A comparison of interactive identification programs

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Contents

Introduction

This is an updated version of a paper presented at the Symposium on Interactive Identification Systems at the International Botanical Congress in August 1999. The programs compared are those that were presented at the Symposium. For contact information for other interactive identification programs, see Dallwitz (1996). The versions originally tested were the latest ones publicly available at the time of the Congress, or ones recommended by the authors. Later versions of some of the programs have since been evaluated — see details below.

Comments on the criteria used, or on the evaluation of particular programs, are welcome. They will be incorporated in future versions of this document, either directly or by modifying the criteria or evaluations.

For more details about the criteria, see Dallwitz, Paine and Zurcher (1998, 2000).

When testing an interactive-key program, it is tempting to *pretend* to do an identification — that is, to go through the motions of an identification when you already know the answer. This is not generally a good test of the value of a program for real identification. Ideally, the test should be carried out with taxa with which you are unfamiliar (the more so, the better, for example, in a Kingdom different from your speciality). If this is not possible, pay special attention to the easy availability of features which help an inexperienced user: 'best' characters, character illustrations and notes, error tolerance, and expressing uncertainty by selecting more than one state.

Programs Compared

Intkey

Free. Windows 95/NT or later. Reviewed August 2000. Version tested: 5.10, August 2000. http://delta-intkey.com.

IdentifyIt

Commercial. Macintosh, Windows. Reviewed July 1999. Version tested: 'Euphausiids of the World Ocean', Macintosh version, January 1999. http://www.eti.uva.nl.

Lucid

Commercial. Windows. Reviewed March 2000. Version tested: 1.5 Build 18, September 1999. http://lucidcentral.org.

For a critique of this document by K. Thiele (one of the authors of Lucid), see http://delta-intkey.com/www/thiele.htm.

MEKA

Free. Windows. Reviewed July 1999. Version tested: 3.00, January 1996. http://ucjeps.berkeley.edu/meacham/meka/.

NaviKey

Free. WWW. Reviewed July 1999. Version tested: 2.2, July 1999. Internet Archive: http://www.herbaria.harvard.edu/computerlab/web_keys/navikey/. For the latest version, see http://navikey.net.

PollyClave

Free. WWW. Reviewed July 1999. http://prod.library.utoronto.ca:8090/polyclave/.

XID

Commercial. Windows, Macintosh. Reviewed July 1999. Version tested: Demonstration Version 1.31D, January 1999. http://www.xidservices.com.

Comparative Table — General Features

Notes

The entries in the first column of the table are linked to explanatory notes.

Importance of the feature

+++	Essential for correct identification.
++	Very important for identification.
+	Important for identification.
No '+' or '–'	Useful for identification or for other purposes.
–	Undesirable for identification.

Scoring

Y	The implementation of the feature is satisfactory.
y	The implementation of the feature is unsatisfactory (incomplete, inconvenient, or error prone). See Notes for details.
blank	The feature is not implemented.
?	Not known.
*	See Notes.
–	Undesirable for identification.
A	In Intkey, normally available only in Advanced mode. (Any feature can be made available in Normal mode, at the discretion of the author of a data set.)

Weighted count of features

The weighted count of features in the first line of the table is calculated as follows. The basic count depends on the importance of the feature: '+++' counts 16, '++' counts 8, '+' counts 4, '–'counts 0, and other features count 2. The basic count is halved if the implementation of the feature is unsatisfactory (for example, an unsatisfactory implementation of a feature marked '++' would be counted as 4).

	Intkey	Iden-tifyIt	Lucid	MEKA	Navi-Key	Polly-Clave	XID
Weighted count of features (max. 236)	217	56	133	62	71	92	77
Advantages over conventional keys							
Unrestricted character use ++	Y	Y	Y	Y	Y	Y	Y
Character deletion and changing +	Y	Y	Y*	Y	Y	Y	Y
Error tolerance ++	Y*		Y*				
Locating errors +	Y		*				
Expressing uncertainty ++	Y	*	Y*	y*		Y	y*
Numeric characters ++	Y	*	Y		Y	Y	
Guidance in character selection							
Best characters ++	Y	Y	y*			y*	Y
Separating a taxon +	Y^A		*				y*
Best routes			Y				
Differentiating attributes –			y –*	Y –*			
Removing redundant characters	Y*	Y*	Y*	Y*	Y*		Y*
Removing redundant character states –			y –*		y –*		y –*
Character reliabilities +	Y					Y	Y
Attribute reliabilities +	*						
Searching the character list +	Y		Y			y*	
Recording and matching character values							
Retaining unknowns +++	Y	*	Y	Y	Y	Y	y*
Character dependencies +	Y		y*				
Automatic controlling characters +	Y*						
Gaps for integer numerics +	Y		Y		Y	Y	

	Intkey	Iden-tifyIt	Lucid	MEKA	Navi-Key	Polly-Clave	XID
Text characters	Y				y*	y*	
Special values for keys +	*		y*				
Probabilistic identification +			*				
Inapplicable versus unknown	Y				y*	Y	
Expanded ranges for numerics	y*					y*	
Unknown state values			Y	Y			
Exact characters	Y^A						
Fixing character values	Y^A		Y				
Subsets							
Named subsets of characters +	Y*		Y*	Y*			Y*
Global subsets of characters +	Y*		Y*	Y*			
Local subsets of characters	Y^A						y*
Named subsets of taxa +	Y						
Global subsets of taxa +	Y*						
Local subsets of taxa	Y^A						
Character interpretation							
Character notes +	Y*	y*	Y*				Y*
Glossaries +		*					
Character illustrations +	Y*	y*	y*			Y*	Y*
State selection from illustrations +	Y*	y*	y*				
Images and sounds							
Taxon illustrations +	Y	Y	Y	Y	Y	y*	y*
Taxon illustrations by subject +	Y*	Y*	Y*				
Flexible display of illustrations +	Y	*	*	*	*	*	*
Text with illustrations	Y		Y				Y
Sounds	Y	Y	Y				
Videos	Y	Y	Y				
Running without illustrations	Y*	*	*	*	*	*	*
Linked keys							
Integral hierarchical keys	Y						
Separate hierarchical keys	Y		Y				
Information retrieval							
Searching the taxon names	Y		y*			y*	
Descriptions from the data	Y	Y	Y		Y	Y	Y
Differences between taxa +	Y*	y*	y*				
Similarities between taxa	Y^A*	y*	y*				
Diagnostic descriptions +	Y*						
Taxon retrieval by attributes	Y		y*	*	*	*	*
Control of value matching	Y^A*		y*	y*			y*
Character-value distributions	Y^A						y*
Most similar taxa	*		Y				
Text files attached to taxa	Y	Y	Y				
Data sharing							
Importing DELTA format	Y		y*		Y	Y	
Exporting DELTA format	Y		y*		Y	Y	
Data output	Y^A*						
Links with description writing	Y				Y	Y	
Links with key generation	Y				Y	Y	
Links with classification	Y				Y	Y	

	Intkey	Iden-tifyIt	Lucid	MEKA	Navi-Key	Polly-Clave	XID
Usability							
Online help	Y	y*	y*		y*	y*	Y
Command files or macros	Y		y*	y*			
User-definable toolbar +	Y						
External program text	Y		Y				
Log files	Y[A]		*				
Unlimited data size +	Y	y?*	Y?	Y?	Y?	Y?	Y
Unlimited field lengths	Y*	*	y*	*	Y*	Y*	Y
No special memory requirements	Y	Y	Y	Y	Y	Y	Y
Fast execution +	Y*	Y*	*	Y*	*	*	Y*
Internet capability	Y*				Y*	Y*	
Installation unnecessary	Y			Y			Y

Comparative Table — User Interface

The table shows the number of operations (mainly mouse clicks or double clicks) required for components of an identification. Full details of the operations are given in the Notes, which are linked to the entries in the first column. Separate figures are given for using text only (T) and using illustrations (I). The use of illustrations is particularly important for users who are unfamiliar with the group treated in the key.

