Arundinaria japonica* Sieb. & Zucc., and several species of Phyllostachys. The latter genus may be distinguished by the internodes, flattened on one side. The species of Phyllostachys seldom flower in cultivation. The spikelets of *Arundinaria japonica* are large and several-flowered. The only bamboo native in the United States is the wild cane (*Arundinaria macrosperma* Michx.) (Fig. 63), found in our southern states where it often forms large masses called cane-brakes. A small form of this or possibly a distinct species, *A. tecta* Muhl., is called small cane or scutch cane.

The floral characters of the bamboos are of little importance to students, as the cultivated forms do not often flower. The critical study of the group is too technical for any but the expert. The structure of the spikelets is, however, comparatively simple. They

FIG. 63. Arundinaria macrosperma. Portion of culm with inflorescence, reduced; floret, palea showing lodicules, and a caryopsis, reduced. (U. S. Dept. Agr., Div. Agrost., Bull. No. 20.)

are usually 2- to 8-flowered, rarely 1-flowered, often in tufts at the nodes of the flowering branchlets. Glumes 2, the lower lemmas often sterile and gradually passing into the glumes. Blades usually short and rather broad and usually articulated with the sheath, and often with a short petiole. The stamens are 3 to 6, and the styles 2 or 3. The fruit is sometimes a nut or even a berry.

CHAPTER XXV

NOMENCLATURE

Attention has already been called to the classification of plants into genera and species and the grouping of the genera into larger divisions, the tribes and families. The method of applying names to these divisions will now be reviewed. The language of botanical nomenclature is Latin. If names or words are taken from other languages they are latinized.

GENERIC NAMES

271. A generic name is a noun (or rarely an adjective used as a noun) and is always written with an initial capital. The names may be original Latin names such as Festuca and Hordeum, or Greek, such as Briza and Bromus. Or they may be derived from Latin names, as Digitaria (from *digitus,* a finger), or compounds of Latin words as Trisetum (*tri,* three, *seta,* a bristle). More often the name is compounded from two Greek words, as Leptochloa (*leptos,* slender, *chloa,* grass) and Agropyron (*agros,* a field, *puros,* wheat). The generic name may be a latinized personal name, as Muhlenbergia (for Dr. Henry Muhlenberg, an American botanist, 1753–1815), and Deschampsia (for Loiseleur-Deslongchamps, a French botanist, 1774–1849). A few names have been taken from other languages than Latin or Greek without being latinized, as Sabal (a kind of palm). Such aboriginal names are known as barbarous names. Some of these have been latinized, as Ananas, Ananassa (the pineapple). Several generic names of grasses with their derivations are given below:

Erianthus (Greek, *erion*, wool, *anthos*, flower).
Manisuris (Greek, *manos*, slender, *oura*, tail).
Andropogon (Greek, *aner*, man, *pogon*, beard).
Paspalum (Greek name for millet).
Panicum (an ancient Latin name for foxtail millet).
Echinochloa (Greek, *echinos*, hedgehog, *chloa*, grass).
Anthoxanthum (Greek, *anthos*, flower, *xanthos*, yellow).
Stipa (Greek, *stupe*, tow.)
Aristida (Latin, *arista*, an awn).
Sporobolus (Greek, *spora*, seed, *bollein*, to cast forth).
Agrostis (Greek, *agros*, a field, also a kind of grass).
Calamagrostis (Greek, *kalamos*, a reed, *agrostis*, a grass).
Ammophila (Greek, *ammos*, sand, *philein*, to love).
Avena (classical Latin name).
Danthonia (for Danthoine, a French botanist).
Spartina (Greek, *a cord*).
Chloris (the goddess of flowers).
Bouteloua (for Boutelou, a Spanish horticulturist).
Bromus (Greek, *broma*, food).

SPECIFIC NAMES

272. The specific name may be (1) an adjective, (2) a noun in the genitive case, (3) a noun in apposition. An adjective name being a modifier of the generic name, must agree with that in gender, and the ending changes according to the rules of the Latin grammar governing inflection. The specific adjective may be a Latin adjective or a latinized Greek adjective or it may be derived from a person or a place.

A few examples are appended to illustrate the adjective specific name:

Bromus erectus
Bromus arvensis.
Bromus purgans.
Festuca rubra.
Festuca occidentalis.
Festuca nutans.
Festuca elatior.
Panicum virgatum.
Panicum capillare.
Panicum anceps.
Panicum agrostoides.
Panicum præcocius.
Panicum Wilcoxianum.
Panicum tennesseense.

