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TAXONOMY PROJECT

A NUMERICAL TAXONOMIC STUDY OF THE GENUS *THAMNOCHORTUS*, BERG. (FAMILY : RESTIONACEAE).

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BOTANY HONOURS
1979.

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University of Cape Town

A B S T R A C T

Numerical taxonomic techniques were applied to the genus Thamnochortus (Restionaceae). 37 species were coded for 95 modal properties. The BOLAID package of numerical classificatory aids was employed in producing a dendogram and comprehensive key. The dendogram demonstrated close linkage within the group, though several sub-groups could be detected. However, both the data base and key will require further modifications, and suggestions for work in this respect are presented.

1. INTRODUCTION

The Restionaceae are a family of perennial, wiry aphyllous hemicryptophytes bearing close morphological resemblance to members of the Juncaceae and Cyperaceae (Cutler, 1969), in the order Juncales (Hutchinson, 1959). The distribution is almost entirely in the southern hemisphere (Figure 1, Hutchinson, 1934), with the main concentration being in south and south-western Australia, and the Cape Province, South Africa. No Restionaceous genera are shared between both countries (Cutler, 1972).

In South Africa, the family is represented by twelve genera, all found between latitude 31S and 35S, in the Cape Province. They are most prolific in the south-western corner of the province - the wettest region, receiving up to 2000 mm of rainfall per annum locally in a normal winter (Cutler, 1969). As a result, their invariable presence characterizes the fynbos, the broad category of sclerophyllous shrublands which dominate the vegetation in the region of the Cape Floral Kingdom (Capensis) (Kruger, 1977; Taylor, 1978), and they comprise the dominant or co-dominant physiognomic element (Taylor, 1977; 1978).

Capensis, the smallest of the floral kingdoms, is known for its species richness, and high number of endemic taxa (Goldblatt, 1978). Approximately 21% of the typical Cape genera are restricted to Capensis - possibly the highest rate in the world (Good, 1974). Thamnochortus, Berg. - a genus of the Restionaceae is one such endemic.

First described in 1767, and recognized as a genus in its own right since 1836 (Cutler, 1969), Thamnochortus was investigated taxonomically by Pillans (1928, 1942, 1945, 1952), in his extensive survey of the African genera and species of the Restionaceae.

However, Pillans' terminology (see Glossary I) and descriptions were complicated. This study was therefore aimed at contributing an analysis and

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key that would meet modern taxonomic requirements in a more readily understandable way, as the use of mathematical techniques would mean better defined and precise criteria would be employed.

With respect to this latter point, the key forming matrix is of considerable interest, as it is an attempt to combine features of gross morphology, and male and female inflorescence characters, to produce a generalized key. The previous key (see Pillans, 1928) is incomplete with respect to the number of species considered, and is based only on characters derived from the female plants. Keys of this nature however, hinder correct classification of a large proportion of the male plants.

The genus is comprised of 37 species (see Table I for listing).

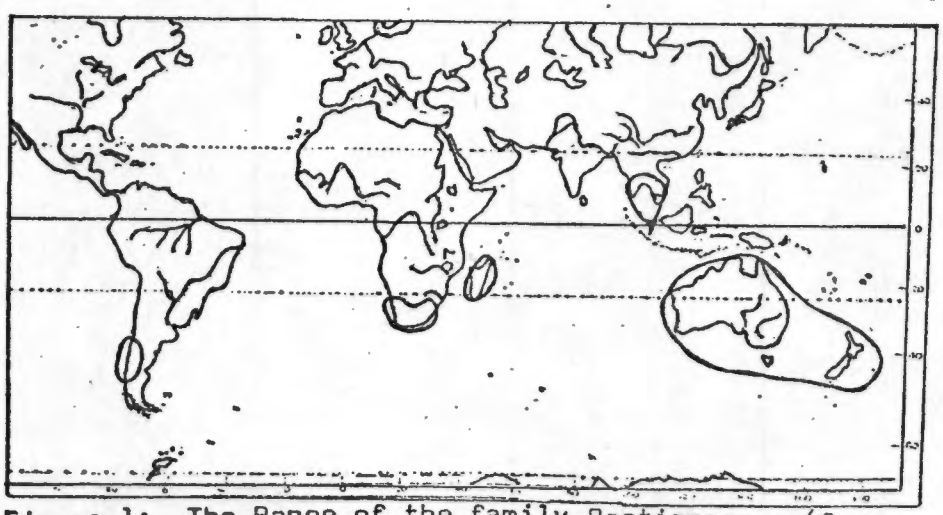


Figure 1: The Range of the family Restionaceae (from Hutchinson, 1934).