In some cases, the number of operations depends on the circumstances. For example, when character states are individually illustrated, it may not be necessary to view all the illustrations. In these cases, the number is given as a range. When changing values of a character, it may be necessary to find the required character in a list. The number of operations required is indeterminate, but in large data sets it would usually be quite large. For simplicity, it has been scored by adding 1 to the upper end of the range, and appending '+'.

For a comparison of the main screens of Intkey and Lucid, see Dallwitz (2000).

	Intkey	IdentifyIt		Lucid		MEKA	Navi-Key	Polly-Clave		XID	
	T or I	T	I	T	I	T	T	T	I	T	I
Start a new identification	1	2	2	2	2	1	1	1	1	1	1
Basic cycle with 'best'	2	3	4–8	3	3–7			4	6	3	6–9
Use a multistate character	2	3	4–10	2	3–9	1	2	4	6	3	6–12
Use a numeric character	3			4	5–7		3	4	6		
Use multiple state values	3			3	5–13	4		5	7	6	9–18
Change state values	3	5–6+	6–11+	2–4+	(4–9+)	3–4+	4+	5–6+	7–8+	4–5+	7–11+
Display character notes	1	1–6		3–6	2–6					2–9	0

Notes

Advantages over conventional keys

Unrestricted character use

No restrictions on the order in which characters can be used (apart from restrictions imposed by 'Character dependencies' — see below).

Intkey. Yes. *IdentifyIt*. Yes. *Lucid*. Yes. *MEKA*. Yes. *NaviKey*. Yes. *PollyClave*. Yes. *XID*. Yes.

Character deletion and changing

Removing characters used in an identification, or changing their values.

Intkey. Yes. *IdentifyIt*. Yes.

Lucid. Yes, but not when using the 'character-graphics' window — see 'Change state values' below.

MEKA. Yes. *NaviKey*. Yes. *PollyClave*. No. *XID*. Yes.

Error tolerance

The ability to reach a correct identification after errors have been made, or if there are errors in the data.

Intkey. The error tolerance can be set manually or automatically (when no taxa match the specimen).

IdentifyIt. No.

Lucid. The error tolerance can only be set manually.

MEKA. No. *NaviKey*. No. *PollyClave*. No. *XID*. No.

Locating errors

When the error tolerance is non-zero, a taxon that differs from the specimen can remain in contention in an identification. The differences may be due to errors by the user, errors in the data, or both. The program should be able to display these differences.

Intkey. Yes. *IdentifyIt*. No.

Lucid. No. There is no direct way find the differences between the specimen and a taxon that is still in the 'taxa remaining' window. It can be done indirectly by reducing the error tolerance to 0, selecting the required taxon in the 'taxa discarded' window (where it can be difficult to find because all the taxa are usually there), and pressing 'why discarded?'.

MEKA. No.

NaviKey. No. *PollyClave*. No. *XID*. No.

Expressing uncertainty

The user can specify uncertainty by entering more than one state value, or a range of numeric values.

Intkey. Yes.

IdentifyIt. No. Selected states are combined with 'and'. Users need to be aware that selecting more than one state will usually lead to an incorrect identification.

Lucid. Yes. Difficult when using character images (a non-default setting is required, and the selected states cannot be seen).

MEKA. Yes. The user has the option of marking states 'present', 'absent', 'or-present', or 'or-absent'. These markings are then combined with 'and'. To express uncertainty, the user must press 'Begin or', mark states 'present' or 'absent' as required, then press 'End or'. Multiple states sometimes cannot be selected from the 'subset' windows (because states are removed from these windows if they do not discriminate between the remaining taxa).

NaviKey. No. *PollyClave*. Yes.

XID. Yes. The user has the option of marking states 'yes', 'no', or 'or'. These markings are then combined with 'and'. To express uncertainty, the user must mark states with 'or'. Users need to be aware that marking more than one state with 'yes' will usually lead to an incorrect identification.

Numeric characters

Using numeric characters directly (without converting to multistate by dividing the values into ranges).

Intkey. Yes.

IdentifyIt. No. Numerical values are stored as multistate characters, although in the identification process the user may enter a numerical value, and the program selects the corresponding state.

Lucid. Yes. *MEKA*. No. *NaviKey*. Yes. *PollyClave*. Yes. *XID*. No.

Guidance in character selection

Best characters

Advice on the most suitable characters for use at any stage of an identification. It is important that numeric characters be included, as they tend to be better than multistate characters.

Intkey. Yes. *IdentifyIt*. Yes.

Lucid. Yes. Numeric characters are not included. There is no indication of which characters do not have any separating power (although these can be removed with a separate command — see 'Removing redundant characters' below). Also, the computation is prohibitively slow for moderately sized data sets (a few hundred characters and taxa) unless only a small number of taxa remain (see Fast execution below).

MEKA. No. *NaviKey*. No.

PollyClave. Yes. There is no indication of which characters do not have any separating power.

XID. Yes.

Separating a taxon

Ranking characters according to how well they separate a given taxon from the rest. This is useful for confirming a tentative identification.

Intkey. Yes. *IdentifyIt*. No.

Lucid. No. The 'Diagnose' option searches only for single attributes that are diagnostic for any of the remaining taxa.

MEKA. No. *NaviKey*. No. *PollyClave*. No.

XID. Yes, but the characters cannot be directly used from the list.

Best routes

Paths, similar to conventional keys, embedded in the interactive key. A path may be followed from the start of an identification; after it is left, ordinary interactive identification is resumed. This provides some guidance in the choice of characters. The method is inherently much less flexible than 'Best characters' (see above), and this limits its usefulness.

Intkey. No. *IdentifyIt*. No. *Lucid*. Yes. *MEKA*. No. *NaviKey*. No. *PollyClave*. No. *XID*. No.

Differentiating attributes

Attributes that are exhibited by only a small number of the remaining taxa. This is not a desirable feature for identification, but it is included here because it is implemented in some programs. These characters tend to be the worst to use in identification, apart from those that do not differentiate the taxa at all.

Intkey. No. *IdentifyIt*. No.

Lucid. Yes. Attributes are listed only if exhibited by only one of the remaining taxa.

MEKA. Yes. Attributes are sorted by the number of remaining taxa that exhibit the attribute.

NaviKey. No. *PollyClave*. No. *XID*. No.

Removing redundant characters

Removing from the list of available characters those that cannot separate the remaining taxa in an identification.

Intkey. Yes. This is done as part of the 'Best characters' computation (see above).

IdentifyIt. Yes. This is done as part of the 'Best characters' computation (see above). The characters are not actually removed, but the separating power is shown as 0.

Lucid. Yes. However, the computation is prohibitively slow for moderately sized data sets (a

few hundred characters and taxa) unless only a small number of taxa remain. Furthermore, there is no way of aborting the calculation once it has started. The implementation is scored 'satisfactory', because execution speed has been scored separately (see Fast execution below).

MEKA. Yes. This is done as part of the 'Differentiating attributes' computation.

NaviKey. Yes. The computation is rather slow (see 'Fast execution' below).

PollyClave. No.

XID. Yes. This is done as part of the 'Best characters' computation (see above).

Removing redundant character states

This is a way of preventing the selection of character states that are not exhibited by any of the remaining taxa in an identification. It can be done either by removing the states entirely from the display, or by greying them (which is preferable, as the user is then aware of the situation). Numeric characters can be treated similarly, by not allowing the entry of values not exhibited by the remaining taxa. This is not a desirable feature for identification, but it is included here because it is implemented in some programs. The feature encourages the user to enter values consistent with the values of previously used characters, thereby hindering the detection and correction of errors.

Intkey. No. *IdentifyIt*. No.

Lucid. Yes. This is combined with the option for 'Removing redundant characters' (see above).

MEKA. No.

NaviKey. Yes. This is combined with the option for 'Removing redundant characters' (see above).

PollyClave. No.

XID. Yes. This is always done automatically.

