Poaceae (Gramineae)

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Introductory article

Article Contents

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The grass family (Poaceae or Gramineae) is the fourth largest flowering plant family and contains approximately 11 000 species in nearly 800 genera worldwide. We currently recognise 12 subfamilies: Anomochlooideae, Pharoideae, Puelioideae, Bambusoideae, Ehrhartoideae, Pooideae, Aristidoideae, Panicoideae, Arundinoideae, Micrairoideae, Danthonioideae and Chloridoideae, and in these subfamilies we recognise 50 tribes and 81 subtribes. Grasses are well adapted to open, marginal and frequently disturbed habitats, and can be found on every continent, including Antarctica. A grass is characterised by having a caryopsis or grain, and the primary inflorescence is referred to as a spikelet with a lemma and palea. The incorporation of two photosynthetic or carbon dioxide assimilation pathways has led to the family's ability to occupy 31–43% of the Earth's surface in various climatic environments as the dominant component, the grasslands.

Economically Important Species

The grasses are the most important plant family for food production. Rice (*Oryza sativa* L.), wheat (*Triticum aestivum* L.), corn (*Zea mays* L.), barley (*Hordeum vulgare* L.), rye (*Secale cereale* L.), oats (*Avena sativa* L.), sorghum (*Sorghum bicolour* (L.) Moench), pearl millet (*Pennisetum glaucum* (L.) R. Br.), finger millet (*Eleusine coracana* (L.) Gaertn.) and tef (*Eragrostis tef* (Zucc.) Trotter) are widely cultivated grains. Grains were one of the first plants domesticated by humans and are the basis for all early civilisations. Corn or maize originated in Mexico and formed the basis for the Aztec, Inca and Mayan civilisations. Wheat and barley originated in the Middle East or Fertile Crescent and were used to make breads, pastas and beer. Rice originated in southeastern Asia and can be called the world's most important crop, because it is estimated that over 200 million tonnes of rice are consumed each year by 1.6 billion people. In wheat, two proteins, gliadin and glutein, along with starch combine to form gluten. When these proteins in bread flour are mixed with water and kneaded, the resultant product is an elastic dough mixture perfectly suited, with the addition of yeast, for baking. The domestication of modern wheat, a hexaploid ($6n=42$), is an interesting story in the coevolution of man and food, because early domesticates of wheat, the einkorns (*Triticum monococcum* L., $2n=14$) and emmers (*Triticum turgidum* L., $4n=28$), were harder to harvest, that is, separate the grains from florets called threshing, and when baked produced inferior breads. Other notable economic uses of grasses include landscaping, construction (primarily bamboos), and sugar cane (*Saccharum officinarum* L.) production. Using perennial grasses such as switchgrass (*Panicum virgatum* L.) or giant miscanthus (*Miscanthus* × *giganteus* Greef and Deuter ex Hodkinson and Renvoize), for biofuel production is gaining popularity worldwide, simply because burning renewable pelleted grasses lowers airborne particulate matter in comparison to burning coal and other fossil fuels. **See also**: Poales (Grasses); Starch and Starch Granules; Triticum Aestivum L (Wheat); Zea Mays (Maize, Corn)

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Morphology

The most important feature of this family is a one-seeded indehiscent fruit (seed coat is fused with the ovary wall), known as a caryopsis or grain (**Figure 1**). The grain is rich in endosperm starch, although it can contain protein and small quantities of fat. The embryo is located on the basal portion of the caryopsis and contains high levels of protein, fats and vitamins. The stems are referred to as culms and the roots are fibrous, principally adventitious or arising from lower portions of the culms. Silica is a conspicuous component of the epidermis and stored in silica cells. Many grasses have rhizomes (underground stems) or stolons (horizontal above-ground branches) that allow for vegetative reproduction in perennial grasses. Another important feature of grasses is intercalary meristems, which allow growth well below the apex, typically near the base of the