273. Nouns in the genitive.—Specific names in the genitive are usually in the singular and are usually proper names. It is common for botanists to name a plant for the collector, as *Panicum Werneri*. Whether or not the specific name takes one or two i's in the genitive is a matter of taste or euphony. If the name Smith is latinized to Smithus in the nominative it becomes Smithi in the genitive; if it is latinized to Smithius, it becomes Smithii. In rare cases the genitive plural is used for personal names, as *Lindsaya Sarasinorum*, for the brothers Sarasin. Occasionally a common noun is genitive plural, as *Bromus tectorum*. Further examples are given below:

Panicum Huachucæ.
Panicum tsugetorum.
Panicum Leibergii.
Muhlenbergia Schreberi.
Agropyron Richardsonis.
Eriogonum Thompsonæ.
Panicum virgultorum.
Viola viarum.
Uromyces Trifolii.

274. Nouns in apposition are not inflected when used as specific names since they are always in the nominative case. Such specific names are usually old generic or other proper names, as *Arundo Donax, Capriola Dactylon, Hystrix Hystrix* and *Achillea Millefolium*. There are a few specific names that consist of two words, the first in the nominative and the second in the genitive, as *Echinochloa Crus-galli, Apera spica-venti, Elymus caput-medusæ*. The two portions of the specific name are usually joined by a hyphen. Similarly, the specific name may be composed of two parts having other relations, as *Opuntia Ficus-indica*, *Puccinia Mariæ-Wilsoni*, *Polypodium Donnell-Smithii*. An extreme case is *Prosaptia Frederici et Pauli*. Native names of plants have been used as specific names without being latinized, giving rise to such names as *Vigna Catjang* and *Dolichos Lablab*. Another category of nominatives as specific names is illustrated by words ending in cola (an inhabitant of) such as *Poa saxicola*, *Astragalus monticola*, *Panicum oricola*, *P. sphagnicola*.

275. Names of a lower category.—Subdivisions of the species are sometimes recognized, these being, subspecies, variety, subvariety and form. The names used to indicate these subdivisions are formed in the same manner as specific names. If the name is an adjective it should agree with the genus in gender. The usual subdivision of the species is the variety. There are two general methods of writing the names of the subdivisions of the species. Most European and many American botanists write the name, for example, thus: *Festuca rubra* var. *multiflora*. The other method, used by many American botanists, is to recognize but one named category below the species, to call this the subspecies, and to write the name as a trinomial, thus: *Festuca rubra multiflora*.

276. Transferring specific names.—As indicated under Classification, the botanist's conception of a species or of its relation to other species may change as his knowledge concerning these species increases, and the opinions of different botanists are not infrequently in disagreement concerning the same species. Consequently it may become necessary to transfer a species from one genus to another, thus causing a corresponding change in the name. The specific name is retained under the new genus provided there is not already in that genus a species with the same name. If the specific name is an adjective its ending must be changed when necessary to agree in gender with the new genus. Thus *Panicum frumentaceum* becomes *Echinochloa frumentacea.*

AUTHORS OF NAMES

277. The student will observe after the name of a genus or species, where these are written formally, the name of a person either in full or abbreviated. This is the name of the author of the genus or species, that is, the name of the person first describing the genus or species, or who first applied to these groups the name as it stands. For convenience the name of the author is usually abbreviated unless it consists of one syllable, or is not often used, or unless its abbreviation would be ambiguous.

A few common abbreviations are given below. The name is usually abbreviated to the vowel of the second syllable. A few well-known names are further abbreviated.

Beauv.—Beauvois.
R. Br.—Robert Brown.
DC.—De Candolle.
Ell.—Elliott.
H.B.K. or HBK.—Humboldt, Bonpland and Kunth.
L. or Linn.—Linnæus or Linné.
Michx.—Michaux.
Muhl.—Muhlenberg.
Nutt.—Nuttall.
Torr.—Torrey.
Walt.—Walter.

278. Use of parentheses.—Recent custom sanctions the use of the parentheses to indicate the original author of a specific or varietal name. A name written thus, *Kœleria cristata* (L.) Pers., indicates that Persoon was the author of the accepted combination and that Linnæus was the author of the name *cristata* under some other genus, in this case under Aira. Persoon transferred the species to Kœleria. If a variety has been raised to a species, or the reverse, the parentheses are used to indicate the original author. If the parentheses are not used, as is the case in most of the older works, the name retained is the author of the combination. Among zoölogists the custom often prevails of retaining only the original author in parantheses, omitting the author of the combination. The use of the parentheses is often referred to as double citation.

CAPITALIZATION

279. As previously stated, the generic name always begins with a capital letter. The specific or varietal name begins with a small letter unless the word is a proper name. Many botanists decapitalize all specific names regardless of derivation. The latter system conduces to uniformity but violates the rules of the Latin language, which is the language of botanical nomenclature. Conforming to the first system, specific names are capitalized if they are proper nouns. Such nouns may be derived from a personal name, or they may be proper names such as are mentioned under nouns in apposition. Some authors capitalize geographic adjectives, as *Virginiensis* and *Carolinianus*, but this is not required by Latin usage.

