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Water quality — Guidance standard for designing and selecting taxonomic keys

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Foreword

This document (EN 16164:2013) has been prepared by Technical Committee CEN/TC 230 “Water analysis”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by July 2013, and conflicting national standards shall be withdrawn at the latest by July 2013.

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Introduction

The importance of ecology in new legislation such as the EC Water Framework Directive (2000/60/EC) means, that ecological data from aquatic environments shall be of a known and verifiable quality. European Standards recognise the need for ecologists to use reliable and up-to-date taxonomic keys when performing their assessments. However, determining the most appropriate literature to use for any particular analysis is not always straightforward. This guidance standard is designed to provide an overview of the characteristics of a taxonomic key appropriate to applied ecological analyses. This has two goals: first, to help end-users to determine the most suitable taxonomic literature to use for a particular analysis and, second, to help those commissioning new identification guides to produce 'fit-for-purpose' specifications, and those writing keys to meet such specifications.

It is important to state very clearly at the outset that the role of this document is not to replace but rather to complement the guidance on nomenclature and taxonomy given by ICBN [3] and ICZN [4].

Identification materials are increasingly being presented using electronic, rather than conventional printed, media. The general principles are the same, regardless of the media.

1 Scope

This European Standard defines standard principles for the design of taxonomic keys to ensure proper use of nomenclatural rules and reproducible and traceable identification. These principles also allow for the selection of the best key available.

2 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

2.1
accuracy
correct identification of a specimen to the relevant taxonomic category (e.g. family, genus, species)

Note 1 to entry: The definition refers to the context of this European Standard.

2.2
International Code of Botanical Nomenclature
ICBN
official international taxonomic code for botany

2.3
International Code of Zoological Nomenclature
ICZN
official international taxonomic code for zoology

2.4
nomenclatural rules
rules for naming of organisms that are laid down in official taxonomic codes

2.5
traceable identification
identification of a taxon which can be traced back to its original publication either directly or indirectly

3 Principles of biological identification

The objective of all biological identification is to assign the correct biological name to a specimen, irrespective of the amount of morphological or other variability shown by the taxon in question. This should be done as efficiently as possible, in order to minimise time and resources. Identification provides a link between a specimen of an organism and the original 'type specimen' of that taxon. This is often one or more individuals of the species, preserved in a museum collection (or, in the case of many algae, an illustration), which has been described according to the rules of the ICBN or ICZN using text, measurements and illustrations.

There are two methods of identifying organisms: by 'matching' (pattern recognition) and by 'logical comparison' (typically through the use of keys). The academic taxonomic literature often assumes that logical reasoning is used exclusively but, in practice, most biologists use a combination of approaches: relying on memory for naming common organisms and a mix of pattern recognition and logical reasoning for the less common organisms. It is arguably the poor quality of identification literature that causes biologists to switch from logical reasoning to pattern recognition.

4 Requirements for taxonomic keys

4.1 General principles

Most identification guides assume that logical comparison plays a large part in the identification of organisms, and the guides have a key, or similar device, at their core. These work by presenting users with a limited number of choices from which to choose either in sequence ('dichotomous keys') or in parallel ('multiaccess keys'). The same principles apply, regardless of the type of key.

Taxonomic keys are used to come to an accurate and reproducible identification. Within this context, ‘accurate’ is defined as the correct identification of all specimens of a taxonomic group likely to be encountered in a defined geographical region. Therefore, any lack of clarity which may lead to mis-identification should be anticipated at all taxonomic levels.

Requirements for an appropriate identification guide include:

— keys appropriate to the geographic area under consideration;

— appropriate taxonomic level for the analysis in question;

— all known taxa from the region;

— written in a language familiar to the analyst.

The key itself should provide:

— a clearly defined title and scope (completeness of taxonomic group);

— robust characters;

— clear layout;

— clear language;

— complete glossary.

The points mentioned above are especially relevant since academic taxonomists often write from the perspective of an ‘expert’ and do not always empathise with the skills of those performing the analyses.

These points are described in more detail below.