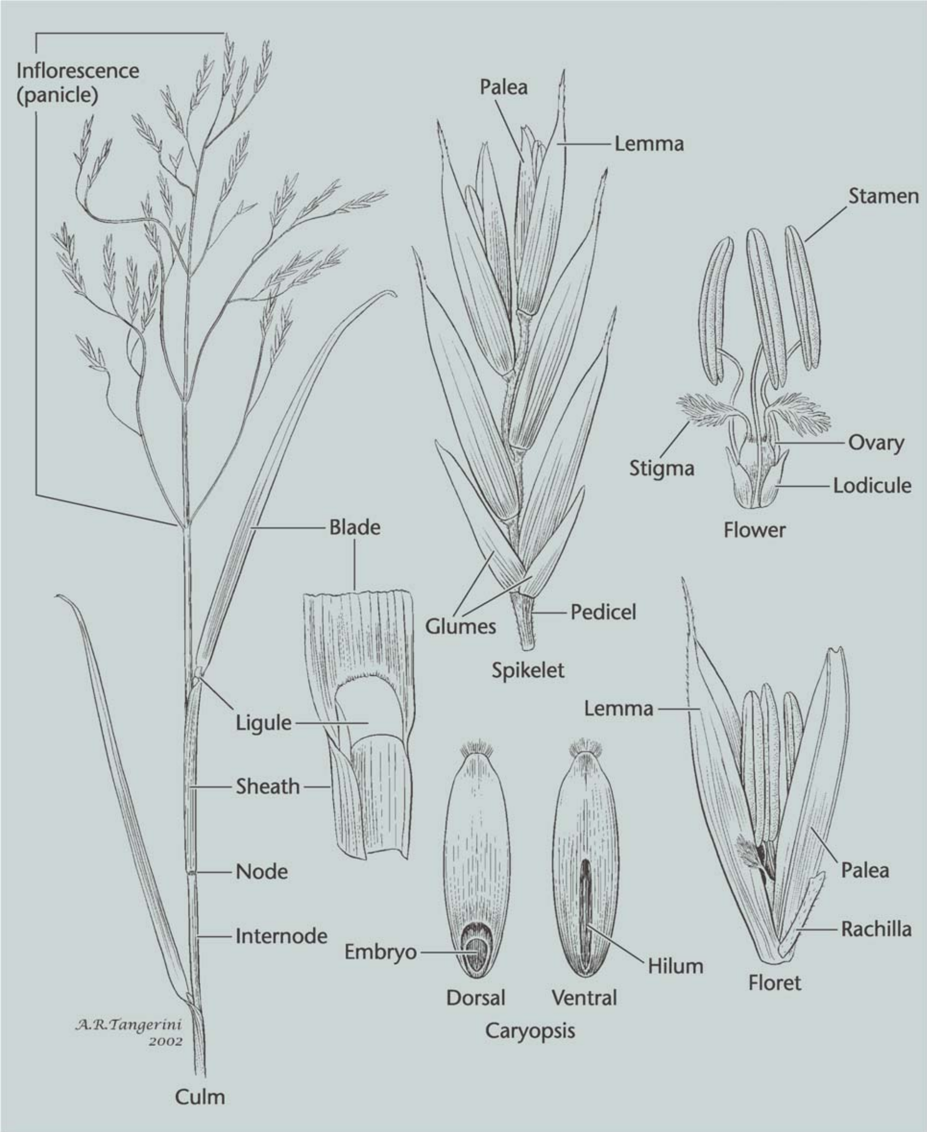

Figure 1 Diagnostic features of a grass, *Festuca californica* Vasey: caryopsis, culm, floret, flower and spikelet. Illustrated by Alice R. Tangerini.

plant. The leaves are parallel-veined and two-ranked, with the basal portion forming cylindrical sheaths and the upper portions referred to as a blade. A ligule, located on the upper surface at the junction of the blade and sheath, commonly consists of flaps of tissue or hairs. The primary inflorescence is referred to as a spikelet with 1–many, two-ranked bracts inserted along the floral axis or rachilla. The lowest two bracts of each spikelet, inserted opposite each other, are called glumes above which, along the rachilla, are borne pairs of bracts termed florets. Each floret consists of a lemma (lower bract) and palea (upper bract). Within each palea the highly reduced flowers can be found. Because the morphological features are often cryptic or lacking, identification to species is often very difficult and requires a trained specialist. Each grass flower usually consists of two or three small scales at the base called lodicules, an ovary with a style and two plumose stigmas and 1–6 but more commonly three stamens with basifixed anthers that contain single-pored, wind-dispersed pollen grains. Lodicules function to open the florets during flowering and possibly represent reduced perianth (sepals and petals) segments. **See also**: Silica

