

PANKEY

Programs for the identification and
description of plants of animals

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 **Exeter Software**

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PANKEY is a package of programs for problems of identification or diagnosis. It is usually applied to the naming of plants or animals, but it can also be used for medical diagnosis and for problems outside the life sciences. Program output of diagnostic keys and descriptions of species will typically be used in taxonomic publications such as monographs, Floras and Faunas. Also included is an expert identification program which is used interactively, with images, in order to name unknown specimens. Data for **PANKEY** is stored in the DELTA format, which is an international standard.

The **PANKEY** programs include:

- construction of diagnostic keys, both automatically and interactively
- construction and printing of species descriptions
- expert interactive identification, with colour images
- identification by comparison (matching)
- character analysis
- conversion to other formats, for clustering or cladistics
- DEDIT, a special purpose editor for DELTA data (comes free of charge)

PANKEY as described here is a development package, so that you can set up and modify your own data sets. You are encouraged to share and distribute the data files that are created, free of charge. Special licences are available for the distribution of runtime only **PANKEY** programs. **PANKEY** is particularly suitable for teaching, in conjunction with the textbook "Practical Taxonomic Computing" by R.J.Pankhurst (Cambridge University Press, 1991).

PANKEY comes with a 150 page user manual, and is provided with online help. **PANKEY** system requirements are very modest. This is deliberate, so that it can be used in all parts of the world. The minimum machine specification is:

- 2.4 Mb of hard disk
- 640K RAM (but extended memory is better)
- 286 processor or above
- DOS 5 or above (operating system)
- monochrome VGA graphics (although colour is better)

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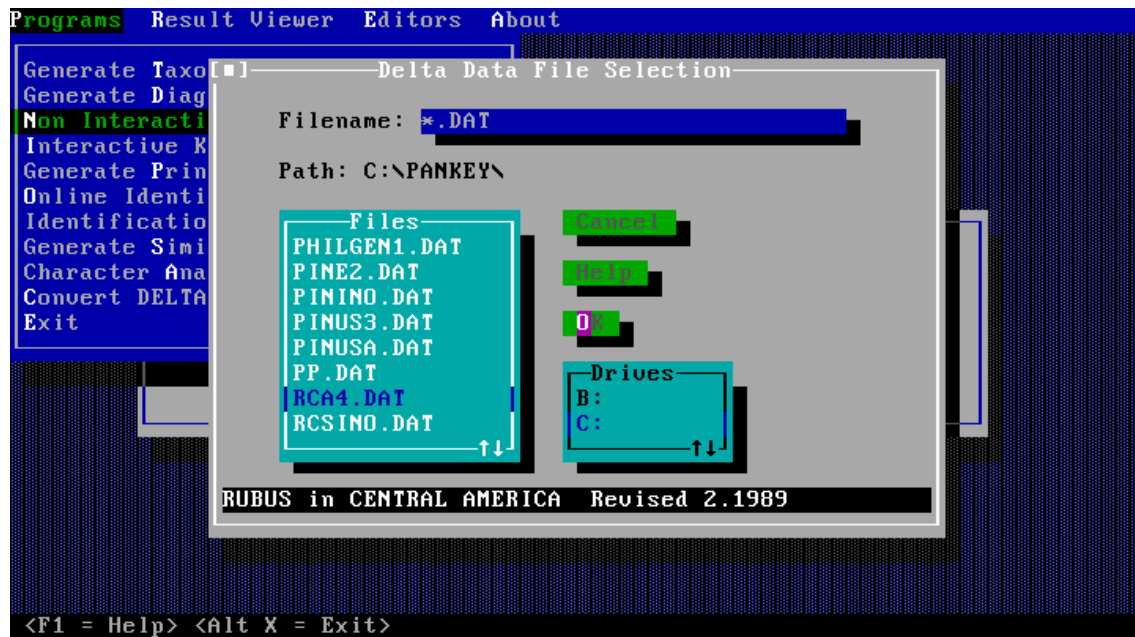
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PANKEY startup screen

This shows the selection of one of the 10 program options and the selection of an input DELTA data file.



Key-generation program, automatic

The only interaction needed is to specify the data file. The following key was generated from a DELTA data set for *Jurinea* (see Appendix)

