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Recommended Citation

Smith, James P. Jr, "Dichotomous Keys - Their Structure and Use" (2017). *Botanical Studies*. 58.
https://digitalcommons.humboldt.edu/botany_jps/58

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DICHOTOMOUS KEYS - THEIR STRUCTURE AND USE

"Keys are written by people who don't need them, for people who can't use them."
(Anonymous crank)

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There are at least three ways that you can identify an unknown organism. I will focus on plants. You can use "the leaf method." You leaf through a picture book until you find a drawing or photograph that seems to match your specimen. Of course, now you go into your favorite internet search engine to look for images if you have some ideas. A second alternative is to present your unknown to a local expert, perhaps a botany professor, in hopes that he or she will immediately make a pronouncement. Such individuals are increasingly rare.

The third method is for you to "key out" your unknown by using a key found in a printed flora or on-line. Most keys take the form of a series of paired, parallel, contrasting, and mutually exclusive statements that describe various features of the plant. We say paired because you typically have two choices; parallel because the two statements address the same features in the same order, and mutually exclusive because the unknown will fit as described by one member of the pair, but not the other.

Each statement is called a **lead**; the two leads together constitute a **couplet**, as seen in this example.

- 1. Florets 1; palea reduced or absent Agrostis
- 1. Florets 2 or more; palea well-developed. . . . Festuca

You must decide in each case which of the two statements best describes your unknown plant. These decisions then direct you through a series of subsequent couplets. Because you are presented with paired statements, it is called a **dichotomous key** (Greek, in two + to cut).

There are different styles of keys. Some authors create **natural keys** in which closely related plants come out next to one another. These have become increasingly rare as systematics has come to rely more heavily on molecular and chemical data, features not that useful in routine identification. In an **artificial key**, the goal is to provide a means of identifying a plant, without attempting to also indicate closeness of relationship. The vast majority are of this type. Most of us who write keys view them strictly as a tool for identification, not as an opportunity to express phylogenetic relationships.

Traditional keys also differ in their physical appearance. In the **bracket key**, the two leads remain together, as seen in the example below. This format takes less space on the page. Its main disadvantage is that is more difficult to retrace your steps through a longer key if you encounter difficulty.

- 1. Plants 0.5 mm to 3 cm in diameter, free-floating 2
- 1. Plants much larger, not free-floating on water's surface 3
- 2. Plant body not differentiated into stems and leaves. **Lemnaceae**
- 2. Forked stems and two-ranked leaves present **Salviniaceae**
- 3. Plants completely submersed 4
- 3. Some or all leaves floating on the surface of the water 5
- 4. Plants of freshwater sites; leaves spirally arranged in grass-like tufts Isoëtaceae
- 4. Plants of marine waters; leaves alternate, two-ranked. **Zosteraceae**

In the **indented key**, couplets are indented beneath the step that led you there. They take more space, especially in longer keys that require several orders of indentation, but the logic of the key is more evident. It is easier to retrace your steps if you get into trouble.

1. Plants 0.5 mm to 3 cm in diameter, free-floating **2**
 2. Plant body not differentiated into stems and leaves **Lemnaceae**
 2. Forked stems and two-ranked leaves present **Salviniaceae**
1. Plants much larger, not free-floating on water's surface **3**
 3. Plants completely submersed. **4**
 4. Plants of freshwater sites; leaves spirally arranged in grass-like tufts **Isoëtaceae**
 4. Plants of marine waters; leaves alternate, two-ranked **Zosteraceae**
 3. Some or all leaves floating on the surface of the water **5**

There is a fundamental problem with our traditional keys. The person who wrote the key has determined which features you must examine and in what order. What if you are asked whether the fruits have warts or spines, but you don't have any fruits on your plant? What if you just grabbed the top half of the plant and now you are asked if it had bulbs or rhizomes? The solution is the **interactive key**. The structure is entirely different. The author presents you with a long list of plant features. In their earlier form, beside each one them is the number of every plant with that feature. There could be scores of them. You move through the list, picking the features that you can see in the specimen before you. You keep reducing the number of possibilities. Eventually you determine that only #45 meets the criteria you have selected and then you turn to a plant list to find its name. Now such keys, in a more sophisticated form are available on-line. For instance, if you go to the U. S. Department of Agriculture website (plants.usda.gov) you will see the 269 features for the grasses in California. Select any one of them and the software will produce the names of the grasses that have that feature. As you select more features that you can observe, you keep narrowing the field.