Table I / -

Table 1: Species list of the genus Thamnochortus, Berg.

1) T. fruticosus, Pillans
2) T. argenteus, Kunth
3) T. glaber, Pillans
4) T. levynsiae, Pillans
5) T. nutans, Pillans
6) T. muirii, Pillans
7) T. scabridus, Pillans
8) T. ellipticus, Pillans
9) T. paniculatus, Mast
10) T. fraternus, Pillans
11) T. pluristachyus, Mast
12) T. guthriae, Pillans
13) T. schlechteri, Pillans
14) T. dumosus, Mast
15) T. platypteris, Kunth
16) T. bachmannii, Mast
17) T. stokoei, Pillans
18) T. punctatus, Pillans
19) T. dichotomus, R. Br
20) T. gracilis, Mast
21) T. erectus, Mast
22) T. insignis, Mast
23) T. spicigerus, R. Br
24) T. acuminatus, Pillans
25) T. papyraceus, Pillans
26) T. pulcher, Pillans
27) T. comptonii, Pillans
28) T. lewisiae, Pillans
29) T. muticus, Pillans
30) T. nervosus, Pillans
31) T. obtusus, Pillans
32) T. papillosus, Pillans
33) T. pellucidus, Pillans
34) T. piketbergensis, Pillans
35) T. plumosus, Pillans
36) T. similis, Pillans
37) T. sporadicus, Pillans

2. DESCRIPTION OF GENUS (from Pillans, 1928).

Flowers dioecious. Male spikelets many in panicled cymes, often declinate, usually oblong, many-flowered. Perianth compressed; segments 6, the outer lateral navicular, carinate along the median nerve, usually longer than the inner. Anthers linear-oblong, tapered above the middle into an apiculus. Rudimentary ovary with 1 style or absent. Female spikelets many in panicled cymes, few in spicate cymes or solitary and terminal erect, larger than the male, many-flowered, with few empty bracts. Perianth subtrigonous or compressed; segments 6, the outer lateral navicular, keeled or winged along the median nerve. Staminodes tongue-shaped, short, or absent. Ovary compressed or subtrigonous, 1 - celled; style solitary, simple. Fruit subtrigonous or compressed, indehiscent.

Flowering stems tufted or on creeping rhizomes, erect, simple or with fertile or barren branches, terete. Leaf-sheaths closely convolute or loose in parts, persistent. Much-branched, weaker and shorter barren stems are often present.

Thamnochortus - from the Greek thamnos - a shrub, chortos - green herbage (Adamson and Salter, 1950).

3. NUMERICAL TAXONOMY

Before proceeding, it is necessary to clearly define the use of the term 'numerical taxonomy,' as employed here. It means 'the grouping by numerical methods of taxonomic units into taxa on the basis of their character states ' (Sneath and Sokal, 1973 : p.4). The term includes the drawing of phylogenetic inferences from the data by statistical or other mathematical methods to the extent to which this is possible. These methods require the conversion of information about taxonomic entities into numerical quantities.

The views represented by the principles of numerical taxonomy (see below) are classed as neo-Adansonian. These principles (modified from Sneath, 1958) summarize the fundamental position of numerical taxonomy (Sneath and Sokal, 1973).

1. The greater the content of information in the taxa of a classification and the more characters on which it is based, the better a given classification will be.

2. A priori, every distinctive character is of equal weighting in creating natural taxa.

3. Overall similarity between any two entities is a function of their individual similarities in each of the many characters in which they are being compared.

4. Distinct taxa can be recognized because correlations of characters differ in the groups of organisms under study.

5. Phylogenetic inferences can be made from the taxonomic structures of a group and from character correlations, given certain assumptions about evolutionary pathways and mechanisms.

6. Classifications are based on phenetic similarity.

A few of the advantages of numerical taxonomy may be listed briefly (after Sneath and Sokal, 1973).

1. Numerical taxonomy has the power to integrate data from a variety of sources, such as morphology, physiology, and chemistry. This is very difficult to do by conventional taxonomy.