- | | | |
|----|---|----------------------|
| 1 | Sterile rosettes present. | 2 |
| 2 | Outer involucral bracts patent, or recurved. | 3 |
| 3 | Cauline leaves auriculate, pappus 0.8 times achene. | 11.J.polyclonos |
| 3 | Cauline leaves without auricles, pappus 1.1 to 1.2 times achene. | 4 |
| 4 | Cauline leaves amplexicaul. | 12.J.ledebourii |
| 4 | Cauline leaves not amplexicaul. | 5 |
| 5 | Achene 1.0 to 2.0 mm. | 14.J.glycacantha |
| 5 | Achene 3.0 to 5.0 mm. | 10.J.mollis |
| 2 | Outer involucral bracts erect. | 6 |
| 6 | Upper surface of leaves white, or grey, basal leaves arachnoid-tomentose above. | 7 |
| 7 | Basal leaves entire, leaf margins revolute, capitula hemispherical, corona of achene inconspicuous, pappus 1.2 to 1.4 times achene. | 7.J.kirghisorum |
| 7 | Basal leaves pinnatifid, leaf margins plane, capitula obconical, corona of achene conspicuous, pappus 3.0 to 4.0 times achene. | 4.J.pinnata |
| 6 | Upper surface of leaves green, basal leaves subglabrous above, or setose above. | 8 |
| 8 | Basal leaves setose above, capitula obconical, corona of achene conspicuous, pappus 3.0 to 4.0 times achene. | 3.J.tzar-ferdinandii |
| 8 | Basal leaves subglabrous above, capitula subglobose, or hemispherical, corona of achene absent, or inconspicuous, pappus 1.1 to 2.0 times achene. | 9 |
| 9 | Capitula subglobose, corona of achene absent. | 17.J.fontqueri |
| 9 | Capitula hemispherical, corona of achene inconspicuous. | 13.J.consanguinea |
| 1 | Sterile rosettes absent. | 10 |
| 10 | Leaf margins revolute. | 11 |
| 11 | Basal leaves setose above. | 12 |
| 12 | Pappus 1.5 to 2.0 times achene. | 2.J.stoechadifolia |
| 12 | Pappus 3.0 to 4.0 times achene. | 3.J.tzar-ferdinandii |
| 11 | Basal leaves arachnoid-tomentose above. | 13 |
| 13 | Capitula cylindrical, achene glabrous. | 1.J.linearifolia |
| 13 | Capitula obconical, achene hairy. | 14 |
| 14 | Outer involucral bracts erect, distal part of bracts purple. | 16.J.taygetea |
| 14 | Outer involucral bracts patent, or recurved, distal part of bracts green. | 15.J.humilis |
| 10 | Leaf margins plane. | 15 |
| 15 | Stem woody at base. | 16 |
| 16 | Achene 6.0 to 7.0 mm, corona of achene inconspicuous, pappus 1.5 times achene. | 6.J.albicaulis |
| 16 | Achene 3.0 to 4.5 mm, corona of achene conspicuous, pappus 2.5 to 4.0 times achene. | 17 |
| 17 | Basal leaves entire, capitula cylindrical. | 1.J.linearifolia |
| 17 | Basal leaves pinnatifid, capitula obconical. | 4.J.pinnata |
| 15 | Stem herbaceous. | 18 |
| 18 | Upper surface of leaves white, or grey, basal leaves arachnoid-tomentose above, capitula obconical, outer | |

- involucral bracts coriaceous. 5.J.tanaitica
- 18 Upper surface of leaves green, basal leaves subglabrous above,
capitula subglobose, outer involucral bracts herbaceous. 19
- 19 Cauline leaves without auricles, outer involucral bracts
erect, achenes obpyramidal. 8.J.cyanoides
- 19 Cauline leaves auriculate, outer involucral bracts recurved,
achenes subcylindrical. 9.J.ewersmanii

This key can be transferred to the next program, interactive key construction, for detailed editing and unlimited improvement, only provided that the DELTA data file is unchanged.

For further reading and explanation of the program, see:

PANKHURST, R.J. (1970) A computer program for the generation of diagnostic keys. *Computer Journal*, 12:145-151.

PANKHURST, R.J. (1970) Key generation by computer. *Nature* 227: 1269-1270.

PANKHURST, R.J. & WALTERS, S.M. (1971) Key generation by computer, in *Data processing in Biology and Geology*, ed. J.L.Cutbill, for Systematics Association, Academic Press: 189- 203.

PANKHURST, R.J. (1971) Botanical keys generated by computer. *Watsonia* 8:357-368.

PANKHURST, R.J. (1991) "Practical Taxonomic Computing" Cambridge University Press. A text book of taxonomic computing.

Key-generation program, interactive

Screen 1: Using the BEST command to find which characters contain the most information for key construction. The same command appears in the ONLIN7 program.

```
JURINEA TEST
BEST CHAR DELE DIAG DIFF EXAM EXPA FINI HELP RENU SAVE SCOP TAXA VIEW

  Sepn   Characters
   91    16 Capitula shape
   78    10 Basal leaves hair above
   66    17 Outer involucre bracts habit
   59    23 Corona of achene size
   56     6 Sterile rosettes presence
   53    24 Pappus relative length
   52     5 Rhizome presence
   42     9 Upper surface of leaves colour
   42    11 Leaf margins recurved
   34    20 Achene size
   33    19 Distal part of bracts colour
   30    22 Achene hair
   28     8 Basal leaves cut
   14    21 Achenes shape
   12     7 Basal leaves shape
   12    15 Capitula length
   10    14 Capitula no.
   10    18 Outer involucre bracts texture

Waiting for command                               Tax  17 Cha  18 Sco 1 Leads  0
```

Screen 2: Using the EXAM command to examine the leads of a key which would result from using the character 10 'Basal leaves hair above'. Duplicated taxa due to variable characters are highlighted in blue.

```
JURINEA TEST
BEST CHAR DELE DIAG DIFF EXAM EXPA FINI HELP RENU SAVE SCOP TAXA VIEW
Next Taxa Quit Recombine Delete Order Skip

  1  (10)Basal leaves (=1)subglabrous above.
     TAXA 8 9 10 11 12 13 17

  2  (10)Basal leaves (=2)arachnoid-tomentose above.
     TAXA 1 4 5 6 7 10 14 15 16

  3  (10)Basal leaves (=3)setose above.
     TAXA 2 3

This will be lead number          1

Accept(A), abandon(Q) display again(D)? Tax  17 Cha  18 Sco 1 Leads  0
```

