Fasciation in Plants

Robert L. Geneve
Department of Horticulture, University of Kentucky, Lexington, Kentucky 40564

The typical fasciated plant produces a large flat, ribbon-shaped stem. Any growing plant part can become fasciated including stems, flowers, fruits, and roots. However, the most observable and spectacular fasciations occur in rapidly growing vegetative and flowering stems. Here, the change in size and shape of the stem leads to an increase in the number of leaves and flowers along the flattened stem. I have observed normal flowering lily stems with 13 to 15 flowers, while nearby, fasciated stems produced 45 flowers bunched together across the stem (Fig. 1).

The word, fasciation, comes from the Latin word, *fascia*—to fuse. So in a broad sense, the fusion of plant parts can be considered a form of fasciation. This fusion of plant parts has been the driving force behind evolution and it is interesting to think of degrees of fasciation as the normal condition of modern plant species.

The primitive flower form is represented by having many leaf-like petals. The star magnolia (*Magnolia stellata*) is a good example of a primitive flower. Flowers are

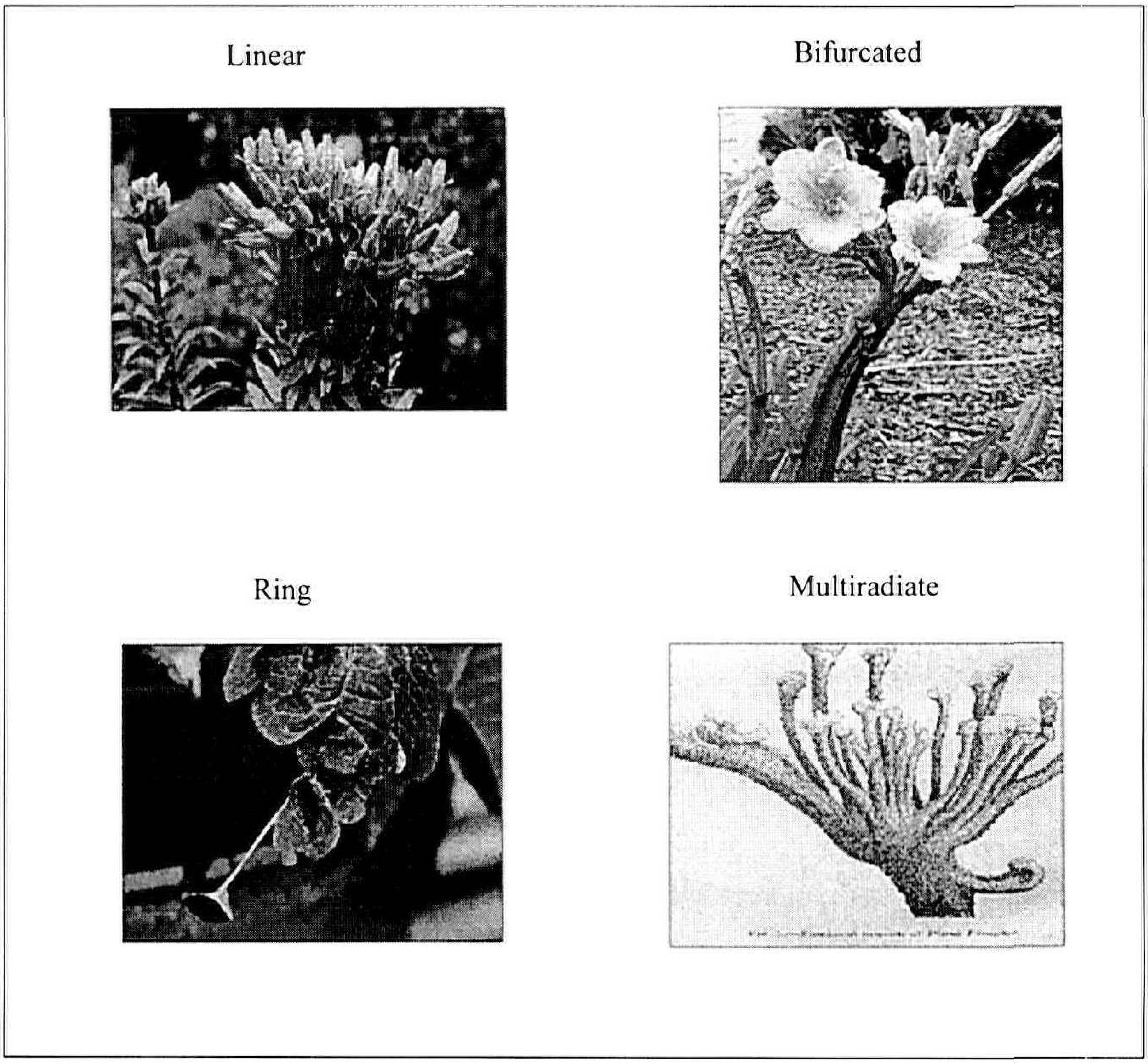

Figure 1. Types of fasciation.