2. Through the automation of large portions of taxonomic processes, greater efficiency is promoted (Sokal and Sneath, 1966).

3. Being quantitative, the methods provide greater discrimination along the spectrum of taxonomic differences and are more sensitive in delimiting taxa. Thus, they should give better classifications and keys than can be obtained by the conventional methods.

4. The creation of explicit data tables for numerical taxonomy forces the use of more and better-defined characters.

So, to summarise the information presented above, in numerical taxonomy the principal aims are repeatability and objectivity, and an estimation of resemblance is the most important and fundamental step.

4. MATERIALS AND METHOD

4.1. Data Capture

The data was extracted from Pillans (1928-1952) and personal measurements from herbarium specimens. The descriptions of the 37 species were tabulated under stem, sheath, male inflorescence and female inflorescence properties. The properties selected under these four major categories (see Table 2) were based on universality and ease of observation. Missing data was supplied where possible.

All 95 properties selected were modal i.e. 'having at least the potential for a range, with an imaginable mode, over a set of items' (Hall, 1973). 10 characters had strings (character numbers: 22, 23, 39, 45, 48, 54, 62, 63, 72 and 73). Instead of giving average values for each item, strings allow some idea of the distribution of a property. These modal-plus-strings characters referred to minimum and maximum height, length or diameter values. Decimal values were re-scaled to give whole numbers.

The remaining modal properties were coded over ranges of 0 - 10; 0 - 20; and 0 - 100 (with zero being the base state). The range chosen depended on the information content of the character, that is, its relative importance in contributing information about the items.

4.2. Treatment for Group-forming

4.2.1. Character weighting

It will be observed from Table 2 that 52 of the characters listed are de-weighted. In group studies de-weightings are used for sets of properties that are to some degree homologous, or alike in nature and relative position (Hall, 1969a). A pair of homologically very similar properties may be allowed to contribute to overall similarity as though they were one : the results for each would have to be de-weighted by 50% (Hall, 1973). In this study for

example / -

example, characters 24 and 25 : degree of convoluteness of sheaths and degree of looseness at upper part of sheath, both refer to the arrayment of the sheath around the stem, and are homologous in nature. Consequently a de-weighting of 50% is employed.

Character de-weighting is an important concept in NT studies, as it reduces information loss with respect to the information available about the relative closeness of states within a character. This information may be intrinsic (e.g. colour), or inherent in the definition of the states as in developing characters (Baum, 1976).

4.2.2. Space conservation

Space conservation was set at 50%. Space conservation gives the degree of departure from maximum compactness in a group-study. The values range from 0 (no space conservation : compact) to 100 (maximum space conservation : least possible compactness). Least compactness is needed for studies where any single item may represent a distinct population : classification-space must be left around it to show its possible importance, and to allow for likely insertion of (future) allies. Zero space-conservation is used for strictly finite populations where a very compact classification is wanted (Hall, 1967; 1969b).

4.3. Treatment for Key-forming

4.3.1. Character weighting

In key-forming, the de-weightings are used for the more hard-to-observe properties. Such properties are then given a lower priority for use in a key (Hall, 1973).

However, in this study the key-forming characters are unweighted (i.e. all characters carry equal weight). Primary leads are chosen for (a) numerical distinctness (as opposed to visual difference), and (b) evenness of sub-division of set.

The / -

The key-forming program has the arbitary value of 20, on the scale 0 - 100, as the threshold below which properties are considered unusuable for a key (Hall, 1973).

One or two characters and an accessory feature are given for each branch-test (Hall, 1973). The results are set down to give the most commonly identified taxa (Hall, 1975).

4.4. Computation Method

The coded data matrix (see Glossary II for definition of NT terminology), was then punched onto cards and run on the BOLAID package. Subroutines PARDAT, Groups and Keys were used (see Hall, 1973).

Size factors were abstracted for the runs, to allow shape properties to be expressed fully (Hall, 1969a and b; Sneath and Sokal, 1973). Shape characters are important with respect to information content, whilst size is governed by very few genes or one gene, and is also very sensitive to environmental factors. Thus size cannot be considered a very 'good' character (Davis and Heywood, 1963). In test runs it has been found that items first cluster for size, then shape - so to avoid information loss runs must be modified to give preference to shape characters.