4.2 Title and scope

An identification guide should be clear about the taxonomic groups and life stages covered, and the geographical scope of the guide. These should be reflected both in the title and, in more detail, in the introduction.

EXAMPLE 1 Titles like “Chironomidae larvae of the Lowlands of Northwesttern Europe”, “Oligochaeta of North-West Europe” and “Chironomidae exuviae of the West Palaearctic Region” suggest a defined overview of the content. However, a number of terms within each title would need amplification in the introduction. Terms such as ‘lowlands’ would need to be explained in more detail, whilst maps and text showing the limits of the author’s understanding of ‘North-West Europe’ and ‘West Palaearctic’ would also be useful.

On the other hand, it is often inappropriate to define the geographical scope too precisely; firstly, because the geographical ranges of many species are themselves known only imprecisely and secondly, because the ranges of many species are changing.

EXAMPLE 2 Two species of the Trichopertan genus *Drusus* have been recorded from the Netherlands: *D. trifidus* and *D. annulatus*. A third species, *D. biguttatus* is similar to *D. annulatus* and has been recorded from sites close to the Dutch border, though not yet from within the Netherlands. A Dutch Trichopteran key which made no reference at all to *D. biguttatus* runs the risk of users ‘shoehorning’ specimens into *D. annulatus*.

A similar situation exists for the Mollusc genus *Corbicula* in Britain and Ireland. *C. fluminea* is described in “Freshwater Bivalves of Britain and Ireland”; however, *C. fluminalis* has not yet been recorded from Britain and Ireland and is omitted. Users may not realise that *C. fluminalis* is spreading throughout Europe and may, in time, also spread to Britain and Ireland.

For this reason, authors should always produce an accurate description of the geographical region primarily covered by the key and illustrate it by a detailed map. In addition, all species recorded from the region should be mentioned in the key. Relevant species known from adjacent regions should be explicitly listed. If data are absent this should also be clearly mentioned.

4.3 Characters

Choosing the best characters:

— How easy are they to describe?

— Are they appropriate for the potential users?

— Are they very fragile or easily damaged?

— Are they sex specific?

— Are they restricted or limited to particular regions?

— Are they restricted to particular seasons?

— Are they adult or juvenile?

Use obvious characters even if they do not differentiate all specimens or do not define the taxon (e.g. habitat, markings, size). The use of characters requiring very high magnification or special preparations should be avoided where possible, and included only as a last resort. If such characters are essential then this should be mentioned as part of the description.

4.4 Layout

The layout of the key should guarantee easy routing through the identification couplets enabling accurate identification in the minimum time. Layout comprises both typography and graphics.

4.5 Description of Morphology

4.5.1 Couplets

4.5.1.1 As far as possible, couplets in a dichotomous key (or choices in a multi-access key) should be discrete and categorical in nature. Common and obvious taxa should be differentiated early in the key. Couplets should be simple and focus on those aspects of a taxon's morphology that best distinguish it from similar taxa.

The number of features which are not relevant should be limited. Avoid geographical and ecological characters within the body of the key itself as far as possible (although such information may, occasionally, be useful: for example, if all the taxa in one couplet are all endo-parasites and those in the other are free living).

As far as possible, each choice within a couplet should be based on positive attributes of the taxa in question and it is especially important to give clear guidance when the absence of a character is used to differentiate between taxa.

The presence of an adipose fin, for example, is a useful means of recognising a Salmonid fish. However, the absence of an adipose fin is only a useful taxonomic character of a non-Salmonid fish if the key contains a clear description (ideally alongside the couplet) showing what an adipose looks like and where, on the fish, it can be found, so that the user can be sure that s/he has recorded a genuine 'absence'.

It is useful to have illustrations of critical characteristics.

The step-wise routing through a key should be easily traced back to the origin. This can be accomplished by indicating the number of the last couplet especially when a step involves more than one couplet.

At the end of each key, reference should be made to a complete description of the identified taxon for final confirmation of the identification. All descriptions within a guide should be structured in the same way, to make it easy for users to find the information they require. Descriptions vary in format, but always start by giving the correct latin name of the taxon, along with the authority and year of publication, and consist of three further sections:

4.5.1.2 Morphological characteristics of the taxon, including dimensions. Where continuous variables are used in keys (e.g. dimensions), then either the ranges chosen should not overlap, or each range should be accompanied by a discrete variable that can be used to differentiate taxa in the zone where continuous characteristics overlap.