History and Phylogeny

The grass family was probably characterised as a distinct entity in most cultures. Three hundred years before the

Christian era, Theophrastus, a Greek scholar, recognised the grass family and began to teach his students the concepts of plant morphology. The first scientific subdivision of the family was made by Brown (1814), who recognised two different spikelet types between Panicoideae and Pooideae (Festucoideae) subfamilies. Bentham (1881) recognised 13 tribes grouped in to two major subfamilies. Hitchcock (1935) and Hitchcock and Chase (1951) in their treatments of the grasses of the US, recognised 14 tribes in these two major subfamilies. The two-subfamily classification was used by most agrostologists for almost 150 years until more modern syntheses. With the infusion of molecular data, our present concept and classification of the grasses is changing at a rapid rate. We currently recognise 12 subfamilies: Anomochlooideae, Pharoideae, Puelioideae, Bambusoideae, Ehrhartoideae, Pooideae, Aristidoideae, Panicoideae, Arundinoideae, Danthonioideae and Chloridoideae, and in these subfamilies we recognise 50 tribes and 81 subtribes (Barkworth *et al.*, 2003, 2007; Soreng *et al.*, 2012). The crown age for the grasses has been estimated to be 71 $\pm$ 9 million years old (Vicentini *et al.*, 2008). **See also**: Brown, Robert

Ecology

The highly reduced floral structure and wind pollination in the grasses have enabled the family to be extremely successful in planet-wide radiation and colonisation. Grasses are well adapted to open, marginal and frequently disturbed habitats, and can be found on every continent, including Antarctica. Two major photosynthetic CO_2 assimilation pathways can be found in the grasses (C_3-fixing of CO_2 by ribulose 1,5-diphosphate (Calvin–Benson cycle found in all vascular plants)) and C_4-fixing of CO_2 by an additional enzyme (phosphoenolpyruvate) to form four carbon molecules (oxaloacetate or malate) and there are anatomical, physiological, phytogeographical and ecological differences between these two types. The C_3 grasses are well adapted to temperate climates with winter precipitation, whereas C_4 grasses are well suited to tropical environments with summer/autumn precipitation. The addition of C_4 photosynthesis has allowed the grasses to outcompete other plants in warm, tropical environments by lowering the oxidation levels (photorespiration) of photosynthetic products. All of these features have led to the family's ability to occupy 31–43% of the Earth's surface in various climatic environments as the dominant component, the grasslands (Gibson, 2009). Historically, the grassland biome has been maintained by a myriad of biotic, climatic and edaphic effects. First, there must be a dry season in which grasses and adjacent forest border dry out and become flammable. Repeated fires favour grasses over most tree and shrub species, because they very easily re-sprout from the base. Second, large herbivorous mammals (e.g. bison, antelope, yaks, guanacos, vicuñas and llamas) are instrumental at maintaining and further opening up grassland communities. An often overlooked consequence of grazing animals is their effect on soil compaction which again favours sod-forming grasses over trees and shrubs. **See also**: Calvin, Melvin; Grasslands; Grazer-dominated Ecosystems; Photosynthesis: Ecology; Photosynthetic Carbon Metabolism

Although the grasses seem well suited to ecosystem margins and moderately disturbed sites, the major threat to extant species is loss of habitat. Grasses have been very successful in an evolutionary sense and in their ability to adapt to human needs as major food sources for all complex civilisations. It is important for us to maintain and manage these critical resources for future generations. One way to accomplish this goal is to preserve as many of the wild relatives as possible because they may carry the genetic code for improved production and/or pest resistance. Once these genes are introduced into a crop species, the hybrid vigour of a crop can be dramatically improved, thus allowing increased pest resistance and productivity.

For planet Earth, Walter and Gillett (1997) list 776 grass species as threatened; this includes possibly extinct, endangered, rare, vulnerable and indeterminate categories. In North America there are 215 species listed as threatened with 40 of these occurring in California (19%) alone (Peterson and Soreng, 2007). In comparison, there are only 80 species listed as threatened in South America. South America is only three-quarters the size of North America, but there are approximately twice as many threatened grass species per square mile in North America as in South America. Obviously, a major factor in determining the status of these threatened grass species is the extent of botanical knowledge that scientists have gathered on these plants. We still need to learn more about the grasses in South America.

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