Screen 3: Since this key has three leads, and a dichotomous key would be preferred, the two leads for 'hairiness' are combined.

```
JURINEA TEST
BEST CHAR DELE DIAG DIFF EXAM EXPA FINI HELP RENU SAVE SCOP TAXA VIEW
Next Taxa Quit Recombine Delete Order Skip

1 (10)Basal leaves (=1)subglabrous above.
TAXA 8 9 10 11 12 13 17

2 (10)Basal leaves (=2)arachnoid-tomentose above or (=3)setose above.
TAXA 1 2 3 4 5 6 7 10 14 15 16

This will be lead number 1

Accept(A), abandon(Q) display again(D)? Tax 17 Cha 18 Sco 1 Leads 0
```

Screen 4: Expanding the 'Capitulum shape' character in order to see which states are involved and how they are distributed.

```
JURINEA TEST
BEST CHAR DELE DIAG DIFF EXAM EXPA FINI HELP RENU SAVE SCOP TAXA VIEW

16 Capitula shape
1.cylindrical 2.subglobose 3.hemispherical 4.obconical
States 1 2 3 4
1.1.J.line Y N N N
2.2.J.stoe Y N N Y
3.3.J.tzar N N N Y
4.4.J.pinn N N N Y
5.5.J.tana N N N Y
6.6.J.albi Y Y N N
7.7.J.kirg N N Y N
10.10.J.mo N Y Y N
14.14.J.gl N N Y N
15.15.J.hu N N N Y
16.16.J.ta N N N Y

Waiting for command Tax 11 Cha 18 Sco 1 Leads 7
```

Screen 5: Viewing the partially constructed key. Although this is shown in the 'parallel' style without indentation, other key styles are available at output time.

```
JURINEA TEST
BEST CHAR DELE DIAG DIFF EXAM EXPA FINI HELP RENU SAVE SCOP TAXA VIEW

1 Basal leaves subglabrous above. 2
  Basal leaves arachnoid-tomentose above or setose above. 0
2 Outer involucrel bracts erect. 3
  Outer involucrel bracts patent or recurved. 5
3 Rhizome present, corona of achene absent. 17.J.fontqueri
  Rhizome absent, corona of achene inconspicuous. 4
4 Stem leafy at base, sterile rosettes present. 13.J.consanguinea
  Stem leafy throughout, sterile rosettes absent. 8.J.cyanoides
5 Cauline leaves auriculate. 6
  Cauline leaves without auricles. 7
6 Sterile rosettes present, leaf margins revolute. 11.J.polyclonos
  Sterile rosettes absent, leaf margins plane. 9.J.ewersmanii
7 Cauline leaves amplexicaul, achene 1.0 to 2.0 mm, achene puberulent,
  corona of achene inconspicuous. 12.J.ledebourii
  Cauline leaves not amplexicaul, achene 3.0 to 5.0 mm, achene glabrous,
  corona of achene conspicuous. 10.J.mollis

Waiting for command Tax 11 Cha 18 Sco 1 Leads 7
```

Further reading:

PANKHURST, R.J. (1988) An interactive program for the construction of identification keys. Taxon 37(3): 747-755.

On-line identification

Screen 1: Startup screen

```
Please wait...  
Searching directory for DELTA binary files.  
Expanded memory found
```



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Online identification V.7

Hit any key to continue

Screen 2: Menu of available commands

*** Online identification ***
JURINEA TEST

BEST Finds the best character(s) to use next

CHAN n Changes characters of taxon n

CHAR Lists all available characters

CHAR i Enter states for character i

CHAR = Find character by name or part of name

CSET i Selects group(s) of characters

DELE i Deletes character(s) from the specimen description

DESC Describes the specimen

More↓

↑,↓,PgDn,PgUp or Esc to quit	Taxa 17	Chars 24	Limit 0.0	Print OFF	Command
------------------------------	------------	-------------	--------------	--------------	---------

Screen 3: Listing of all available characters. You can just pick the character that you feel like using and go ahead.

```
*** Online identification ***
JURINEA TEST

1 Stem presence
2 Stem height
3 Stem leaf distribution
4 Stem shrubbiness
5 Rhizome presence
6 Sterile rosettes presence
7 Basal leaves shape
8 Basal leaves cut
9 Upper surface of leaves colour
10 Basal leaves hair above
11 Leaf margins recurved
12 Cauline leaves amplexicaul
13 Cauline leaves auricles
14 Capitula no.
15 Capitula length
16 Capitula shape
17 Outer involucre bracts habit
18 Outer involucre bracts texture
19 Distal part of bracts colour
20 Achene size
21 Achenes shape
22 Achene hair
23 Corona of achene size
```