Decapitalization of proper names may lead to ambiguity. The specific name *Leonis* would indicate that the species was named for a man by the name of Leon, but if the name is decapitalized, *leonis*, it may mean merely, of the lion. More serious is the decapitalization of a name like *Millefolium* (*Achillea Millefolium*). This is an old proper name and when used as a specific name is indeclinable. If it is decapitalized it is at once confused with the adjective *millefolium*, which is declinable.

BIBLIOGRAPHY

280. It is frequently necessary, or at least desirable, to refer to works, serials and periodicals. For convenience, the titles are usually abbreviated, and the citation of volume and page follows a definite form. If titles are abbreviated it is the aim to make abbreviations understandable, concise and consistent. The important words of the title are selected and are abbreviated as are the names of authors, that is, to the vowel of the second syllable. In referring to an article in a periodical, the volume and page of the original are given rather than a reference to a separate of the article. Many botanists have adopted the convenient system of citing the volume of a periodical or work in arabic in bold-faced type. Following the volume number is a colon and the page and finally the year.

The examples given below will illustrate the system:

Vasey, Bot. Gaz. **9**: 97. 1884.
H. B. K., Nov. Gen. & Sp. **1**: 99. 1816.
Swartz, Prod. Veg. Ind. Occ. 23. 1788.
Scribn. & Merr. U. S. Dept. Agr. Div. Agrost. Circ. **35**: 3. 1901.
Beyr. in Trin. Mem. Acad. St. Pétersb. VI. Sci. Nat. **1**: 341. 1834.
Nees; Doell in Mart. Fl. Bras. $\mathbf{2^2}$: 213. 1877.

If a botanist describes a species in the work of another, the name of the former is followed by "in," as in the last two examples. A semicolon following an author's name indicates that the author proposed the name but the description was written by the botanist whose name follows the semicolon.

VALID NAMES AND SYNONYMS

281. The student is often disconcerted when he finds that a species has more than one name. It should be understood that a given species, as viewed by a given botanist, has but one valid name, all other names being synonyms. A genus bears the name assigned to it by the botanist who first indicated or described it. (By common consent names dating publication prior to 1753 are excluded.) A later botanist may describe the same genus as new, not being acquainted with the earlier description. The second name then becomes a synonym. Sometimes an author describes a new genus and assigns to it a name which has already been used for an earlier genus. Such a name is a homonym, and can not be accepted as valid, hence the genus must receive a new name. A botanist may divide a genus of an earlier author into two or more distinct genera (generic concepts being opinions), in which case he retains the original generic name for one of the parts and assigns new names to the other parts. It is clear, then, that the same species might have two valid names according to the varying concepts of two botanists. Barnyard-grass would be called *Panicum Crus-galli* by one botanist who considered Echinochloa to be a section of Panicum, and *Echinochloa Crus-galli* by another who considered the group Echinochloa to constitute a distinct genus.

Specific names are governed by the same rule, that is priority. The earliest name is used if there is no reason for rejecting it. In transferring a species from one genus to another the original specific name is retained unless there is already in the second genus a species by that name, in which case the transferred species receives a new name.

CODES OF BOTANICAL NOMENCLATURE

282. Botanists have recognized the necessity of being governed by a definite system in nomenclatorial matters, and many have adopted sets of rules or codes. The best known of the earlier codes is that adopted at the International Botanical Congress held in Paris in 1867. The report was edited by Alphonse de Candolle and the English translation is entitled "Laws of Botanical Nomenclature." The report should be read by all interested in nomenclature.

283. Vienna code.—The most important recent code is that adopted by the International Botanical Congress held at Vienna in 1905, and entitled, "International Rules of Botanical Nomenclature." A few of the principles are here excerpted in order to indicate the general trend of the rules.

Botanical nomenclature begins with the "Species Plantarum" of Linnæus (1753) for all vascular plants. (Art. 19.)

However, to avoid disadvantageous changes in the nomenclature of genera by the strict application of the rules of nomenclature, and especially of the principle of priority in starting from 1753, the rules provide a list of names which must be retained in all cases. The list forms an appendix to the rules [usually referred to as "list of nomina conservanda"]. (Art. 20.)

No one is authorized to reject, change or modify a name (or combination of names) because it is badly chosen, or disagreeable, or another is preferable or better known, or because of the existence of an earlier homonym which is universally regarded as non-valid, or for any other motive either contestible or of little import. (Art. 50.)

When a species is moved from one genus into another, its specific epithet must be changed if it is already borne by a valid species of that genus. (Art. 53.)