Although other packages are available (see Bibliography of Computer programs. In Pankhurst, R.J. (ed), 1975); BOLAID was used because it is available at U.C.T. and the author is resident at the Bolus Herbarium, U.C.T.

It is important to bear in mind that although the group-forming matrix and numerical key are produced very rapidly by the computer; the initial character selection and coding still require a great deal of time from the human component (refer advantages of NT, point 2).

TABLE 2: MORPHOLOGICAL CHARACTERS SCORED FROM THAMNOCHORTUS SPECIES (1)

	CHARACTER	QUALITATIVE CHARACTER STATES	DEWEIGHT
STEM	1. Degree of pubescence.	Glabrous or pubescent.	
	2. Degree of shoot growth.	No shoot growth or shoot growth.	
	22-1. Minimum height. (cm)		
	22-2. Maximum height. (cm)		
	23-1. Usual minimum diameter. ($\times 10^{-2}$ mm)		
	23-2. Usual maximum diameter. ($\times 10^{-2}$ mm)		
	40. Degree of white speckling.	No white speckling or white speckling.	33%
	41. Degree of yellow speckling.	No yellow speckling or yellow speckling.	33%
	42. Degree of grey speckling.	No grey speckling or grey speckling.	33%
	86. Degree of presence of punctules.	Non-puncticulate or puncticulate.	
	87. Degree of presence of sulcae.	Non-sulcate or sulcate.	
	88. Degree of presence of tubercles.	Non-tubercled or tubercled.	
	89. Degree of branching of culm.	Non-branching culm or branching.	
SHEATHS	3. Degree of pubescence.	Glabrous or pubescent.	
	4. Degree of acuteness of apex.	Obtuse, mucronate or aristate.	
	5. Degree of striateness of veins.	Non-striate, closely or nervose striate.	
	24. Degree of convoluteness of sheaths.	Closely or tightly.	50%
	25. Degree of looseness of upper parts.	Not loose or loose.	50%

	CHARACTER	QUALITATIVE CHARACTER STATES	DEWEIGHT
SHEATHS (contd.)	26. Degree of paleness.	Not pale or pale.	25%
	27. Degree of red-browness.	Not red-brown; or light brown, brown, chestnut-brown or red-brown.	25%
	28. Degree of purple colouration.	Not purplish or purplish.	25%
	29. Degree of speckling.	Not speckled or speckled.	25%
	30. Degree of oblongness (varying width).	Linear-oblong, oblong-lanceolate or oblong.	50%
	31. Degree of lanceolateness (varying width).	Oblong-lanceolate, lanceolate or linear-lanceolate.	50%
Series?	32. Degree of membranousness.	Non-membranous or membranous.	25%
	33. Degree of chartaceousness.	Non-chartaceous or chartaceous.	25%
	34. Degree of coriaceousness.	Non-coriaceous or coriaceous.	25%
	35. Degree of cartilaginousness.	Non-cartilaginous or cartilaginous.	25%
	36. Degree of membranousness of margins.	Non-membranous or membranous.	33%
	37. Degree of width of margins.	Narrow or wide.	33%
	38. Degree of laceratenes of margin.	Non-lacerate or lacerate.	33%
	39-1 Usual minimum length. (mm)		
	39-2 Usual maximum length. (mm)		
	90. Degree of position of sheaths.	Not situated distantly or situated distantly.	
	91. Degree of ribbing on sheath.	Not ribbed longitudinally or ribbed longitudinally.	

	CHARACTER	QUALITATIVE CHARACTER STATES	DEWEIGHT
MALE INFLORESCENCE	6. Degree of mucronateness of apex of bracts.	Obtuse, acuminate, acute, mucronulate, or mucronate.	
	7. Degree of red-browness of bracts.	Pale or red-brown.	
	8. Degree of attachment of perianth.	Sessile or stipitate.	
	9. Degree of apiculateness of apex of outer perianth segments.	Obtuse, acute, mucronate or apiculate.	
	10. Degree of keeling of outer perianth segments.		
	11. Degree of acuteness of apex of inner perianth segments.	Truncate, obtuse or acute.	
	43. Shape of spikelets (degree of width of middle).	Linear, lanceolate, ovate-lanceolate, oblanceolate, elliptic, ovate, oblong or obovate.	50%
	44. Degree of roundness of base of spikelets.	Cuneate, attenuate or rounded.	50%
	45-1. Usual minimum length of spikelets (mm).		
	45-2. Usual maximum length of spikelets (mm).		
	46. Degree of arrangement of bracts.	Loosely convolute, loosely imbricate or erect-spreading.	
	47. Degree of quinquefariusness.	Non-quinquefarius or quinquefarius.	
	48-1. Usual minimum length of bracts (mm x 10^{-1}).		
	48-2. Usual maximum length of bracts (mm x 10^{-1}).		