Character reliabilities

The 'reliability' of a character is a subjective measure, usually supplied by the author, of the character's accuracy and/or ease of use. The 'Best characters' algorithm (see above) should take into account both the separating power of a character, and its reliability. This is especially important with large character lists, so that the user does not have to skip over large numbers of inconvenient or unreliable characters when choosing a character.

Intkey. Yes. *IdentifyIt*. No. *Lucid*. No. *MEKA*. No. *NaviKey*. No. *PollyClave*. Yes. *XID*. Yes.

Attribute reliabilities

An 'attribute' is the value or values of a character for a particular taxon. The 'reliability' of an attribute is a subjective measure, supplied by the author, of the attribute's accuracy and/or ease of

use. It is recorded as a increase or decrease in the overall or average reliability of the character (see 'Character reliabilities' above). Attribute reliabilities allow better performance of the 'Best characters' algorithm (see above).

Intkey. Not yet implemented. See Dallwitz, Paine and Zurcher (1993b, 1993c) for proposals for storing this information in DELTA format.

IdentifyIt. No. *Lucid*. No. *MEKA*. No. *NaviKey*. No. *PollyClave*. No. *XID*. No.

Searching the character list

Finding text strings in the character list.

Intkey. Yes. *IdentifyIt*. No. *Lucid*. Yes. *MEKA*. No. *NaviKey*. No.

PollyClave. Yes, via the Web browser.

XID. No.

Recording and matching character values

Retaining unknowns

Taxa for which a character is not recorded are retained when that character is used (with any value) in an identification.

Intkey. Yes.

IdentifyIt. No. 'Unknown' is treated as an additional state of each character. Missing values in the database will lead to incorrect identifications.

Lucid. Yes. *MEKA*. Yes. *NaviKey*. Yes. *PollyClave*. Yes.

XID. No. There is no distinction between 'unknown' and 'inapplicable'. Missing values are designated 'not specified', and taxa for which a character is 'not specified' are eliminated if the character is scored 'YES' or 'OR'. The author of XID recommends that database authors should treat 'not specified' as 'inapplicable', and code 'all states present' if the values are unknown. Treating 'not specified' as 'unknown' will lead to incorrect identifications.

Character dependencies

Relationships specifying that some characters are inapplicable when other characters take certain values.

Intkey. Yes. *IdentifyIt*. No.

Lucid. Yes. By default, inapplicable characters are automatically removed from the 'available' list. However, dependency relationships in the information entered by the user are not checked, and this can lead to incorrect results. (Also, the Lucid Builder does not check the data for consistency in relation to the dependencies.)

MEKA. No. *NaviKey*. No. *PollyClave*. No. *XID*. No.

Automatic controlling characters

Automatically setting controlling characters to the appropriate value(s) when dependent characters are used. The author must have the option of overriding the automatic setting in the (rare) cases when it would lead to incorrect or inconvenient results. In these cases, the user should be required to use the controlling character before the dependent character.

Intkey. Yes. *IdentifyIt*. No. *Lucid*. No. *MEKA*. No. *NaviKey*. No. *PollyClave*. No. *XID*. No.

Gaps for integer numerics

The possibility of gaps in recorded values for integer numeric characters, e.g. '5 or 10' distinguishable from '5 to 10'.

Intkey. Yes. *IdentifyIt*. No. *Lucid*. Yes. *MEKA*. No. *NaviKey*. Yes. *PollyClave*. Yes. *XID*. No.

Text characters

Storing and searching free-text information about taxa.

Intkey. Yes. *IdentifyIt*. No. *Lucid*. No. *MEKA*. No.

NaviKey. Stored, but not searchable.

PollyClave. Stored, but not searchable.

XID. No.

Special values for keys

Flagging values in the data for use only in keys. This would be done for values which are not strictly exhibited by a taxon, but which a user might be likely to assign erroneously to a specimen belonging to the taxon. The use of these values should be under the control of the user of the key, as the true values give better discrimination.

Intkey. Not yet implemented. See Dallwitz, Paine and Zurcher (1993b, 1993c) for proposals for storing this information in DELTA format.

IdentifyIt. No.

Lucid. Yes, except for numeric characters.

MEKA. No. *NaviKey*. No. *PollyClave*. No. *XID*. No.

Probabilistic identification

Using probabilities of state values in the taxa, and probabilities of user errors, to calculate the probabilities that the specimen belongs to a given taxon.

Intkey. No. *IdentifyIt*. No.

Lucid. No. Taxa having state values designated as 'rare' are sorted to the end of the list of remaining taxa.

MEKA. No. *NaviKey*. No. *PollyClave*. No. *XID*. No.

Inapplicable versus unknown

Distinguishing inapplicable values, including those not resulting from character dependencies, from unknown values.

Intkey. Yes. *IdentifyIt*. No. *Lucid*. No. *MEKA*. No.

NaviKey. Inapplicables *not* resulting from dependencies are distinguished, but those resulting from dependencies are treated as unknown.

PollyClave. No.

XID. No. Missing values are designated 'not specified'. The author of XID recommends that database authors should treat 'not specified' as 'inapplicable', and code 'all states present' if the values are unknown.

Expanded ranges for numerics

Expanding the range of values recorded for a numeric character that has been poorly sampled in a taxon.

Intkey. Single numeric values in the data can be transformed to a range during the translation from DELTA to Intkey format. However, the original value is not available to the Intkey user for other purposes.

IdentifyIt. No. *Lucid*. No. *MEKA*. No. *NaviKey*. No.

PollyClave. As for Intkey.

XID. No.

Unknown state values

Recording individual state values of multistate characters (as opposed to the character as a whole) as unknown.

Intkey. No. *IdentifyIt*. No. *Lucid*. Yes. *MEKA*. Yes. *NaviKey*. No. *PollyClave*. No. *XID*. No.

Exact characters

Specifying characters whose values are assumed not be subject to error.

Intkey. Yes. The feature is used in two ways in Intkey. Firstly, exact characters are not subject to the 'Error tolerance' mechanism (see above). Secondly, if the user enters a value for a controlling character that has been specified as exact, then all dependent values that are inconsistent with the specified controlling value are effectively removed from the data matrix.

IdentifyIt. No. *Lucid*. No. *MEKA*. Yes. *NaviKey*. No. *PollyClave*. No. *XID*. No.

Fixing character values

Specifying character values that are not to be cleared when a new identification is started. This is convenient when identifying several specimens that are known (or thought) to share some attributes, usually the place of origin or belonging to a higher taxon.

Intkey. Yes. *IdentifyIt*. No. *Lucid*. Yes. *MEKA*. No. *NaviKey*. No. *PollyClave*. No. *XID*. No.

Subsets

Named subsets of characters

A mechanism for naming subsets of the characters.

Intkey. Yes. Can be defined by the author or the user.

IdentifyIt. No.

Lucid. Yes. Must be defined by the author.

MEKA. Yes. Must be defined by the author.

NaviKey. No. *PollyClave*. No.

XID. Yes. Must be defined by the author.

Global subsets of characters

Specifying subsets of characters to which all subsequent operations will be restricted.

Intkey. Yes. Characters can be restricted to the sets named by the author or the user, or to sets made up of any combinations of the named sets and individual characters or characters selected by the user.

IdentifyIt. No.

Lucid. Yes. Characters can be restricted to one of the sets defined by the author.

MEKA. Yes. Characters can be restricted to one of the sets defined by the author.

NaviKey. No. *PollyClave*. No. *XID*. No.

Local subsets of characters

Specifying subsets of characters for a single operation.

Intkey. Yes. *IdentifyIt*. No. *Lucid*. No. *MEKA*. No. *NaviKey*. No. *PollyClave*. No.

XID. Yes. Available only for selecting characters (as arranged in the data) in an identification. The 'best' operation cannot be applied to a subset.

Named subsets of taxa

A mechanism for naming subsets of the taxa.

Intkey. Yes. Can be defined by the author or the user.

IdentifyIt. No. *Lucid*. No. *MEKA*. No. *NaviKey*. No. *PollyClave*. No. *XID*. No.