Two other types of information that are useful to include are:

— the most useful diagnostic characters for a particular organism;

— taxa that are likely to be confused with the organism (include cross-references).

4.5.1.3 Essential taxonomic information, including synonyms. It is recommended that, for identification guides, which are not intended as the standard taxonomic work for a group of organisms in a particular region, the synonyms should be limited to those that are used in the works that are widely available, and that users are likely to consult during the course of their work. If there have been nomenclatural changes or taxonomic revisions in recent years, it is useful to include justification for the approach adopted. This is particularly important for groups of organisms where there have been significant recent changes or there is an ongoing debate about taxonomic concepts. Where authors decide to amalgamate taxa (as “agg.” or “ag.”, they should explain which taxa are included, reasons that may prevent routine separation of these (e.g. lack of sexual organs) and provide references to more detailed literature.

Whilst it is not necessary to provide a reference to the holotype (original description) in a practically oriented identification guide, it is essential to provide enough information to provide a traceable link with this.

4.5.1.4 Ecological and distribution notes. These should be based, as far as possible, on the direct experience of the authors in the region where the guide is to be used and include information on the type of habitat along with seasonal preferences and phonological information.

Vague qualitative terms, such as "oligotrophic" and "mesosaprobic", should be avoided as far as possible. Use of quantitative information is preferred but if qualitative terms are unavoidable the range of chemical variables embraced by such terms should be specified. Users also need to know if the application of such a term is based on actual measurements or on the association of the taxon in question with other taxa with known preferences for those conditions. Bar charts and scatter plots, relating the distribution of organisms to key environmental variables are generally more useful than such phrases.

Distribution maps are useful if there are sufficient data to allow meaningful geographic comparisons, otherwise the maps reflect sampling activity, rather than the true distribution.

4.5.2 Illustrations

Illustrations opposite couplets make keys easy to use. Grouped illustrations allow rapid comparisons between similar taxa. Depending on exact circumstances, either approach may be appropriate. However, grouping illustrations together purely for ease of printing should be avoided.

A key should adopt a consistent format for images. If a series of illustrations are to be compared, then all should be presented at the same magnification to enable rapid visual comparisons of size. Relevant characters should be clearly marked. An indication of scale (ideally a scale bar) is essential on all illustrations.

Each taxon should be illustrated with examples of that taxon from the region covered by the guide. Several images per taxon are often necessary, in order to show the range of morphological variation likely to be

encountered. These should show the organism as seen by an observer. Whilst photographs give the opportunity to show the organism as seen by the observer, there are still situations where illustrations may be more appropriate. Where high magnifications are necessary, for example, it is often difficult to obtain sufficient depth-of-field in photomicrographs and a three-dimensional shape may be better conveyed by a drawing.

Colour illustrations are only necessary if colour is an important diagnostic property of the group in question. If used, colour illustrations should show the full range of colour variability within the taxa in the region covered by the guide. However, caution is required as the perceived colour can be influenced by the surroundings. It is also important to note that inconsistencies can occur in the printing of colours in the final publication (or in their display by computer monitors, in the case of electronic identification guides).

4.5.3 Binding

Identification guides are subject to large amounts of wear and tear, and a strong, appropriate binding is essential. The choice of binding will depend, to some extent, on where the guide is to be used. A guide that is designed for field use should have waterproof covers, at the very least. Such covers are also useful in laboratories, particularly for analysing aquatic organisms, where work surfaces often get wet. A binding that allows the guide to lie open, rather than springing shut, allows the user to focus on the identification without distraction. It is also useful to have the title on the spine (but this may not be possible if the document is spiral bound, for example).