	CHARACTER	QUALITATIVE CHARACTER STATES	DEWEIGHT
MALE INFLORESCENCE (contd.)	49. Degree of lanceolateness of bracts.	Ovate-lanceolate, oblanceolate or lanceolate.	50%
	50. Degree of oblongness of bracts.	Oblanceolate, ovate-oblong, elliptic-oblong or oblong.	50%
	51. Degree of chartaceousness of bracts.	Non-chartaceous or chartaceous.	33%
	52. Degree of coriaceousness of bracts.	Non-coriaceous or coriaceous.	33%
	53. Degree of cartilaginousness of bracts.	Non-cartilaginous or cartilaginous.	33%
	54-1. Usual minimum length of perianth (10^{-2} mm).		
	54-2 Usual maximum length of perianth (10^{-2} mm).		
	55. Degree of membranousness of perianth segments.	Non-membranous or membranous.	50%
	56. Degree of cartilaginousness of perianth segments.	Non-cartilaginous or cartilaginous.	50%
	57. Degree of lanceolateness of outer perianth segments.	Oblanceolate, linear-lanceolate or lanceolate.	33%
	58. Degree of linearness of outer perianth segments.	Linear-oblong, linear-lanceolate or linear.	33%
	59. Degree of oblongness of outer perianth segments.	Linear-oblong, oblanceolate or oblong.	33%
	60. Degree of lanceolateness of inner perianth segments.	Oblanceolate, linear-lanceolate or lanceolate.	50%
	61. Degree of oblongness of inner perianth segments.	Linear-oblong, obovate or oblong.	50%
	92. Degree of membranousness of margins.	Non-membranous or membranous.	

	CHARACTER	QUALITATIVE CHARACTER STATES	DEWEIGHT
FEMALE INFLORESCENCE	12. Degree of tapering of base of spikelets.	Rotundate, attenuate or cuneate.	
	13. Degree of arrangement of bracts.	Loosely convolute, loosely imbricate or erect-spreading.	
	14. Degree of aristateness of apex of bracts.	Acute, mucronate or aristate.	
	15. Degree of red-browness of bracts.	Non red-brown or red-brown.	
	16. Degree of attachment of perianth.	Sessile or stipitate.	
	17. Degree of roundness of shape of perianth.	Elliptic, oblong, obovate, rotundate or orbicular.	
	18. Degree of apiculateness of apex of outer perianth segments.	Obtuse, acuminate, acute mucronulate, mucronate or apiculate.	
	19. Degree of keeling of outer perianth segments.		
	20. Length of inner perianth segments / length of outer perianth segments.	Shorter, equal to, or longer.	
	21. Degree of acuteness of apex of inner perianth segments.	Obtuse or acute.	
	62-1. Usual minimum length of inflorescence (cm).		
	62-2. Usual maximum length of inflorescence (cm).		
	63-1. Usual minimum length of spikelets (mm).		

	CHARACTER	QUALITATIVE CHARACTER STATES	DEWEIGHT
FEMALE INFLORESCENCE (contd.)	63-2. Usual maximum length of spikelets (mm).		
	64. Degree of oblongness of spikelets.	Oblanceolate, oblong-ovate or oblong.	33%
	65. Degree of lanceolateness of spikelets.	Oblanceolate, ovate-lanceolate, linear-lanceolate or lanceolate.	33%
	66. Degree of ellipticness of spikelets.	Non-elliptic or elliptic.	33%
	67. Degree of lanceolateness of bracts.	Oblanceolate, ovatelanceolate, linear-lanceolate or lanceolate.	50%
	68. Degree of oblongness of bracts.	Oblanceolate, ellipticoblong or oblong.	50%
	69. Degree of chartaceousness of bracts.	Non-chartaceous or chartaceous.	33%
	70. Degree of cartilaginousness of bracts.	Non-cartilaginous or cartilaginous.	33%
	71. Degree of coriaceousness of bracts.	Non-coriaceous or coriaceous.	33%
	72-1. Usual minimum length of bracts (mm).		
	72-2. Usual maximum length of bracts (mm).		
	73-1. Usual minimum length of perianth (mm x 10^{-2}).		
	73-2. Usual maximum length of perianth (mm x 10^{-2}).		
	74. Degree of membranousness of perianth segments.	Non-membranous or membranous.	25%