Global subsets of taxa

Specifying subsets of taxa to which all subsequent operations will be restricted.

Intkey. Yes. Taxa can be restricted to the sets named by the author or the user, or to sets made up of any combinations of the named sets and individual characters or taxa selected by the user.

IdentifyIt. No. *Lucid*. No. *MEKA*. No. *NaviKey*. No. *PollyClave*. No. *XID*. No.

Local subsets of taxa

Specifying subsets of taxa for a single operation.

Intkey. Yes. *IdentifyIt*. No. *Lucid*. No. *MEKA*. No. *NaviKey*. No. *PollyClave*. No. *XID*. No.

Character interpretation

Character notes

Extensive text to aid interpretation of characters conveniently available within the system.

Intkey. Yes. Notes are attached to characters.

IdentifyIt. Yes. Notes are attached to individual states, rather than to the character as a whole, and are available only as an alternative to images.

Lucid. Yes. Notes are attached to individual states, rather than to the character as a whole.

MEKA. No. *NaviKey*. No. *PollyClave*. No.

XID. Yes. Notes may be attached to both characters and individual states.

Glossaries

Linking definitions to words in the database.

Intkey. No.

IdentifyIt. No. Only words in descriptions are linked to the glossary. Words in the character list (that is, in the 'identify', 'examine', and 'compare' modules) are not linked.

Lucid. No. *MEKA*. No. *NaviKey*. No. *PollyClave*. No. *XID*. No.

Character illustrations

Displaying illustrations of characters.

Intkey. Yes. Characters and individual states can be illustrated, and there is no limit to the number of images.

IdentifyIt. Yes. Only individual states can be illustrated, and there can be only one image per state. Simultaneous display of state illustrations is not possible. Sequential display is cumbersome: a state must be selected to view its illustration, and then deselected before viewing another (the *first* selected state is illustrated).

Lucid. Yes. Only individual states can be illustrated, and there can be only one image per state. Simultaneous display of state illustrations is cumbersome to impossible. Thumbnails of all the state images can be displayed simultaneously via the 'information' button next to the 'feature' line in the 'characters available' list. To view the thumbnails at full size, they must be dragged one by one onto a 'projector' icon. Depending on the number of states and the size of the images, it may then be possible to manually arrange the images so that all are visible. Alternatively, each state illustration may be displayed via the 'information' button next to the 'state' line in the 'characters available' list, and then manually arranged.

MEKA. No. *NaviKey*. No.

PollyClave. Yes. Only one image per character.

XID. Yes. Characters and individual states can be illustrated, each with a single image.

State selection from illustrations

Selecting character state values from illustration screens during identification.

Intkey. Yes. All states are normally illustrated in a single image, which may be of any size. If the image is too large for the screen, it is automatically scaled to fit (the user has the option of turning off the scaling and scrolling to view the entire image). Any number of states may be selected or deselected by clicking on the appropriate text or part of the image.

In the example below, state 1 was selected first, and state 3 has just been selected. The cursor is still over the part of the image corresponding to state 3, and this part is consequently surrounded by a box.

Note the flexibility of the layout, and the potentially unlimited space available for the text. The text and buttons are not part of the image, but are superimposed when the image is displayed. The text is normally taken directly from the character list, but it may be modified, as exemplified by the words '(not illustrated)' in state 6.
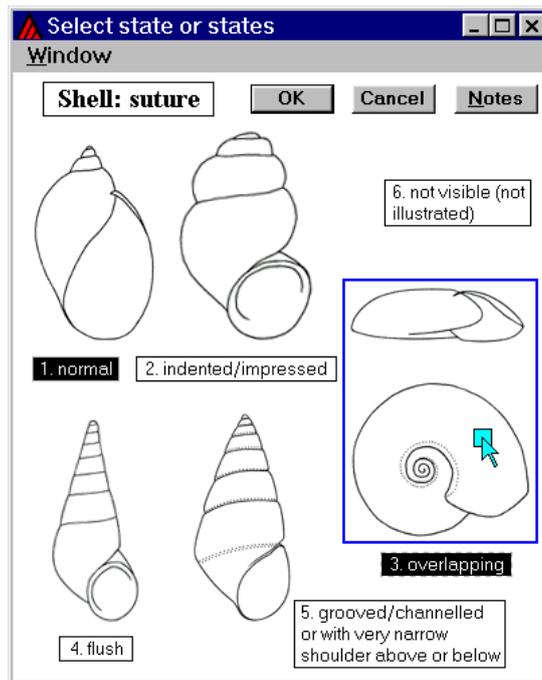

IdentifyIt. Yes. States are illustrated individually, and can only be viewed one at a time. The window is of fixed size. A state must be selected to view its illustration, and then deselected before viewing another.

In the example below, note the abbreviations in the feature and state text; these are necessary because of the limited space available. The expanded text on the image is part of the image itself.
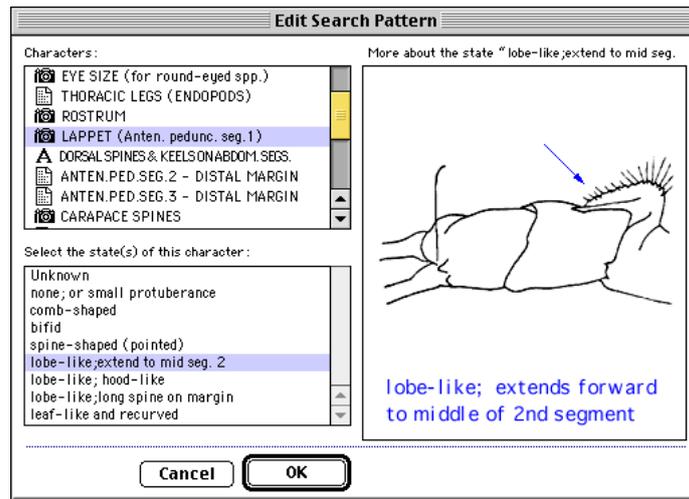
Lucid. Yes. The character-graphics window is of fixed size, and reserves space for 15 thumbnail images (the maximum number of states in Lucid is 15). Multiple selection is awkward: a non-default setting is required, and the selected states cannot be seen, or changed once selected. The space available under each thumbnail for the state description is often too small; moving the cursor over the thumbnail displays more (but not necessarily all) of the state description at the bottom of the window. Selection is not possible from the full-sized versions of the illustrations, and full-sized illustrations that have been displayed must be individually closed.