TOOLS OF THE TRADE

Let me recommend three items that most of us who write keys will assume that you have at your disposal – a hand lens or magnifying glass (loupe), a metric ruler, and a pair of forceps or tweezers. You may be asked to determine some surface feature of a stem or seed that requires magnification. An 8X lens or loupe is usually sufficient. By the way, you may be able to get an application for your smart phone that will serve nicely. Most of the keys that you will find in more technical floras use the metric system to express the size of the plant and its parts. (An editorial comment: the United States is one of only two countries in the world that has not adopted the metric system). An plastic millimeter ruler of 6" or 15 cm works most of the time. Depending on which plant you are attempting to identify, especially if it is a grass or sedge, you will need to tease (dissect sounds more scientific) parts from one another to get a better look. Inexpensive tweezers that you probably have around the house will work, but you may want to upgrade. Look for ones with finer points that meet properly.

INFORMATION ABOUT THE UNKNOWN PLANT

Keys may also ask you about where you collected the plant. Your unknown may be widespread weed that could come from almost anywhere in the western United States. Or the lead may take you to a plant known from only a few counties in northwestern California. Keys regularly ask you about the plant's habitat. Was it a free-floating aquatic or one growing on a serpentine outcrop. If you are working from pressed and dried specimens collected some time ago, it is helpful if you make yourself notes about the plant itself. Was it pleasantly or unpleasantly aromatic? Did it have irritating or stinging hairs? What was the color of the flowers when they were fresh? That color may change dramatically in dried material. Obviously you cannot collect an entire tree or shrub. If your specimen of a smaller herbaceous plant is not complete, make a note about its size.

I have another paper on plant collecting techniques that you might find useful at this same website (digitalcommons.humboldt.edu/botany_jps).

HOW TO USE A KEY

- Make sure that you are using the right key. It is a bit embarrassing and a waste of time to attempt to identify a plant in the wrong key. Watch more helpful descriptors, such as "native trees," or "plants of Story County, Iowa" that define the cast of characters.
- Check to see if there is a glossary at the back of the key. Authors vary in our use of certain terms.
- Read the key very carefully. If it is a good key, the author has spent a great deal of time selecting the right words. Much frustration results from misreading. There is a world of difference in the meaning of "and" and "or." They are not interchangeable.
- Watch for weasel words, such as "mostly" and "usually." Keep in mind the variability, such as the length of a leaf or the size of the plant itself, that you may encounter. I once collected a wild oat about 3 m high, far exceeding its usual limit. One way of expressing this range of measurements is, for example, "Leaf blade [1] 2-5 [-7] cm long," which translates as the leaf blade is typically 2-5 cm long, but it can be as short as 1 cm or up to 7 cm.
- Read both leads of the couplet before making your decision. The first lead may sound pretty good, but the second lead may be a much better choice.
- Do not base your decision on a single observation, particularly when you are asked about measurements.
- If neither lead seems to make any sense at all, you have probably made an error in keying and should not be at that couplet. Go back a step or two and check yourself.
- Do not assume that a key says something that it does not. In the second lead below, the author has not said anything about the plant, other than it is a perennial. It might also have red flowers.
 1. Plant annual; flowers red
 1. Plants perennial
- If you are not confident about which lead to take, try both of them. One pathway should get you into difficulty fairly quickly.
- If one side of a dichotomy will take you to a relatively small number of plants, check out their descriptions or look at drawings. This additional knowledge may be helpful to you. Also, as you gain more knowledge of the flora you will be able to eliminate certain leads because they will take you to plants that you know.
- Learn to weigh the relative values of characters used in keys. Features of reproductive structures tend to be more important than those of plant height, for instance.
- Confirm your determination. Check it against a technical description, illustration, or better yet, a specimen.

A closing thought. Dichotomous keys have heuristic value. They can teach you the plant features that botanists use to distinguish families, genera, and species. You will quickly see how much emphasis is placed on reproductive structures. Repeated use may also allow you to be more efficient in your identifications. Yes! My unknown must be that other shrub with opposite leaves of three leaflets that I keep passing by in the key. It's that other grass with the awn that comes out next to Panicum.

Revised: 13 May 2017