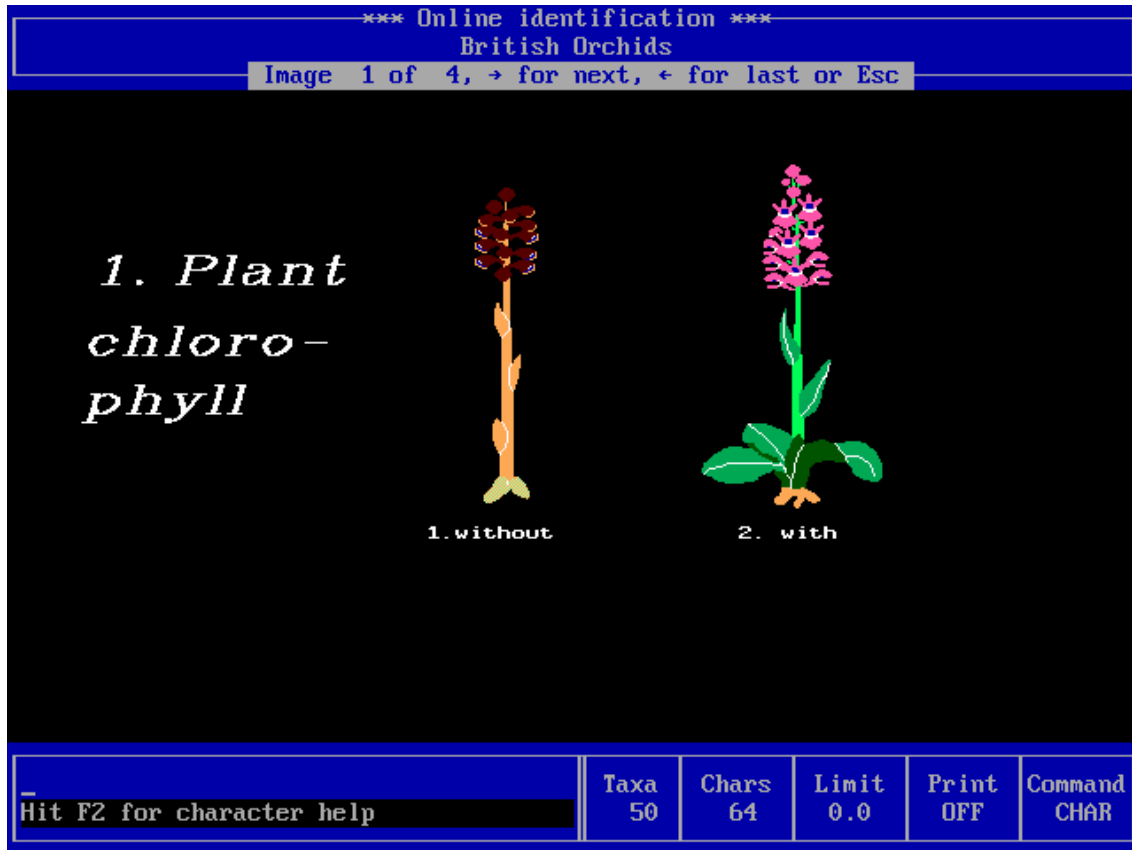
↑,↓,PgDn,PgUp,Home,Esc or command	Taxa 17	Chars 24	Limit 0.0	Print OFF	Command CHAR
-----------------------------------	------------	-------------	--------------	--------------	-----------------

Screen 4: BEST command, showing character information values, with weighting. This is much better than just choosing characters from the list, unless you are an expert in the group, since you will advance much more rapidly towards a solution. You can also use the DIAG command, to get characters for a specific taxon, and the DIFF command, to see differences between two taxa, when you think you might have one of them, but are not sure which. It is also possible to set and to vary, the number of 'wrong' characters that you are willing to allow, with the LIMIt command. If the LIMIt is zero, then the specimen has to agree exactly with the target taxon, or if set to 1, then one difference is allowed, and so on.

*** Online identification ***				
JURINEA TEST				
Seprn	No.	Wt.	Character	
107	24	1	Pappus relative length	
91	16	1	Capitula shape	
78	10	1	Basal leaves hair above	
67	15	1	Capitula length	
66	17	1	Outer involucre bracts habit	
63	2	1	Stem height	
59	23	1	Corona of achene size	
56	6	1	Sterile rosettes presence	
48	4	1	Stem shrubbiness	
48	20	1	Achene size	
42	9	1	Upper surface of leaves colour	
42	11	1	Leaf margins recurved	
42	13	1	Cauline leaves auricles	
33	19	1	Distal part of bracts colour	
30	22	1	Achene hair	
28	8	1	Basal leaves cut	
15	12	1	Cauline leaves amplexicaul	
14	21	1	Achenes shape	
12	7	1	Basal leaves shape	
10	14	1	Capitula no.	
10	18	1	Outer involucre bracts texture	
55	3	0	Stem leaf distribution	

	Taxa	Chars	Limit	Print	Command
↑, ↓, PgDn, PgUp, Home, Esc or command	17	24	0.0	OFF	BEST

Screen 5: When choosing a state for a character, illustrations can be provided. This image comes from the classic key for British orchids, showing the difference between a saprophytic and an autotrophic species. Illustrations can also be attached to the TAXA command, for viewing once a tentative identification has been reached.



For further reading:

PANKHURST, R.J. & AITCHISON, R.R. (1975) An on-line identification program. In "Biological Identification with Computers", ed. R.Pankhurst for the Systematics Association, Academic Press: 181-194.

PANKHURST, R.J. (1989) A computer program with colour graphics to identify orchids. *Orchid Review* 97(1144): 53-55,67.

Identification by Matching

This program does not carry out the step by step elimination of the taxa by characters as in a key or an online program but calculates a similarity between a complete description of the specimen and each of the taxa

Screen 1: Shows the highest scoring taxa in the genus *Jurinea*, with plus signs for the 'special' characters that have been pre-selected. The correct answer is not necessarily the taxon with the highest score.

```
File Edit Search Options Help
JJ
Jurinea <pinnata?>
Special characters are -
Stem <shrubbiness>
Basal leaves <shape>
Upper surface of leaves <colour>
Cauline leaves <auricles>

Seq   Sim.   Count   Species
1     54.8   18 *** +   6.J.albicaulis
2     50.7   19 * + +   2.J.stoechadifolia
3     49.1   19 ** ++   4.J.pinnata
4     45.5   19 ** +   1.J.linearifolia
5     42.9   18 * +   3.J.tzar-ferdinandii

Resembles group 1

Special taxa compared
3 49.1 * 4.J.pinnata

MS-DOS Editor <F1=Help> Press ALT to activate menus N 00016:001
```

Further reading:

PANKHURST, R.J. (1975) Identification by matching. In "Biological Identification with Computers", ed. R.Pankhurst for the Systematics Association, Academic Press: 79-92.