In the example below, the thumbnails were generated automatically from the full-sized images; their quality could have been improved by creating them individually with an image editor. The thumbnail of the third state has been dragged onto the projector icon to produce the full-sized version, which has then been dragged aside. Note the limited space available for text below the thumbnails, and in the title bar of the full-sized image. The cursor is over the thumbnail of the fifth state, whose full text is consequently shown at the bottom of the window. To allow selection of more than one state, it is necessary to check 'Don't skip' (at the bottom right of the window).
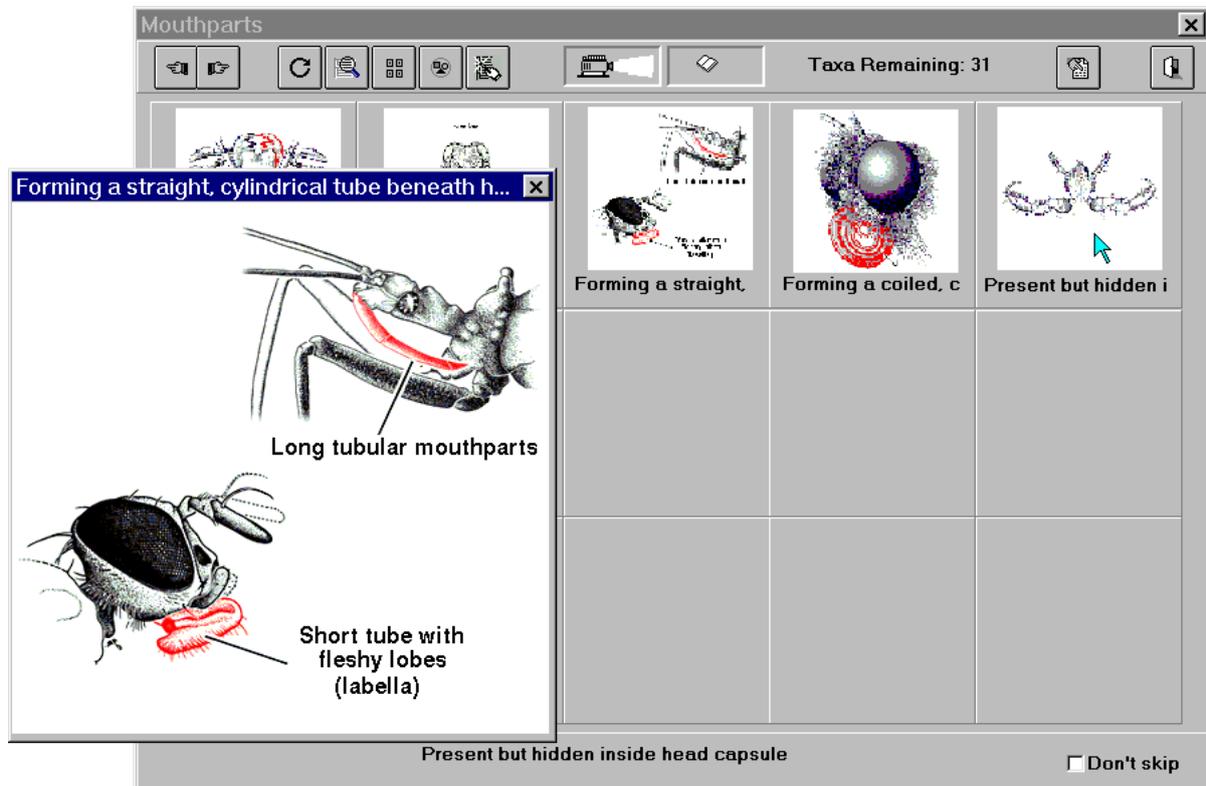
MEKA. No. NaviKey. No. PollyClave. No. XID. No.

Images and sounds

Taxon illustrations

Displaying illustrations of taxa.

Intkey. Yes. *IdentifyIt*. Yes. *Lucid*. Yes. *MEKA*. Yes. *NaviKey*. Yes.

PollyClave. Yes. Only one image per taxon.

XID. Yes. Only one image per taxon.

Taxon illustrations by subject

Selecting illustrations of taxa by subject (for example, flowers, habitat, distribution map).

Intkey. Yes. When images are requested directly, the first image is displayed. The subject menu and other menus relating to image display (for example, for displaying multiple images) are in the image window. Alternatively, the 'information' option can be used to open a window from which images and other material can be selected by subject.

IdentifyIt. Yes. Double-clicking on a taxon name opens an information window with several tabs. The multimedia tab contains a list of subjects.

Lucid. Yes. When the 'information' button is pressed, a menu is presented for selecting 'notes' or 'images'; submenus allow selection by subject. This procedure must be repeated to select another subject. From the image window, only sequential viewing is possible.

MEKA. No. *NaviKey*. No. *PollyClave*. No. *XID*. No.

Flexible display of illustrations

Illustrations of any size can be scaled, scrolled, repositioned, displayed simultaneously, and tiled or cascaded. All images can be closed with a single operation.

Intkey. Yes.

IdentifyIt. No. The entire image window can be zoomed in and out, in multiples of 2. Simultaneous display of images is cumbersome: they must be selected one by one, and manually positioned. Tiling and cascading are not possible. Images must be closed one by one.

Lucid. No. The image window cannot be resized, and scaling and scrolling are not possible. Consequently images larger than the screen dimensions cannot be viewed in their entirety. Simultaneous display of images is cumbersome: they must be selected one by one, and manually positioned (within the limitations imposed by the absence of scaling facilities). Tiling and cascading are not possible. The images are always on top of other applications. Images must be closed one by one.

MEKA. No. Illustrations are displayed one at a time. The image window can be resized, but this is of no value as the image cannot be scaled or scrolled.

NaviKey. No. Illustrations can be resized, scrolled, and displayed simultaneously.

PollyClave. No. Images can be scrolled and displayed simultaneously via Web browser features.

XID. No. Illustrations are displayed one at a time. The window, which also contains any text associated with the taxon, can be resized and scrolled, and the image can be scaled to fit within the window.

Text with illustrations

Text can be associated with illustrations (instead of being built into the illustrations).

Intkey. Yes. *IdentifyIt*. No. *Lucid*. Yes. *MEKA*. No. *NaviKey*. No. *PollyClave*. No. *XID*. No.

Sounds

Sounds can be attached to characters and taxa.

Intkey. Yes. *IdentifyIt*. Yes. *Lucid*. Yes. *MEKA*. No. *NaviKey*. No. *PollyClave*. No. *XID*. No.

Videos

Videos can be attached to characters and taxa.

Intkey. Yes. *IdentifyIt*. Yes. *Lucid*. Yes. *MEKA*. No. *NaviKey*. No. *PollyClave*. No. *XID*. No.

Running without illustrations

A package normally containing illustrations can run well without them.

Intkey. Yes. The presence or absence of each image is automatically detected, and appropriate action taken (associated menu items and buttons are greyed, and automatic display of the image is not attempted).

IdentifyIt. No. A space is still reserved for character images. Attempting to access a missing taxon image causes an error message.

Lucid. No. The character image screens still appear, and contain the message 'Not illustrated'. Attempting to access a missing taxon image causes an error message.

MEKA. No. Attempting to access a missing image causes an error message.

NaviKey. No. Attempting to access a missing image produces an empty window.

PollyClave. No. Attempting to access a missing image causes an error message

XID. No. Attempting to access a missing image causes an error message.

Linked keys

Integral hierarchical keys

Having keys for different taxonomic levels within a single data matrix.

Intkey. Yes. *IdentifyIt*. No. *Lucid*. No. *MEKA*. No. *NaviKey*. No. *PollyClave*. No. *XID*. No.

Separate hierarchical keys

Linking taxa to other keys (for example, a genus linked to a key to the species of the genus).

Intkey. Yes. *IdentifyIt*. No. *Lucid*. Yes. *MEKA*. No. *NaviKey*. No. *PollyClave*. No. *XID*. No.

Information retrieval

Searching the taxon names

Finding text strings in the taxon names and, optionally, the synonyms and common names.

Intkey. Yes. *IdentifyIt*. No.

Lucid. Yes. Searching by accepted names only (not synonyms).

MEKA. No. *NaviKey*. No.

PollyClave. Yes, via the Web browser.

XID. No.

Descriptions from the data

Displaying descriptions generated directly from the data used in identification.

Intkey. Yes. *IdentifyIt*. No. *Lucid*. No. *MEKA*. No. *NaviKey*. Yes. *PollyClave*. Yes. *XID*. Yes.

Differences between taxa

Finding the differences between members of a set of taxa.

Intkey. Yes. The meaning of a 'difference' is controlled by a 'matching' parameter — see 'Control of value matching' below.

IdentifyIt. Yes. Applies only to pairs of taxa, and limited by the available options for 'matching' descriptions (see below). It is combined with the 'similarities' option: the output must be scanned visually to find the differences and similarities.

Lucid. Yes. Applies only to all of the 'remaining' taxa, limited to at most 20 taxa, and limited by the available options for 'matching' descriptions (see 'Control of value matching' below).

MEKA. No. *NaviKey*. No. *PollyClave*. No. *XID*. No.

Similarities between taxa

Whether the program can find the similarities between members of a set of taxa.

Intkey. Yes. The meaning of a 'similarity' is controlled by a 'matching' parameter — see 'Control of value matching' below.

IdentifyIt. Yes. Applies only to pairs of taxa, and limited by the available options for 'matching' descriptions (see 'Control of value matching' below). It is combined with the 'differences' option: the output must be scanned visually to find the differences and similarities.