	CHARACTER	QUALITATIVE CHARACTER STATES	DEWEIGHT
FEMALE INFLORESCENCE (contd.)	75. Degree of cartilaginousness of perianth segments.	Non-cartilaginous or cartilaginous.	25%
	76. Degree of coriaceousness of perianth segments.	Non-coriaceous or coriaceous.	25%
	77. Degree of chartaceousness of perianth segments.	Non-chartaceous or chartaceous.	25%
	78. Degree of linearness of lateral segments of perianth.	Linear-lanceolate, linear-oblong, or linear.	50%
	79. Degree of lanceolateness of lateral segments of perianth.	Oblong-lanceolate, linear-lanceolate, or lanceolate.	50%
	80. Degree of lanceolateness of inner perianth segments.	Deltoid-lanceolate, oblong-lanceolate, linear-lanceolate or lanceolate.	33%
	81. Degree of oblongness of inner perianth segments.	Linear-oblong, oblong-lanceolate or oblong.	33%
	82. Degree of ovateness of inner perianth segments.	Non-ovate or ovate.	33%
	83. Degree of scabridness of ovary.	Present or absent.	33%
	84. Degree of papilloseness of ovary.	Present or absent.	33%
	85. Percentage area of ovary scabridness or papilloseness.	50% or 100% coverage.	33%
	93. Degree of membranousness of margins of bracts.	Non-membranous or membranous.	
	94. Degree of presence of wings on outer perianth segments.	Non-winged or winged.	
	95. Degree of hirsuteness of style.	Non-hirsute or hirsute.	

5. RESULTS AND DISCUSSION

5.1. The Dendogram

The product of the grouping study is a dendogram (Figure 2), showing the similarity levels at which the items are clustered. The dendogram is structured to give the clusters most unrelated to the array as a whole on the right, the most 'core-like' on the left-based on averaged peculiarity indices (Hall, 1965; 1969b). The peculiarity indices are given for each item (see Appendix).

The dendogram demonstrated close linkage within the group, although 6 sub-groups could be detected (A-F in Figure 2). The criteria as to how the sub-groups differ, and in what properties has not been determined in this study - though this is possible using BOLAID subroutine HOMDIF. (see Hall, 1973). For the purposes of this study, it was only necessary to investigate the overall similarity of the items.

The lower similarity of item 2 (T. argenteus) is explainable in that items 1, 2, and 24 (T. Fruticosus, T. argenteus and T. acuminatus) are linked on the property: stems - pubescent. These items should therefore cluster to the right of the dendogram. Items 1 and 24 are however, more closely affiliated - thus in terms of overall similarity item 2 should show up as most unrelated.

Species which Pillans (1942 - 1952) recorded as possessing affinities, and which are present at least in the same sub-group in the dendogram, are:

T. papyraceus and T. stokoei	Items 25 and 17.
T. comptonii and T. stokoei	Items 27 and 17.
T. papillosus and T. Dichotomus	Items 32 and 19.
T. pellucidus and T. schelechteii	Items 33 and 13.
T. piketbergensis and T. dichotomus	Items 34 and 19.
T. sporadicus and T. dichotomus	Items 37 and 19.

Affinities / -

Affinities between species recorded by Pillans' which are not demonstrated in the dendogram clusters are:

T. acuminatus and T. fruticosus	Items 24 and 1.
T. lewisiae and T. muirii	Items 28 and 6.
T. muticus and T. dichotomus	Items 29 and 19.
T. nervosus and T. fraternus and T. paniculatus	Items 30, and 10 and 9.
T. plumosus and T. nutans	Items 35 and 5
T. similis and T. dichotomus and T. stoekoei	Items 36 and 19 and 17.