Description printing

The following text was generated using the standard PANKEY DELTA data example '*Jurinea*' and shows the generalised description using constant or nearly constant characters (qualified by 'usually') in the first section of the genus, and then a description of the first species '*linearifolia*' with characters set out in paragraphs with (optionally) their DELTA character numbers left in, as an aid to proofreading the correctness of the DELTA data.

JURINEA PART 1

(5) Rhizome usually absent. (1) Stem present, (2) 4.0 to 80.0 cm, (3) usually leafy throughout. (12) Cauline leaves usually not amplexicaul, (13) usually without auricles. (14) Capitula 1 to 20, (15) 0.5 to 7.0 cm. (17) Outer involucre bracts usually erect. (20) Achene 3.0 to 7.0 mm, (22) usually glabrous. (24) Pappus 0.8 to 4.0 times achene.

1.*J.linearifolia*

(5) Rhizome absent. (6) Sterile rosettes absent. (1) Stem present, (4) woody at base, (2) 12.0 to 40.0 cm, (3) leafy throughout.

(7) Basal leaves linear-lanceolate or lanceolate, (8) entire, (10) arachnoid-tomentose above. (11) Leaf margins plane or revolute. (12) Cauline leaves not amplexicaul, (13) without auricles.

(15) Capitula 0.5 to 1.8 cm, (16) cylindrical. (17) Outer involucre bracts erect, (18) herbaceous. (19) Distal part of bracts pink, reddish, or purple.

(20) Achene 3.5 to 4.5 mm, (21) tetragonal, (22) glabrous. (23) Corona of achene conspicuous. (24) Pappus 2.5 to 3.5 times achene.

2.*J.stoechadifolia*

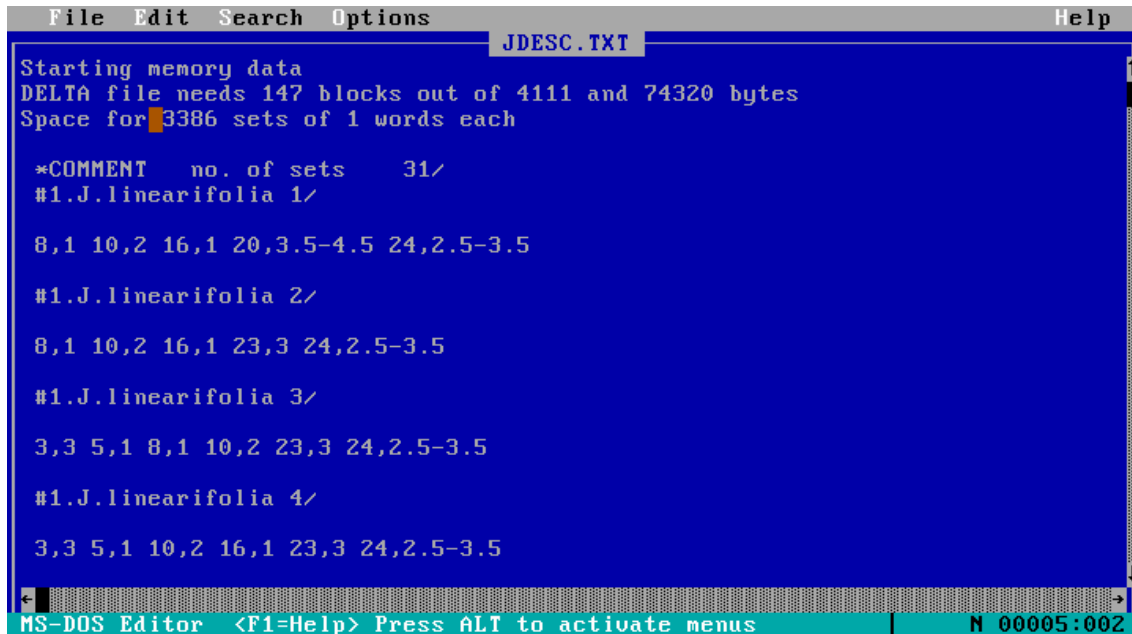
.....

Further reading:

PANKHURST, R.J. (1978) The printing of taxonomic descriptions by computer. *Taxon* 27:65-68.

Diagnostic descriptions

Screen 1: The program has been set to find all diagnostic character sets of minimum size with the LIMIT set to 1, so that the 31 different character sets will each distinguish *Jurinea linearifolia* from all other taxa by at least 2 characters



The screenshot shows a text editor window titled 'JDESC.TXT' with a menu bar containing 'File', 'Edit', 'Search', 'Options', and 'Help'. The text content is as follows:

```
Starting memory data
DELTA file needs 147 blocks out of 4111 and 74320 bytes
Space for 3386 sets of 1 words each

*COMMENT no. of sets 31/
#1.J.linearifolia 1/

8,1 10,2 16,1 20,3.5-4.5 24,2.5-3.5

#1.J.linearifolia 2/

8,1 10,2 16,1 23,3 24,2.5-3.5

#1.J.linearifolia 3/

3,3 5,1 8,1 10,2 23,3 24,2.5-3.5

#1.J.linearifolia 4/

3,3 5,1 10,2 16,1 23,3 24,2.5-3.5
```

The status bar at the bottom of the window displays 'MS-DOS Editor <F1=Help> Press ALT to activate menus' and 'N 00005:002'.