Lucid. Yes. Applies only to all of the 'remaining' taxa, limited to at most 20 taxa, and limited by the available options for 'matching' descriptions (see 'Control of value matching' below).

MEKA. No. *NaviKey*. No. *PollyClave*. No. *XID*. No.

Diagnostic descriptions

Finding diagnostic descriptions. A diagnostic description for a taxon matches that taxon, but differs from all the other taxa in at least one respect.

Intkey. Yes. The diagnostic description uses only characters not already used in an identification that is in progress. The strength of the diagnosis can be set, that is, the description can be required to differ from the other taxa in more than one respect. Also, the description can be 'specimen diagnostic' or 'taxon diagnostic'; in the latter, characters that are sometimes (but not always) inapplicable to some taxa may be used.

IdentifyIt. No. *Lucid*. No. *MEKA*. No. *NaviKey*. No. *PollyClave*. No. *XID*. No.

Taxon retrieval by attributes

Finding all taxa that have certain attributes or combinations of attributes. It must be possible to eliminate taxa for which the attribute is unknown or inapplicable.

Intkey. Yes. *IdentifyIt*. No.

Lucid. Yes. Limited by the available options for 'matching' queries to the data (see 'Control of value matching' below).

MEKA. No. 'Unknowns' cannot be eliminated.

NaviKey. No. 'Unknowns' cannot be eliminated.

PollyClave. No. 'Unknowns' cannot be eliminated.

XID. No. It is recommended that 'unknowns' should be coded as 'all states present', and they therefore cannot be eliminated.

Control of value matching

Control by the user over which values or pseudovalues are deemed to match other values:

exact, subset, overlap, unknown, inapplicable. See Dallwitz, Paine and Zurcher (1995) or online Intkey documentation for details).

Intkey. Yes. *IdentifyIt*. No.

Lucid. Only overlap and unknown.

MEKA. Only overlap (combining states with 'or') or subsets (combining states with 'and').

NaviKey. No. *PollyClave*. No.

XID. Overlap (combining states with 'or'), subsets (combining states with 'and'), and exact ('only' – equivalent to scoring the required states 'yes', and all the rest 'never').

Character-value distributions

Displaying the distribution of character values within a set of taxa.

Intkey. Yes. *IdentifyIt*. No. *Lucid*. No. *MEKA*. No. *NaviKey*. No. *PollyClave*. No.

XID. Yes. Available only for the 'remaining' taxa.

Most similar taxa

Ranking taxa by their similarity to a given taxon.

Intkey. No. Available in other programs in the DELTA System.

IdentifyIt. No. *Lucid*. Yes.

MEKA. No. *NaviKey*. No. *PollyClave*. No. *XID*. No.

Text files attached to taxa

Text files containing information about taxa.

Intkey. Yes. *IdentifyIt*. Yes. *Lucid*. Yes. *MEKA*. No. *NaviKey*. No. *PollyClave*. No.

Data sharing

Importing DELTA format

Using DELTA-format data to generate the interactive identification system.

Intkey. Yes. *IdentifyIt*. No.

Lucid. Yes, but the number of states is limited to 15, text characters are not supported, missing data are incorrectly imported, and dependencies cannot be imported.

MEKA. No. *NaviKey*. Yes. *PollyClave*. Yes. *XID*. No.

Exporting DELTA format

Exporting DELTA-format data from the interactive key, or from the system that generates the key.

Intkey. Yes. *IdentifyIt*. No.

Lucid. Yes, but character dependencies cannot be exported.

MEKA. No. *NaviKey*. Yes. *PollyClave*. Yes. *XID*. No.

Data output

Output of program results in forms suitable for input to other programs.

Intkey. Lists of character and taxon numbers, DELTA descriptions of individual taxa, combined DELTA descriptions of groups of taxa, diagnostic characters, differences and similarities between taxa.

IdentifyIt. No. *Lucid*. No. *MEKA*. No. *NaviKey*. No. *PollyClave*. No. *XID*. No.

Links with description writing

Generating publication-quality descriptions from the same data that are used to construct the identification system.

Intkey. Yes. *IdentifyIt*. No. *Lucid*. No. *MEKA*. No. *NaviKey*. Yes. *PollyClave*. Yes. *XID*. No.

Links with key generation

Generating conventional keys from the same data that are used to construct the identification system.

Intkey. Yes. *IdentifyIt*. No. *Lucid*. No. *MEKA*. No. *NaviKey*. Yes. *PollyClave*. Yes. *XID*. No.

Links with classification

Carrying out cladistic and phenetic analyses from the same data that are used to construct the identification system.

Intkey. Yes. *IdentifyIt*. No. *Lucid*. No. *MEKA*. No. *NaviKey*. Yes. *PollyClave*. Yes. *XID*. No.

Usability

Online help

Complete, context-sensitive, built-in help.

Intkey. Yes.

IdentifyIt. Yes. Apart from balloon hints, help is not context sensitive.

Lucid. Yes. Help is not context-sensitive.

MEKA. No.

NaviKey. Yes. Help is not context-sensitive.

PollyClave. Yes. Help is not context-sensitive.

XID. Yes.

Command files or macros

A mechanism for storing and repeating a series of operations.

Intkey. Yes. *IdentifyIt*. No.

Lucid. Yes. Limited to carrying out a single identification sequence.

MEKA. Yes. Limited to carrying out a single identification sequence. (However, it was not working in the version tested).

NaviKey. No. *PollyClave*. No. *XID*. No.

User-definable toolbar

The author or user can define toolbar buttons for easy access to commonly used operations or groups of operations.

Intkey. Yes. *IdentifyIt*. No. *Lucid*. No. *MEKA*. No. *NaviKey*. No. *PollyClave*. No. *XID*. No.

External program text

The program text (commands, help, messages, etc.) is external to the program, allowing easy creation and use of different language versions.

Intkey. Yes. *IdentifyIt*. No. *Lucid*. Yes. *MEKA*. No. *NaviKey*. No. *PollyClave*. No. *XID*. No.

Log files

Creating a file showing the history (input and output) of a session.

Intkey. Yes. *IdentifyIt*. No.

Lucid. The log file shows only part of the input, and no output.

MEKA. No. *NaviKey*. No. *PollyClave*. No. *XID*. No.

Unlimited data size

The numbers of taxa, characters, and states are unlimited.

Intkey. Yes. *IdentifyIt*. Yes?

Lucid. Yes (?), except for number of states, which is limited to 15.

MEKA. Yes? *NaviKey*. Yes? *PollyClave*. Yes? *XID*. Yes.

Unlimited field lengths

The lengths of fields (for example, taxon names, text of characters, character notes) are unlimited.

Intkey. In list boxes (for example, for taxon or state selection), text is limited to one line, typically almost the full width of the screen, and the system font is used. (In Advanced Mode, the full text can be displayed in a separate window.) When text boxes are overlaid on images (for example, for state selection), the author controls the size of the box and of the font. If the text does not fit, it may be scrolled by the user. In all other contexts (for example, descriptions and differences) there are no limits.

IdentifyIt. The space available for display of most fields is very limited (for example, about 25 lower-case letters for the state description in the main window), which leads to excessive use of abbreviations and/or truncation of text.

Lucid. In the main window, text is limited to one line, typically almost half the width of the screen, and the font is under user control; up to about 130 characters of the currently active line is shown in a box at the bottom of the screen. In the window for state selection from images, the 'feature' line is displayed in the window's title bar, and the space available for state descriptions is limited to about 20 characters; up to about 100 characters of the currently active state is shown in a box at the bottom of the screen. In other contexts (for example, descriptions) long text is truncated.

The maximum length of the character list (including a separate copy of the 'feature' with each state) is 64KB. The program fails without warning if this limit is exceeded.

MEKA. Taxon names are limited to 40 characters, and character+state descriptions are limited to 80 characters.

NaviKey. Yes. All text is viewable via horizontal scrolling.

