Keys

In the past, keys sometimes served as vehicles for descriptions as well as devices to assist in identification. Descriptions of new taxa within the framework of a key were often fragmented. Each step in the key leading to a new taxon was a part of the description of that taxon. These bits of information were not always repeated in the main body of the description.

The inclusion of descriptions in a key diminished the efficiency of the key in identification. The reader was obliged to sift descriptions for the information necessary to the keying process.

Also, keys were sometimes constructed to express the supposed phylogeny of a group as well as to assist in the identification of its members. The arrangement of such “natural” keys was dictated by the supposed phylogeny. Adherence to a phylogenetic scheme at times required sacrificing the dichotomous key structure. Worse, weak characters were often used at some steps because the characters of phylogenetic importance were unsuitable for a key depending on external morphology.

There is now general agreement that a key intended as an aid in the identification process should not vary from this purpose. Descriptions and phylogeny are best presented apart from the key and from each other. Keys constructed to assist in identification are usually “artificial” keys that use the most decisive and accessible characters even though many of the characters may be phylogenetically trivial.

Forms of Keys

The earliest keys were outline keys. Steps in these keys were not necessarily dichotomous, a single step sometimes having three or more alternatives, and the alternatives were not necessarily placed together. Each set of alternatives was identified by a letter, number, or symbol, or a sequence of these. There was no standard way of identifying sets of alternatives. To facilitate locating all alternatives in a set, short keys were often indented to provide a common left-hand margin for all alternatives of a given set. The next set of alternatives were indented more yet, and so on. Of course, long keys could not be treated in this fashion. Below are three alternate treatments of the outline style:

Scheme 1	Scheme 2	Scheme 3	
I	a	a	
A	b	b	Taxon 1
B	bb	bb	Taxon 2
C	bbb	bbb	
a	c	c	Taxon 3
b	cc	cc	Taxon 4
II	aa	aa	
A	d	d	Taxon 5
B	dd	dd	Taxon 6

The sets of alternatives are most readily seen in scheme 3 because of the indented margins; and the possibility of errors in associating alternatives is minimized by using a different letter for each. The first set is a and aa. If a is true, the next set is b, bb, and bbb.

The modern European key is essentially an outline key, although each set of characters is dichotomous and identified by numbers. The essential identity of the modern European key and the outline key is apparent in the comparison of these keys and a modern American key:

Indented Outline | Modern European | Modern American

a	1(6)	1 2
b . . . . Taxon A	2(3) . . . . Taxon A	1' 4
bb	3(2)	2(1) . . . . Taxon A
c . . . . Taxon B	4(5) . . . . Taxon B	2' 3
cc . . . . . . Taxon C	5(4) . . . . Taxon C	3(2) . . . . Taxon B
aa	6(1)	3' . . . . Taxon C
d . . . . Taxon D	7(8) . . . . Taxon D	4(1) . . . . Taxon D
dd . . . . Taxon E	8(7) . . . . Taxon E	4' . . . . Taxon E

In the modern European key each statement is numbered, and the alternative statement is indicated by the number enclosed in parentheses. Thus, statements 1 and 6 in the above example form a set. If statement 1 is true, the next set is 2 and 3; if statement 6 is true, the next set is 7 and 8. The only objection to this form of key is that the alternatives of a set are sometimes well separated, even on different pages, making a comparison more difficult than when the alternatives are one above the other as they are in modern American keys.

In modern American keys, each set of alternatives is numbered consecutively. Usually the second alternative of each set is indicated by a prime. The next set to be consulted after a true statement is indicated by the number near the right-hand margin unless, of course, the name of a taxon is given. A number in parenthesis indicates the last previously used set, so the key can be run backwards to check for error in interpretation or observation.

The preferred style of key, American or European, is mostly a matter of familiarity. Both serve their purpose about equally well.

Pictorial keys are relatively recent innovations suitable only for small groups. They are especially appropriate for non-professionals.

General Considerations

The function of a key is to eliminate, step by step, taxa to which an unidentified specimen cannot belong, leaving, finally, the one taxon to which the specimen presumably does belong. To perform most effectively, a key should use first the strongest characters, those that offer the clearest differences between character states. The weakest characters, those most likely to be misinterpreted, should be used last. If any of these are wrongly interpreted, the identity of the specimen lies within a residue of a few taxa. The supplementary information needed for the final steps in the process of identification is that relating to these few taxa.

Every statement in one half of a couplet should have a contrasting statement in the other half of the couplet, and these should be arranged in the same order:

12(11) Maxillary palpi fusiform (fig. 23); base of elytra slightly elevated as narrow border; tarsi finely pubescent beneath 13

12' Maxillary palpi conical (fig. 27); base of elytra unbordered, smooth; tarsi glabrous beneath . . . 14

When the contrast between character states is unequal in the pairs of statements, the strongest contrast should take precedence. In this case, the difference between the forms of maxillary palpi is quite clear, and these forms are defined by illustrations, but the other differences are less obvious. Specimens are frequently imperfect, and for this reason pairs of contrasting statements concerning more than one morphological region are desirable. If, in the above example, only the form of the maxillary palpi was used for the couplet, a specimen that had lost these appendages could be keyed only to this couplet.

Contrasting statement pairs should be as informative as practicable. The statement pair “maxillary palpi fusiform” and “maxillary palpi not fusiform” provide a contrast, but the choice between two specified shapes is easier to make than the choice between fusiform shape and an unknown shape which may be closely similar to fusiform. When a contrasting statement pair consists of a positive and negative statement, such as “pulvilli present” and “pulvilli absent,” the positive statement is customarily placed in the first half of the couplet.