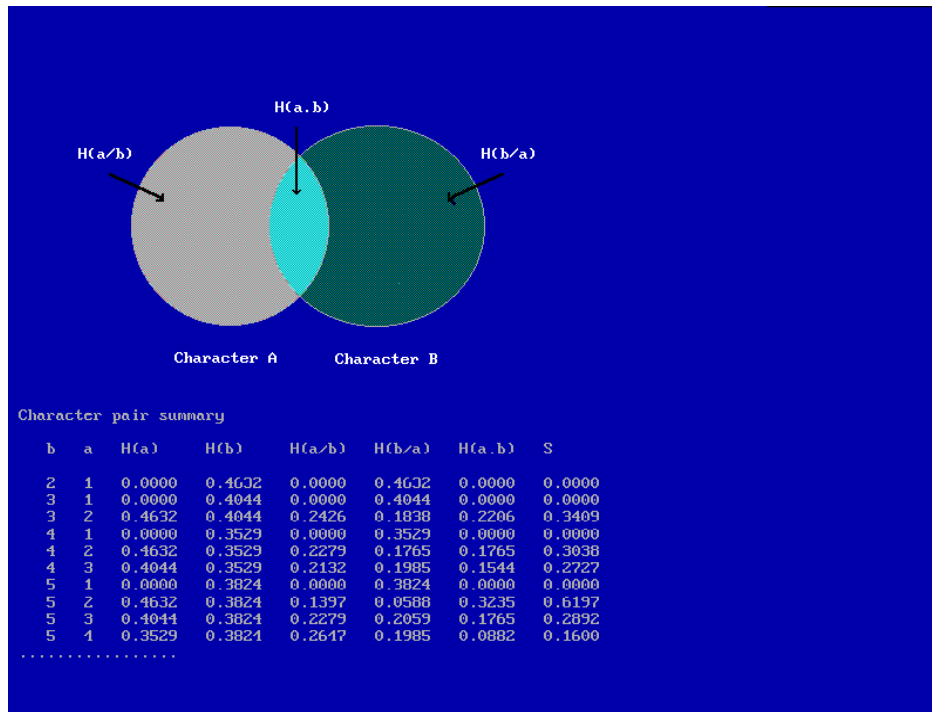
Further reading:

PANKHURST, R.J. (1983) An improved algorithm for finding diagnostic taxonomic descriptions. *Mathematical Biosciences* 65: 209-218.

Character analysis

This program provides a means to assess the correlations between characters. A check is advisable because a DELTA character set might contain redundancy. This cannot be calculated in the statistical sense because we do not have strictly quantitative variables, but instead a mixture of (mainly) qualitative characters and a few quantitative ones. A formula based on the information statistic is used, so that the value S in the diagram represents the common area of variation between two characters, illustrated as the overlapping area between two characters, whose variation is represented by circles. If S approaches unity, then the two characters might be

- 1) two ways of saying the same thing i.e one is redundant, or
- 2) a sign of a meaningful taxonomic grouping, or an indication of synapomorphy or symplesiomorphy



DELTA editor

The PANKEY package provides a special purpose editor for DELTA data, called DEDIT for short. Think of it as a text editor for DELTA, in the same way as a word processor is a system for writing letters.

Screen 1: Choosing a DELTA data file

```
*** DELTA editor ***
Main menu
No DELTA file selected

QUIT      If no files found
ANGIO.DAT Families of Flowering Plants - specifications.
ANGIO2.DAT Families of Flowering Plants. 11 September 199
BORNEO2.DAT Tropical tree groups Revised Thu Oct 31 12:28:
DIPT1.DAT  MEDIUM AND LIGHT HARDWOOD DIPTEROCARPS OF MALE
ELZ0.DAT  Elaeocarpus new additions to DELTA - July 1993
GENCOPY.DAT Genera of Campanulaceae(fullset Version2.2;23
GG.DAT    Genera of Campanulaceae(fullset Version2.2;23
JUR2D.DAT JURINEA TEST
JUR3D.DAT JURINEA TEST
NEWF.DAT  BRITISH FLORA TEST

Use cursor keys, or hit first letter of line,
or type =string. Press Enter key to choose option.
Items 0 Chars 0 Memory 4759680 Line 0
```

Screen 2: Selecting a character from a loaded DELTA set

```
*** DELTA editor ***
Character menu
Elaeocarpus new additions to DELTA - July 1993

Please select a character

Quit
1 Trees height
2 Twigs thickness
3 Twigs indumentum presence
4 Twig hairs on current growth dens
5 Twig hairs on current growth leng
6 Twig hairs on current growth type
7 Twig indumentum on current growth
8 Terminal buds resin
9 Terminal buds indumentum
10 Stipules persistence
11 Stipules shape
12 Stipules length
13 Stipules margin

use cursor keys, or hit first letter of line,
or type =string. Press Enter key to choose option.
Items 251 Chars 154 Memory 4227270 Line 5749
```

Screen 3: Editing the definition of a character

```
*** DELTA editor ***
Character menu
Elaeocarpus new additions to DELTA - July 1993

CHARACTER DEFINE AND EDIT
Character name (max. 5 lines)
Twig indumentum on current growth
Character comment (max. 5 lines)
attitude of hairs
Character units (max. 5 lines)

Hit F1 for field help; F2 for editing instructions
```