The list of nomina conservanda referred to under article 20 includes the following American grass genera:

Tragus (1768) to be used instead of Nazia (1763).
Leersia (1788) to be used instead of Homalocenchrus (1760).
Hierochloë (1810) to be used instead of Savastana (1799).
Cynodon (1805) to be used instead of Capriola (1763).
Ctenium (1814) to be used instead of Campulosus (1810).
Buchloë (1859) to be used instead of Bulbilis (1819).
Lamarckia (1794) to be used instead of Achyrodes (1760).
Glyceria (1810) to be used instead of Panicularia (1763).
Article 50, requires the use of

Setaria Beauv. 1807, not Ach. 1798, nor Michx. 1803, instead of Chætochloa Scribn. 1897.

Digitaria Hall. 1768, not Heist. 1763, instead of Syntherisma Walt. 1788.

284. American code.—"The American Code of Botanical Nomenclature" was prepared by a Nomenclature Commission of the Botanical Club of the American Association for the Advancement of Science. The latest revision of this code was made in 1907. (See Bull. Torrey Club 34: 167–178. 1907.) Although this code has been adopted by neither the Botanical Club nor the American Association, and has no official standing, it is followed more or less closely by many American botanists. Some of its important provisions are given for comparison.

Botanical nomenclature is treated as beginning with the general application of binomial names of plants (Linnæus' "Species Plantarum," 1753). (Principle 2.)

The application of a name is determined by its reference to a nomenclatorial type. (Principle 4.)

In the transfer of a species from one genus to another, the original specific name is retained, unless the resulting binomial has been previously published. (Canon 9.)

The nomenclatorial type of a species or subspecies is the specimen to which the describer originally applied the name in publication. (Canon 14.)

The nomenclatorial type of a genus or subgenus is the species originally named or designated by the author of the name. If no species was designated, the type is the first binomial species in order eligible under the following provisions: [then follow the provisions]. (Canon 15.)

A name is rejected when preoccupied (homonym). (Canon 16.)

A name is rejected when there is an older valid name based on another member of the same group (metonym). (Canon 17.)

285. Comparison of the two recent codes.—The two codes agree in taking 1753 as the starting point for priority and in using the earliest specific name. They disagree chiefly in the following:

The Vienna Code provides a list of nomina conservanda to which the law of priority shall not apply. The American Code does not restrict the law of priority, except as indicated in principle 2.

The Vienna Code allows the use of generic and specific names although there may be earlier but non-valid homonyms. The American Code rejects homonyms. (Digitaria and Setaria are accepted under the Vienna Code and rejected under the American Code; *Bromus altissimus* Pursh, 1814, not *Bromus altissimus* Gilib., 1792, is accepted, under the Vienna Code, because the homonym is itself a synonym of another species and is not valid. Pursh's name is rejected under the American Code.)

The American Code fixes the application of names by reference to nomenclatorial types. The Vienna Code does not mention types. This, in practice, is a very important difference. Under the American Code a specific name stands or falls according to the disposition of the type specimen, and a genus must always include the type species.

In the present work the nomenclature, with a few minor exceptions, follows the American Code.

COMMON NAMES

286. The common name is the name by which a plant is commonly known in the language of the country. Few plants, and these widely and commonly cultivated species, have definite and universally recognized common names in a country. The common names, wheat, oats, rye and barley are definite in their application. Millet is not a definite name as it may mean foxtail millet, proso millet, sorghum, or even pearl millet. Timothy is in some localities called herd's-grass, a name which is often applied to redtop. Kentucky blue-grass is also called June-grass, and Bermuda-grass is called wire-grass. Such terms as bunch-grass, wild oats, barley-grass and many others, are so indefinite in their application that they are of little value as names.

Because of this lack of precision in applying common names it has been found necessary to introduce the use of the botanical or Latin names of the species. Furthermore the Latin name is applicable in all countries regardless of the native language. Well-known common names such as timothy and Johnson-grass may be sufficiently definite. Where common names are applied to different species in different parts of a country it is necessary to supplement the common name with the Latin name, for example, bluejoint (*Andropogon furcatus, Calamagrostis canadensis,* or *Agropyron Smithii*), foxtail (*Chætochloa viridis, C. lutescens, Hordeum jubatum, H. murinum,* and other species), wire-grass (*Capriola Dactylon, Poa compressa, Juncus balticus*) and many others. Furthermore, a large number of grasses have never received common names or only such indefinite local names as bunch-grass and wild oats. For such grasses it is necessary to use the Latin names. That the technical Latin name of a grass is readily accepted by the public is shown by the wide use of *Bromus inermis.* Some botanical works have attempted, with doubtful success, to introduce as common names the translations of the Latin names. Such names may be occasionally used by amateur botanists, but scarcely by the general public.

LIST OF BOOKS AND ARTICLES RELATING TO TAXONOMIC AGROSTOLOGY

From the large number of works on this subject a few of the recent more important and accessible are here indicated. Appended to the main list which deals with North American agrostology is a brief list of representative reference works upon the grasses of foreign countries.

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