PollyClave. Yes. Text is wrapped by the Web browser.

XID. Yes.

No special memory requirements

The program will run with the minimum amount of memory normally needed to run the operating system.

Intkey. Yes. *IdentifyIt*. Yes. *Lucid*. Yes. *MEKA*. Yes. *NaviKey*. Yes. *PollyClave*. Yes. *XID*. Yes.

Fast execution

The figures given below are for a 133MHz Pentium. The Internet connection was running at about 15Kbytes per second.

Intkey. Yes. Simple operations such as using a character in an identification take less than 0.5 seconds. When calculating the 'Best' characters for an identification, the characters found so far are displayed after 2 seconds, and the rest after the calculation is complete. The characters are examined in descending order of character reliability, so a suitable character is almost always available within the first 2 seconds. With a data matrix containing 582 characters and 584 taxa, about 320 characters were processed in this initial period.

When running the same data from the Internet, program startup and downloading took 50 seconds. (Thereafter the program works entirely locally, except for downloading images when required.)

IdentifyIt. Yes.

Lucid. Simple operations are fast, but those that involve scanning fairly large amounts of data are unacceptably slow. With a data matrix containing 582 characters and 584 taxa, calculating and sorting the 'Best' characters took 488 seconds (423 for calculation and 65 for sorting), and removing redundant characters from the list (see 'Removing redundant characters' above) took 530 seconds. The user must wait until the process is finished before characters can be used. Because of this slowness, the documentation recommends not using 'Best' until the number of taxa has been reduced. However, this leaves the user without guidance during the initial stages of an identification. The calculation of the similarities and differences between 9 taxa in the same data set took 620 seconds.

MEKA. Yes. The slowest operation is 'Mismatch', which displays the eliminated taxa with the number of mismatches for each. With a data matrix containing 180 characters and 411 taxa, this operation took 20–25 seconds (depending on the number of taxa eliminated). However, this operation is seldom needed in identification.

NaviKey. No. This program uses Java applets. The 'standalone' version (i.e. running entirely in the user's computer, without special software running in the Web server) was tested. This loads the data from DELTA files when the program is started. Working from a local hard disk, loading the applets and a data matrix containing 582 characters and 584 taxa took 105 seconds. Working from the Internet, the same operations took 230 seconds. Other operations take the same time whether running locally or from the Internet. The program has a feature, 'selection list intelligence', which removes redundant characters from the list (see 'Removing redundant characters' above). With this feature off, using a character took 10 seconds; with it on, it took 65 seconds.

The program has a client/server mode, which was not tested. In this mode, startup time would be greatly reduced.

PollyClave. No. This program uses HTML forms on the client, and all processing is done on the server. The response time is mainly determined by the speed with which the user's input and the program's responses can be transmitted over the Internet. Only small data sets are available on the Internet. The response times for these are typical of small Internet transactions — about 2–4 seconds. With a data matrix of about 500 characters and 500 taxa, I estimate that loading the character list would take about 20 seconds. This operation may be required at each cycle of the identification, but the browser's 'back' button can be used in some circumstances (even that would take 8 seconds). In each cycle, states may be selected from 1 or more characters, though using

several characters without the guidance of 'Best' will increase the chance of errors. After states have been selected, it would take about 7 seconds for the program to respond with the list of remaining taxa.

XID. Yes.

Internet capability

Whether the program can access data, images, and other information over the Internet.

Intkey. Yes. The data are downloaded in compressed form at the start of a session, and may be saved on the local computer for future use (in addition to the caching provided by the operating system). Character and taxon images, and other files attached to taxa, are downloaded as required.

IdentifyIt. No. *Lucid*. No. *MEKA*. No.

NaviKey. Yes. Mainly intended as a WWW application, but can also be run locally.

PollyClave. Yes. WWW application only.

XID. No.

Installation unnecessary

Whether the program can be run directly from a CD-ROM, without installation.

Intkey. Yes. Also, an Intkey package on CD can be installed on the hard disk simply by copying the complete directory tree. It is also easy to put some of the package on the hard disk, and access bulky and less frequently used parts, such as the taxon images, from the CD.

IdentifyIt. No. *Lucid*. No. *MEKA*. Yes. *NaviKey*. No. *PollyClave*. No. *XID*. Yes.

Details of user interface

Start a new identification

Intkey. Press 'Start a new identification'.

IdentifyIt. Press 'Clear', and confirm (press 'OK').

Lucid. Press 'Restart', and confirm (press 'Yes').

MEKA. Press 'Reset'.

NaviKey. Press 'Remove all'.

PollyClave. Press 'New specimen'.

XID. Press 'Reset XID'.

Basic cycle with 'best'

The usual basic cycle of an identification consists of ranking the characters in order of their suitability at the current stage of the identification, selecting a character, and selecting a character state (or entering a numeric value). For the calculation of the number of operations, it is assumed that the character has two states.

Intkey. Click on the required character. Double click on the required state.

IdentifyIt. The default character order is the 'entry order' in the database. To use 'Best' order, press 'Sort', select 'Characters > Separation Coefficients > Descending', and press 'OK'. This setting persists during the session until changed. *Text only*. Press 'Add'. Click on the required character. Click on the required state. Press 'OK. *Illustrations*. Press 'Add'. Click on the required character. To see a state illustration, click on the state, and click again to clear the illustration pane and the state selection if necessary (1–4 operations; state notes are also displayed). Click on the required state if it is not already selected, and press 'OK'.

Lucid. Text only. Press 'Best'. Click on the required character. Double click on the required state (or drag the state to the 'Character states chosen' pane). *Illustrations*. Press 'Best'. Click on the 'i' button adjacent to the required character. Thumbnails of the illustrations are displayed. As necessary, drag the thumbnails onto the 'projector' icon to view the images at full size, and close these image windows (up to 4 operations). Double click on the required character state.

MEKA. No 'best' option.

NaviKey. No 'best' option.

PollyClave. Text only. Press 'Rank characters'. Check the required character state. Click on 'Skip to Show Taxa. Press 'Show taxa matching selections'. *Illustrations*. Press 'Rank characters'. Click on the image link. Press 'Back'. Check the required character state. Click on 'Skip to Show Taxa. Press 'Show taxa matching selections'.

XID. Text only. Press 'Analysis'. Double click on the required character. Double click on the required state. *Illustrations*. Press 'Analysis'. Double click on the required character. To see a state illustration, click on the state, press 'Selection help', and press 'Close' (3–6 operations; state notes are automatically displayed). Double click on the required state.

Use a multistate character

Select a character and select a character state. For the calculation of the number of operations, it is assumed that the character has three states.

Intkey. Click on the required character. Double click on the required state.

IdentifyIt. Text only. Press 'Add'. Click on the required character. Click on the required state. Press 'OK'. *Illustrations*. Press 'Add'. Click on the required character. To see a state illustration, click on the state, and click again to clear the illustration pane and the state selection if necessary (1–6 operations; state notes are also displayed). Click

on the required state if it is not already selected, and press 'OK'.

Lucid. Text only. Click on the required character. Double click on the required state (or drag the state to the 'Character states chosen' pane). *Illustrations*. Press the 'i' button adjacent to the required character. Thumbnails of the illustrations are displayed. As necessary, drag the thumbnails onto the 'projector' icon to view the images at full size, and close these image windows (up to 6 operations). Double click on the required character state. Close the character-graphics window.

MEKA. Text only. Double click on the required character state. *Illustrations*. Not available.

NaviKey. Text only. Double click on the required character. Double click on the required state. *Illustrations*. Not available.

PollyClave. Text only. Check the required character state. Click on 'Skip to Show Taxa. Press 'Show taxa matching selections'. Press 'Back'. *Illustrations*. Click on the image link. Press 'Back'. Check the required character state. Click on 'Skip to Show Taxa. Press 'Show taxa matching selections'. Press 'Back'.