Screen 4: Editing a character state

```
*** DELTA editor ***
State menu
Elaeocarpus new additions to DELTA - July 1993

CHARACTER DEFINE AND EDIT
State name (max. 5 lines)
oblong, sometimes curved
State comment (max. 5 lines)
somewhat foliaceous

Hit F1 for field help; F2 for editing instructions
```

Screen 5: Making changes to the description of a taxon

```
*** DELTA editor ***
Description menu
Elaeocarpus new additions to DELTA - July 1993

Item selected 9. baramii $Elaeocarpus
Select one character, All, Copy last taxon, go to Next, or quit (s/a/c/n/q)?a
1 Trees <height> m high
Current value is --- 5-25
Delete, replace, OK or quit (d/r/y/q)?y
2 Twigs <thickness> mm thick between first 2-3 leaves
Current value is --- 2-3
Delete, replace, OK or quit (d/r/y/q)?y
3 Twigs <indumentum presence>
1 glabrous
2 hairy at tip
3 persistently hairy behind current shoot growth
Current value is --- 1
Delete, replace, OK or quit (d/r/y/q)?r
Type state(s) --- 2

Items 251 Chars 154 Memory 4225990 Item 9. baramii $Elaeocarpus
```

Screen 6: Adding the definition of a new character

```
*** DELTA editor ***
Character menu
Elaeocarpus new additions to DELTA - July 1993

CHARACTER DEFINE AND EDIT
Character name (max. 5 lines)
Twigs
Character comment (max. 5 lines)
thickness
Character units (max. 5 lines)
mm thick between first 2-3 leaves

Hit F1 for field help; F2 for editing instructions
```

General references

PANKHURST, R.J. (1991) "Practical taxonomic computing". Cambridge University Press, 202pp.

PANKHURST, R.J. (1991) Algorithms for identification. In "Symbolic-Numeric Data Analysis & Learning" eds. E. Diday & Y. Lechevallier, Conference INRIA, Versailles Sept. 1991, pp.3-13. Nova Science Publishers Inc., New York

PANKHURST, R.J. (1993) Principles and problems of identification. In "Advances in Computer Methods for Systematic Biology" ed. R.Fortuner, pp. 125-136. Johns Hopkins UP, Baltimore & London.

PANKHURST, R.J. (1998) A historical review of identification by computer, In "Information Technology, Plant Pathology & Biodiversity" eds. P.Bridge, P.Jefferies, D.R.Morse & P.R.Scott, pp. 289-303. CAB Intl., Wallingford.