Statements need to be explicit. “First antennal segment long” is vague, but “First antennal segment equal to interocular distance” provides a definite criterion.

Construction of Keys

A taxa-character matrix facilitates the development of a key containing a moderate number of taxa. The matrix presents all data in one table, so it is easy to scan for a character state usable in separating some taxa from others.

The taxa to be keyed are listed as line headings in the left margin. The character states are indicated as column headings in the top margin. Each character, to be of use in a key, must exist in two or more states, and one less than the total number of observed states may be entered into the matrix. If the number of tarsal segments is two in some taxa and three in the remaining taxa, one of these character states may be entered in the matrix. A binary system of notation, e.g. present “+” or absent “o”, indicates which character state exists in a given taxon. Since “tarsi 2-segmented” was entered in the matrix, the notation “+” for a taxon means that the tarsi of this taxon are two-segmented, and the notation “o” for another taxon means that the tarsi of that taxon are three-segmented. Such discontinuous character states lend themselves well to a matrix.

Continuously variable characters may be used in a matrix once the variability is divided into categories. If the length of a median, ventral spine at the base of the abdomen is reasonably constant within a taxon, but varies almost continuously among taxa, ranging from a tubercle to a long spine passing between coxae and terminating at the base of the head, apine length may be arbitrarily divided into character states:

1. not reaching metacoxae.
2. reaching metacoxae, but not reaching mesocoxae.
3. reaching mesocoxae, but not reaching procoxae.
4. reaching but not surpassing procoxae.
5. surpassing procoxae.

If the last four of these character states are entered in the matrix, the first character state is indicated in the matrix by notations that the other four are absent in a given taxon.

Character states subject to misinterpretation are a principal source of difficulty in key construction. The criterion “metacoxae contiguous” vs. “metacoxae separated” is useful when the metacoxae are clearly touching or are clearly separated. When the metacoxae nearly touch, but actually do not, the use of these character states to separate taxa invites error.

There are three possibilites for disposing of this problem. One is to use the contrasting character states only where the difference is quite clear. The second is to redefine the character states for greater objectively, e.g. “metacoxae separated by at least half the diameter of a metacoxa” vs. “metacoxae contiguous or separated by less than half the diameter of a metacoxa.” Even after redefinition some taxa may be borderline. The third possible disposition of the problem of ambiguity is to treat the character state as a variable one.

Some character states are consistent within most taxa but variable within others. When such characters are used in keying, any taxa presenting more than one character state for that character must be carried along in both divisions of the key and taken out later by another character. Consequently, such a taxon keys out in two or more places in the key. Such multiple exit keys are especially appropriate in separating higher taxa which often are not definable by one unique combination of character states.

Once a taxa-character matrix is constructed, the process of segregating the taxa can begin. For the initial division, an invariable, clearly definable character state is preferable. The taxa can then be regrouped to see if any other character states are usable at this step, and to facilitate selection of the character state for the next step. When all the taxa in one group resulting from the primary division have been keyed out, the other group is processed in the same way.

Practical Considerations

Insofar as possible, characters used in a key should be accessible without elaborate preparation of a specimen or the need to mutilate the specimen. Characters on parts that are often lost from a specimen, or that are subject to distortion in preservation, should not be used as the only criterion in separating taxa if other characters are usable.

A key may often be structured in more than one way. The choice of structure can affect the reliability of the key and the ease of its use. There are two general approaches to key making, the “splitting” and “chipping” techniques. The theoretical advantages of splitting the taxa at successive steps into more or less equal groups is that less time is required to run the key and the probability of error is lessened because fewer decisions are necessary to arrive at the name of a taxon. The additional steps (in a linear or chipping key) take more time and increase the opportunities for a mistake. The shorter key is therefore preferable if the decision to be made at each step is not more difficult. The division of character states among taxa rarely if ever permits structuring a key that conforms entirely to the better of these models. A good key should approach the symmetrical model as closely as possible.

Sometimes a couplet is exceptionally troublesome, not because it is badly phrased or for want of illustration, but because the contrast between character states is not easily seen or interpreted. Tarsal formulae and the fusion or mobility of basal abdominal sternites are character states useful in separating families of beetles. However, a small tarsal segment obscured by the vesture of adjacent segments is easily overlooked; and deciding on the basis of a dried specimen whether or not in life all abdominal sternites were mobile is not an easy matter for the inexperienced. Such couplets will elicit an appreciable number of wrong answers.

An erroneous decision at a difficult couplet can be negated in a multiple exit key. Assume that the symmetrical key worked well for all included taxa except one taxon having a problem at a specific couplet. If the difficult couplet cannot be improved, provision can be made for a wrong decision at this point by adding one more step in that part of the key where the taxon should not have been keyed. Examples of the difficult taxon therefore keys out correctly no matter the choice made at the difficult couplet.

The reticulate key is a device for guiding the user back to the correct path despite a wrong decision. In this case, if a wrong decision is made an couplet in the wrong part of the key will direct the user back to the proper part of the key. Again, specimens key out correctly despite the one erroneous decision.

Computerizing data for the construction of a key containing a large number of taxa may be advantageous because the computer can be programmed to produce all possible key structures. The taxonomist can then examine all the alternatives produced for any structure that in his judgement is superior to others. It is desirable to have this judgement verified or refuted by having as many people try the key as can be coerced into doing so.