XID. Text only. Double click on the required character. Double click on the required state. Press 'Close'. *Character illustration*. Click on the required character. Press 'Selection help' (character notes are automatically displayed). Press 'Close'. Double click on the character. Double click on the required state. Press 'Close'. *State illustrations*. Double click on the required character. To see a state illustration, click on the state, press 'Selection help', and press 'Close' (3–9 operations; state notes are automatically displayed). Double click on the state. Press 'Close'.

Use a numeric character

Select a numeric character and enter a value or values.

Intkey. Click on the required character. Type the value or values. Press 'Enter' or 'OK'.

IdentifyIt. Numeric characters are not available.

Lucid. Text only. Click on the required character. Double click on the '#' line (or drag it to the 'Character states chosen' pane). Type the value or values. Press 'Enter' or 'Tick'. *Illustrations*. Press the 'i' button adjacent to the required character. A thumbnail of the illustration is displayed. If necessary, drag the thumbnail onto the 'projector' icon to view the image at full size, and close the image window (up to 2 operations). Double click on the thumbnail. Type the value or values. Press 'Enter' or 'Tick'. Close the character-graphics window.

MEKA. Numeric characters are not available.

NaviKey. *Text only*. Double click on the required character. Type the value or values. Press 'Add'. *Illustrations*. Not available.

PollyClave. *Text only*. Type the value or values. Click on 'Skip to Show Taxa. Press 'Show taxa matching selections'. Press 'Back'. *Illustrations*. Click on the image link. Press 'Back'. Type the value or values. Click on 'Skip to Show Taxa. Press 'Show taxa matching selections'. Press 'Back'.

XID. Numeric characters are not available.

Use multiple state values

Select a character and select two character states. For the calculation of the number of operations, it is assumed that the character has four states.

Intkey. Click on the required character. Click on the first state. Double click on the second state.

IdentifyIt. Not possible for the normal purpose of expressing uncertainty, because the states are always combined with 'and'.

Lucid. *Text only*. Click on the required character. Double click on the required states. *Illustrations*. Press the 'i' button adjacent to the required character. Thumbnails of the illustrations are displayed. As necessary, drag the thumbnails onto the 'projector' icon to view the images at full size, and close these image windows (up to 8 operations). Check 'Don't skip' (at the bottom right of the window). Double click on the required character states. Close the character-graphics window.

MEKA. *Text only*. Press 'Begin Or'. Double click on the required states. Press 'End Or'. *Illustrations*. Not available.

NaviKey. Not possible.

PollyClave. *Text only*. Check the required character states. Click on 'Skip to Show Taxa. Press 'Show taxa matching selections'. Press 'Back'. *Illustrations*. Click on the image link. Press 'Back'. Check the required character states. Click on 'Skip to Show Taxa. Press 'Show taxa matching selections'. Press 'Back'.

XID. *Text only*. Double click on the required character. Click on the first state. Press 'Mark Or'. Click on the second state. Press 'Quit OR Marking'. Press 'Close'. *Character illustration*. Click on the required character. Press 'Selection help' (character notes are automatically displayed). Press 'Close'. Double click on the character. Click on the first state. Press 'Mark Or'. Click on the other state. Press 'Quit OR Marking'. Press 'Close'. *State illustrations*. Double click on the required character. To see a state illustration, click on the state, press 'Selection help', and press 'Close' (3–12 operations; state notes are automatically displayed). Click on the first state.

Press 'Mark Or'. Click on the other state. Press 'Quit OR Marking'. Press 'Close'.

Change state values

Change the previously entered values of a multistate character. For the calculation of the number of operations, it is assumed that the character has two states.

Intkey. Click on the required character. Click on the previously selected state. (The previously selected state or states are initially highlighted; clicking de-selects them.) Double click on the new state.

IdentifyIt. *Text only*. Click on the previously entered attribute. Press 'Remove'. Press 'Add'. If necessary, scroll to the required character. (This will usually be necessary.) Click on the required character. Click on the new state. Press 'OK'. *Illustrations*. Click on the previously entered attribute. Press 'Remove'. Press 'Add'. If necessary, scroll to the required character. Click on the required character. To see a state illustration, click on the state, and click again to clear the illustration pane and the state selection if necessary (1–4 operations; state notes are also displayed). Click on the required state if it is not already selected, and press 'OK'.

Lucid. *Text only*. If necessary, scroll to the required character in the 'Characters available' window. (This will usually be necessary if the character was not the last one used.) If necessary, click on the required character. (This will be necessary if the character was not the last one used, or if it was used directly with illustrations.) Double click on the previously selected attribute in the 'Character states chosen' window. Double click on the new state in the 'Characters available' window. *Illustrations*. Not possible from the 'character-graphics' window. The illustrations could be viewed, and then the changes made in text mode, as follows. If necessary, scroll to the required character in the 'Characters available' window. Click on the 'i' button adjacent to the required character. Thumbnails of the illustrations are displayed. As necessary, drag the thumbnails onto the 'projector' icon to view the images at full size, and close these image windows (up to 4 operations). Press 'Close'. Double click on the previously selected attribute in the 'Character states chosen' window. Double click on the new state in the 'Characters available' window.

MEKA. *Text only*. If necessary, scroll to the required character state in the 'Score character states' window. (It will usually be necessary if the character was not the last one used. Alternatively, the 'Character state history' window can be opened, and left open; the used states will then usually be visible without scrolling.) Click on the previously selected state, and press 'Clear'.

Double click on the new state. *Illustrations*. Not available.

NaviKey. *Text only*. Click on the previously entered attribute. Press 'Remove selection'. If necessary, scroll to the required character. (This will usually be necessary if the character was not the last one used, or if 'Selection list intelligence' is checked.) Double click on the required character. Double click on the required state. *Illustrations*. Not available.

PollyClave. *Text only*. If necessary, scroll to the required character. (This will usually be necessary if the character was not the last one used.) Uncheck the previously checked state. Check the new state. Click on 'Skip to Show Taxa. Press 'Show taxa matching selections'. Press 'Back'. *Illustrations*. If necessary, scroll to the required character. Click on the image link. Press 'Back'. Uncheck the previously checked state. Check the new state. Click on 'Skip to Show Taxa. Press 'Show taxa matching selections'. Press 'Back'.

XID. *Text only*. If necessary, move to the screen containing the required character. (XID has a rigid system of character subsets; it may be necessary to move up and down a hierarchy of menus to reach the character). Double click on the required character. Press 'Clear Menu'. Double click on the new state. Press 'Close'. *Character illustration*. If necessary, move to the screen containing the required character. Click on the required character. Press 'Selection help' (character notes are automatically displayed). Press 'Close'. Double click on the character. Press 'Clear Menu'. Double click on the new state. Press 'Close'. *State illustrations*. If necessary, move to the screen containing the required character. Double click on

the required character. To see a state illustration, click on the state, press 'Selection help', and press 'Close' (3–6 operations; state notes are automatically displayed). Press 'Clear Menu'. Double click on the new state. Press 'Close'.

Display character notes

For the calculation of the number of operations, it is assumed that the character has three states.

Intkey. Press 'Notes'.

IdentifyIt. *Text only*. To see the notes for a state, click on the state, and click again to clear the notes pane and the state selection if necessary (1–6 operations). *Illustrations*. Notes are available only as an alternative to illustrations.

Lucid. *Text only*. Press the 'i' button adjacent to one state. Click on 'Notes'. As required, scroll to the notes of the next or previous states (up to 2 operations if the first or last state was initially selected, otherwise up to 3 operations). Close the 'Notes' window. *Illustrations*. Drag thumbnails of the required states onto the 'Notebook' icon, and close the 'Notes' windows (2 to 6 operations).

MEKA. Not available.

NaviKey. Not available.

PollyClave. Not available.

XID. *Text only, character notes*. After clicking on the required character, press 'Selection help' (any character illustration is also displayed). Press 'Close'. *Text only, state notes*. Click on each required state, press 'Selection help', and press 'Close' (3–9 operations; any state illustrations are also displayed). *Illustrations*. Notes are automatically displayed with the illustrations.

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