Appendix

DELTA data file for the standard PANKEY example, *Jurinea* (Compositae) in Europe.

```
*HEADING JURINEA TEST/  
*KEY OPTIONS POLYCLAVE=21/  
*NUMBER OF CHARACTERS 24  
*PRINT WIDTH 75  
*MAXIMUM NUMBER OF STATES 7  
*MAXIMUM NUMBER OF ITEMS 17  
*CHARACTER TYPES 2,RN 3,OM 14,IN 15,RN 20,RN 22,OM 23,OM 24,RN  
*NUMBERS OF STATES 3,3 7,6 9,3 10,3 14,0 16,4 17,3 19,7 21,4 22,3 23,3  
*CHARACTER WEIGHTS 3,0 5,0  
*KEY STATES 2,0-10/10-200 14,1-4/5-100 15,0-3/3-100  
                20,0-2.0/2.0-5.0/5.0-100 24,0-1.0/1.-2./2.-4./4.-100  
*CHARACTER DESCRIPTIONS  
#1. Stem <presence>/  
    1. absent/  
    2. present/  
  
#2. Stem <height>/ cm/  
  
#3. Stem <leaf distribution>/  
    1. leafless/  
    2. leafy at base/  
    3. leafy throughout/  
  
#4. Stem <shrubbiness>/  
    1. herbaceous/  
    2. woody at base/  
  
#5. Rhizome <presence>/  
    1. absent/  
    2. present/  
  
#6. Sterile rosettes <presence>/  
    1. absent/  
    2. present/  
  
#7. Basal leaves <shape>/  
    1. linear/  
    2. linear-lanceolate/  
    3. lanceolate/  
    4. spatulate/  
    5. ovate/  
    6. ovate-oblong/  
  
#8. Basal leaves <cut>/  
    1. entire/  
    2. pinnatifid/  
  
#9. Upper surface of leaves <colour>/  
    1. green/  
    2. white/  
    3. grey/  
  
#10. Basal leaves <hair above>/  
    1. subglabrous above/
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- 2. arachnoid-tomentose above/
- 3. setose above/

- #11. Leaf margins <recurved>/
 - 1. plane/
 - 2. revolute/

- #12. Cauline leaves <amplexicaul>/
 - 1. not amplexicaul/
 - 2. amplexicaul/

- #13. Cauline leaves <auricles>/
 - 1. without auricles/
 - 2. auriculate/

- #14. Capitula <no.>/

- #15. Capitula <length>/ cm/

- #16. Capitula <shape>/
 - 1. cylindrical/
 - 2. subglobose/
 - 3. hemispherical/
 - 4. obconical/

- #17. Outer involucre bracts <habit>/
 - 1. erect/
 - 2. patent/
 - 3. recurved/

- #18. Outer involucre bracts <texture>/
 - 1. herbaceous/
 - 2. coriaceous/

- #19. Distal part of bracts <colour>/
 - 1. whitish/
 - 2. green/
 - 3. yellowish/
 - 4. brown/
 - 5. pink/
 - 6. reddish/
 - 7. purple/

- #20. Achene <size>/ mm/

- #21. Achenes <shape>/
 - 1. subcylindrical/
 - 2. tetragonal/
 - 3. obpyramidal/
 - 4. conical/

- #22. Achene <hair>/
 - 1. glabrous/
 - 2. puberulent/
 - 3. hairy/

- #23. Corona of achene <size>/
 - 1. absent/

- 2. inconspicuous/
- 3. conspicuous/

#24. Pappus <relative length>/ times achene/

*DEPENDENT CHARACTERS 1,1:2-4:12-13

*ITEM DESCRIPTIONS

#1.J.linearifolia/

1,2 2,12-40 3,3 4,2 5,1 6,1 7,2/3 8,1 10,2 11,V 12,1 13,1 15,0.5-1.8
16,1 17,1 18,1 19,5/6/7 20,3.5-4.5 21,2 22,1 23,3 24,2.5-3.5

#2.J.stoechadifolia/

1,2 2,10-40 3,3 4,1 5,1 6,1 7,1 8,1 10,3 11,2 12,1 13,1 14,3-20 15,2.7-3
16,1/4 17,1 18,1 19,1/5 20,3.5-4.5 21,2/4 22,1 23,3 24,1.5-2.0

#3.J.tzar-ferdinandii/

1,2 2,15-30 3,3 5,2 6,V 8,1 9,1 10,3 11,2 12,1 13,1 14,5-8 15,1.5-2 16,4
17,1 19,1/2 20,3-4 21,2 22,1 23,3 24,3-4

#4.J.pinnata/

1,2 2,4-13 3,1/2 4,2 5,1 6,V 8,2 9,2/3 10,2 11,1 12,1 13,1 14,2-3
15,1.5-2.3 16,4 17,1 19,6/7 20,3-4.5 21,2 22,1 23,3 24,3-4

#5.J.tanaitica/

1,2 2,15-60 3,3 4,1 5,1 6,1 8,2 9,2/3 10,2 11,1 12,1 13,2 14,2-20
15,1.2-1.5 16,4 17,1 18,2 19,3/4/7 20,3.5-4.5 22,1 23,2 24,2-2.5

#6.J.albicaulis/

1,2 2,30-75 3,3 4,2 5,1 6,1 7,1/2 8,V 9,1/2 10,2 11,1 12,1 13,1
15,1.8-2.5 16,1/2 17,1 18,V 20,6-7 22,1 23,2 24,1.5

#7.J.kirghisorum/

1,2 2,10-25 3,2 4,2 5,1 6,2 7,3/4 8,1 9,2/3 10,2 11,2 12,1 13,1 14,1-3
15,1.1-1.3 16,3 17,1 18,1 20,4-5 23,2 24,1.2-1.4

#8.J.cyanoides/

1,2 2,20-70 3,3 4,1 5,1 6,1 8,V 9,1 10,1 11,1 12,1 13,1 14,1-3
15,1-3 16,2 17,1 18,1 19,2 20,3-4 21,3 22,1 23,2 24,2-2.5

#9.J.ewersmanii/

1,2 2,20-70 3,3 4,1 5,1 6,1 8,V 9,1 10,1 11,1 12,1 13,2 14,1-3 15,1-3 16,2
17,3 18,1 19,2/7 20,5-6 21,1 22,1 23,2 24,2-2.5

#10.J.mollis/

1,2 2,30-70 3,2/3 4,1 5,1 6,2 7,2/3 8,2 9,1/3 10,1/2 11,V 12,1 13,1
14,1-8 15,2-6 16,2/3 17,2/3 18,V 19,7 20,3-5 22,1 23,3 24,1.1

#11.J.polyclonos/

1,2 2,40-80 3,3 4,1 5,1 6,2 8,2 9,1 10,1 11,2 12,V 13,2 14,5-20 15,0.5-2
16,2 17,2/3 18,1 19,7 23,2 24,0.8

#12.J.ledebourii/

1,2 2,15-80 3,2 4,1 5,1 6,2 7,2 8,V 9,1 10,1 11,V 12,2 13,1 14,1-3 15,2-4
16,2 17,2/3 18,1 20,1-2 22,2 23,2 24,1.1

#13.J.consanguinea/

1,2 2,20-35 3,2 4,1 5,1 6,2 8,2 9,1 10,1 11,V 12,1 13,1 15,2-7 16,3 17,1
18,V 22,1/3 23,2 24,1.1

#14.J.glycacantha/

1,2 2,30-60 3,2/3 4,1 5,1 6,2 8,2 9,2/3 10,2 11,1 12,1 13,1 15,4-7.5 16,3
17,2/3 20,1-2 21,4 24,1.2

#15.J.humilis/

1,V 2,0-4 3,3 4,1 5,2 6,1 8,V 9,2/3 10,2 11,2 12,1 13,1 15,2-2.5 16,4
17,2/3 18,1 19,2 20,3-7 22,3 23,2 24,5-7

#16.J.taygetea/

1,V 2,0-4 3,3 4,1 5,2 6,1 8,2 9,2/3 10,2 11,2 12,1 13,1 15,2-2.5 16,4
17,1 18,1 19,7 20,3-7 22,3

#17.J.fontqueri/

1,V 2,0-4 3,1 4,1 5,2 6,2 7,5/6 9,1 10,1 11,1 12,1 13,1 15,3-4 16,2
17,1 18,1 19,2 20,4-6 23,1 24,1.5-2

*END