thought to have evolved from leaves that modified, folded, and fused to become the typical modern flowers containing sepals, petals, anthers, and a pistil. Highly evolved flowers show fusion, modification, and usually a reduction in the number of petals of the flower. It can be argued that the evolution of flowers and the resultant complexity displayed in flower forms is the result of fasciation. Consider the fused petals of the flowers in the Heath family which include the cup-shaped flowers of mountain laurel (*Kalmia latifolia*) and the bell-shaped flowers of Japanese pieris (*Pieris japonica*). Are these examples of fasciations? At least one gene has been isolated from snapdragon (*Antirrhinum*) that is related to flower form and petal fusion that gives the typical, zygomorphic ("dragon") flower appearance. Studies are also underway that are looking for genes responsible for petal fusion in*Petunia* that should extend our understanding of the mechanisms for flower form.

A more convincing case for a role in fasciation during evolution is found in the development of fruit types. Two striking examples are illustrated in the familiar fruits of apple and strawberry. The portion of these fruits eaten is actually receptacle tissue. A receptacle is a part of the flower stem. In these cases, the receptacle continues to grow and elongate. The apple receptacle swells and grows until it completely surrounds the seeds inside the fruit. Strawberry seeds (actually the small nut-like fruits) are distributed on top of the swollen red receptacle. Strawberry fruits can be found that are typically fasciated with broad flattened fruit tips. The old strawberry cultivar, 'Fairfax', consistently had a percentage of large, fasciated fruits when the environmental conditions were favorable.

The most extensively studied example of fasciation in modifying a fruit's shape is in the tomato. Originally, the wild-type tomato fruit contained only two locules. A locule is the seed chamber inside the fruit. The cherry-type tomato is an example of this original condition. Through extensive breeding and selection, all the large commercial tomato cultivars are fasciated. This results in an increase in the number of locules leading to larger fruit. The extreme example is the fasciated 'Beefsteak' tomato that can have over 200 locules in a single fruit. The flower parts (particularly the style) show a typical fasciated condition well before the fruit develops. For tomato, plant breeders have characterized the genes responsible for fasciation and utilize the fasciated condition for increasing tomato fruit size.

Fasciations have fascinated botanists for centuries. One of the first descriptions of fasciated plants is found in the 16th century herbals. Descriptions and an illustration of a fasciated pea called the "tufted", "Scottish", or the "mummy" pease (old English for pea) can be found in John Gerarde's "The Herball or Generall Historie of Plantes" and in John Parkinson's "Paradisium". The mummy pea is a selection that breeds true from seed for the fasciated character when self-pollinated. The appearance of the mummy pea is unique with a typical fasciated stem and all the flowers bunched together at the top of the stem rather than flowers produced in the leaf axils as occurs in normal peas.

Interestingly, the mummy pea figured prominently in the classic genetic experiments with peas conducted by Gregor Mendel (the father of genetics) in 1866. Fasciation was one of the seven characters selected for crosses in pea that led to the illustration of the Mendelian concept of dominant and recessive traits. He found that fasciation was a homozygous recessive trait in pea giving the expected 3 to 1 ratio of normal to fasciated plants from the cross between normal and fasciated parents.

Astonishingly, the classic paper written by Mendel went unnoticed and unappreciated by his contemporary scientific colleagues, who were preoccupied with the Darwinian concept of natural selection. The manuscript was independently rediscovered, 35 years later by three scientists. One of these scientists was Hugo de Vries, a geneticist from Holland who extensively studied the genetics of fasciation in the genus *Oenothera* (primrose).

The prominent 19th century botanist, Julius Sachs (the father of botany) was also fascinated with fasciations. He conducted experiments with bean plants to induce fasciation. Sachs showed that by removing the growing point above the cotyledon from rapidly growing bean seedlings, the resultant shoots that developed from the cotyledonary buds would be fasciated. His inquiries were meant to provide insight into a question posed a century before by Carl von Linnaeus (the father of taxonomy). Linnaeus proposed that fasciations were the result of several growing points fusing to form the typical ribbon-shaped stem.