4.6 Linguistics

Where taxonomy forms an integral part of ecological assessments to underpin legislation such as the Water Framework Directive, the identification guide chosen for a specific monitoring task should be written in a language with which all analysts are familiar. This is important if nuances in the text are not to be lost. Straightforward language should be used throughout: “Crab with more or less than three teeth” is a confusing form of “Never crab with three teeth”. Analysts working with freshwater organisms frequently work with a wide variety of taxonomic groups. For this reason, guides should use non-group-specific terms in the native language of the readers as far as possible.

A common complaint of published keys is the use of ambiguous and relative terms. A prime example is the use of relative measures (“larger than species X”, “relatively long”, “not so long”, “big”), comparing one taxon with another, which implies that the user has a (named) specimen of the (closely related) taxon to hand during the identification process.

Words such as ‘generally’, ‘usually’ and 'more or less' are also not helpful, as they imply that the characteristic with which they are associated is not a constant feature of all individuals within a taxon.

Many of the comments about ambiguity of taxonomic characters also apply to ecological and distribution notes terms such as ‘widespread’ and ‘probably cosmopolitan’, which are often of little help to users.

5 Summarised criteria

Summarised key points for selecting and designing an identification key:

— clear definition of taxonomic group(s) and life stages covered;

— geographical scope;

— choosing best available characters;

— layout features;

— easy routing;

— accurate identification in minimum time;

— high standard typography and graphics;

— multi-access key if advantageous to dichotomous key;

— discrete, categorical, simple and differentiating couplets;

— avoiding overlapping continuous variables or dimensions;

— clearly indicate absence of characters if needed for differentiation;

— back-tracing feature for routing steps;

— complete description of the identified taxon at the key end-point;

— using synonyms only to those used in works widely available;

— in case of taxonomic revision justification should be included;

— provision of traceable links to the holotype;

— ecological and distribution information should be based on regional experience;

— chemical or ecological terms with wide meaning (e.g. “oligotrophic”) should be specified numerically;

— emphasising most useful diagnostic characters and taxa of likely confusion;

— illustrations should not be “pooled” on single page for different taxa;

— images should have a consistent format;

— illustrations used for comparison should have identical magnification and a scale bar included;

— illustrations should use examples from the region covered by the key, and black and white images are often preferable (except for e.g. flowering plants);

— field guides should have waterproof covers, at least;

— wording should be clear and simple;

— any vague wording should be avoided (e.g. “widespread”).

6 Glossary

A glossary should be included. This is especially important for morphological criteria as the usage of terms by experts such as “capitate” and “sub-capitate” can vary between experts. The glossary should also include illustrations and examples.

7 Synopsis of classification

It is also important to include an overview of the morphology of the organism group(s) covered by the guide. This is particularly useful for non-experts, either to explain how the terminology used in the guide relates to the structure of the organism, and as an *aide mémoire*, but also for experts as usage of technical terms often varies from author to author, and it is important to know how terms are applied in a particular work.

As taxonomic ideas are fluid, it is important that the authors explain the basis for the classification that underpins the identification guide, linking this to the primary literature that establishes the higher taxonomic divisions (e.g. class, order, family) and listing the hierarchical organisation of the classification to, at least,

genus. It is useful to include all synonyms that are in common usage, i.e. those that an end-user might encounter in other commonly available identification guides.

8 Methods for collecting, preserving and examining samples

Guidance on sample collection, preservation and examination is important, particularly if identification is dependent upon certain regimes being followed. Some preservatives are better suited than others to particular taxonomic groups, and some types of organisms require samples to be preserved in particular ways, prior to analysis (e.g. diatom valves, chironomid pupal exuviae). Such procedures might be covered by separate documentation, but an overview of the process is useful within the identification guide itself, so that users are aware of any assumptions underpinning the identification.

9 Testing and validation of a key

It is essential that keys and identification guides are subjected to peer review and end-user testing before publication. These have distinct roles: the former ensures taxonomic rigour whilst the latter maximises usability. The final stages of end-user testing should be independent of the authors. The UK Field Studies Council's AIDGAP (Aids for Identification of Difficult Groups of Animals and Plants") project is an excellent model of the latter: draft versions of the key are sent to a selection of people (typically about 50) with a range of experiences (beginners to experts), who use the keys and then send comments back. These are collated and sent on to the author(s), who then can modify the key in light of these comments [5].

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