In 1840, Moquin-Tandon suggested an alternative to the Linnaean hypothesis on the origin of fasciations. He proposed that fasciations were the result of a change in the original growing point to form one large growing ridge. Subsequent anatomical investigations have shown that fasciations can arise from either route. Most of the naturally occurring fasciations studied arise from a single growing ridge, while many artificially induced fasciations show multiple, fused growing points.

Typical stem fasciations can be classified as linear, bifurcated, multi-radiate or stellate, and ring fasciations. Linear fasciations are the typical flat, ribbon-shaped stems. They can be very spectacular. It is common for the stem to begin normal symmetrical growth, then gradually become progressively more flat as the growing point becomes very broad. Commonly, the growing point becomes 2 to 6 in. wide at the tip, however, in some fasciated cristate cactus, the growing ridge can reach several feet wide.

Bifurcated fasciations are linear fasciations that split to produce a "Y" shaped, double, ribbon fasciation. In the multi-radiate fasciation, the stem is split into 3 or more short branches. The least common fasciation in nature is the ring fasciation. Here the growing point folds over and fuses to form a funnel shape. This is a fairly common form of fasciation in plants being grown in tissue culture. The potential for fasciation in tissue culture can be quite high, possibly because of the high levels of growth regulators supplemented in the culture medium.

Fasciations can be produced in plants for a number of reasons. The most interesting is the apparent mutation that occurs in certain plants. In many cases, these mutations are spontaneous and can become an inherited trait. Mendel was able to very nicely explain the inheritance of fasciation in the "mummy" pea as a homozygous recessive trait explaining why seed collected from this fasciated pea produced almost exclusively fasciated plants. For gardeners, the most familiar inherited fasciation occurs in the flower of the cockscomb celosia (*Celosia argentea* var. *cristata*). The colorful, contorted growing ridge that constitutes the celosia's flower is an excellent study in fasciation. In celosia, this trait is heritable and also the size of the fasciated stem and flower is easily influenced by the environmental growing conditions.

The environment has always played an important role in the expression of heritable fasciation making genetic studies difficult. Environmental conditions that favor rapid growth will also favor the expression of fasciation. Particular day lengths have also been implicated in inducing fasciations. However, not all fasciations are induced by mutations or genetically controlled. Many fasciations are induced simply by environmental conditions.

The most common, nongenetic cause for fasciation is damage to the growing point caused by insect, disease, or physical injury. This type of fasciation was demonstrated nicely by Loiseau in 1954. In experiments using tiny glass needles to physically damage the growing point of impatiens, there were fasciations produced in about 30% of the damaged plants. Fasciations in garden asparagus have been attributed to physical damage or pressure exerted on the growing point as it pushes through the soil. In the evening primrose (*Oenothera*), fasciations can be caused by damage to the growing point by the egg laying activity of a moth. Similar documentation can be found implicating gall wasps, caterpillars, and mites for inducing fasciations in a variety of plant species.

Most recently, with the advent of pesticides, herbicides have been the inadvertent cause for some fasciations. The most common damage occurs when low levels of herbicides of the 2, 4-D type are used for broadleaf weed control in lawns. Any drift of these chemicals into nearby vegetable or flower gardens can cause herbicidal symptoms in sensitive plants. One of these symptoms can be a distortion of growth similar to fasciation.

In most cases, it is not known whether the fasciations that occur in woody plants are heritable. However, the fasciated character can be maintained by vegetative propagation through cuttings or grafts. Cultivars with the typical fasciated stem occur in several of the conifers including (*Cryptomeria japonica* and *Chamaecyparis obtusa)*. You will find these listed under descriptive cultivar names like 'Cristata', 'Torulosa', and 'Monstrosa'. Also, the witches brooms that occur in many species of conifers have been correctly or incorrectly termed fasciations. A witches broom usually forms as a mass of short shoots grouped together in the top of a tree. These shoots do not have the typical flattened stems associated with stem fasciations, but can be considered a multi-radiate form of fasciation. Many of our dwarf conifers have been selected from cuttings taken from witches brooms.

Interest in fasciations have persisted for centuries and although fasciations have only proven to have commercial importance in a few species of ornamental and fruit crops, I think the rich history surrounding fasciations will prove rewarding to anyone willing to stop and observe these garden abnormalities.

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