5.2. The Key

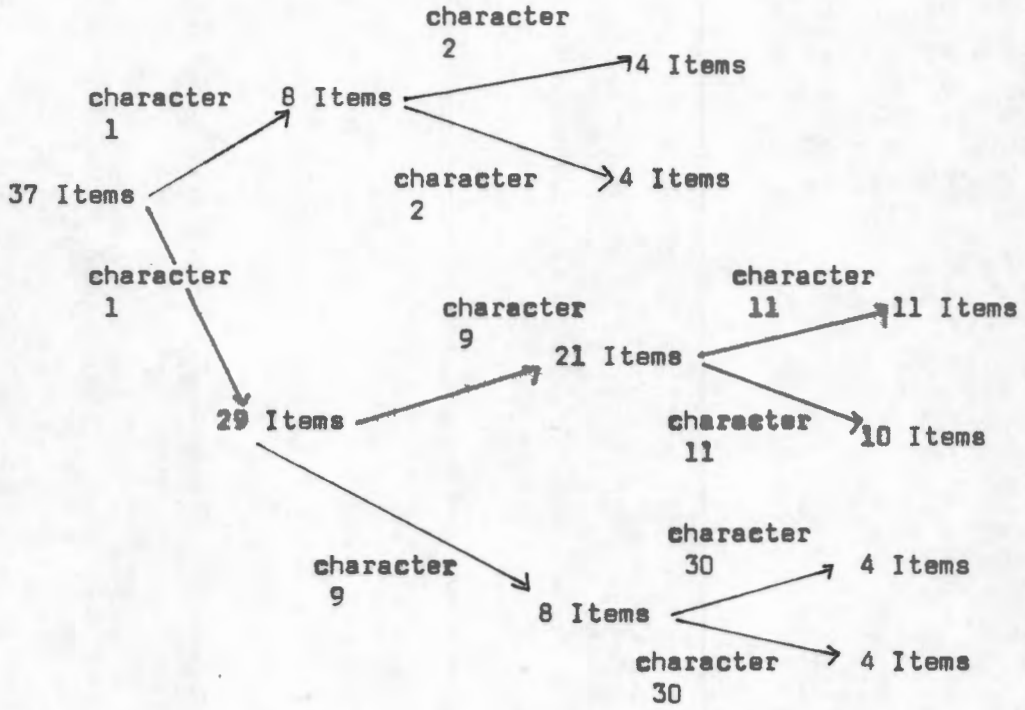
The BOLAID subroutine keys produces an indented numerical key (see Appendix), that must be written out in full for use (Figure 3). All items were successfully keyed out.

Osborne (1963) has confirmed that the key with the smallest average number of questions for identifying taxa gives the most reliable results. This is achieved by using characters that split groups into equal or near-equal sets.

From Figure 3 it will be observed that key character 1 (sheath margins non-membranous/membranous) divides the 37 items into two groups of 8 items and 29 items. Key character 2 (shape of bracts of female inflorescence and colour of male inflorescence), subdivides the group of 8 into 2 subgroups of 4 items.

The group of 29 items is subdivided into 21 and 8 items by key character 9 (stems devoid of yellow speckling/yellow speckled). Key-character 11 (colour of bracts of female inflorescence) divides the group of 21 items into 2 groups of 11 and 10 items. Key-character 30 (shape of perianth of female inflorescence) divides the group of 8 items into 2 groups of 4 items. This

is diagramized below:



Thus the majority of divisive key-characters split groups into equal or near-equal sets.

However, some of these major leads are rather obscure e.g. sheath margins and shape of perianth of female inflorescence. This weakness in the key is as a result of weakness in the data selection. De-weighting characters such as these, and allowing the more easy to observe characters to contribute fully, should be attempted. However, de-weighting characters may result in only some of the items being keyed out, and consequently more data may have to be supplied.

With regards to weakness in the data base, it is felt that the study has not fully complied with the definition of NT characters. The descriptive terminology employed for the shapes of various inflorescence organs (i.e. elliptic-rotundate; linear-oblong; obovate etc.) have not been redefined numerically (refer section 3 - advantages of NT, point 4). The shapes should have been coded on criteria such as: diameter at middle; and length : width ratio.

Rearrangement of the data base may contribute to providing a stronger key.

A character that is used often in this key is degree of shoot growth off culms. It features mainly at the level of differentiating between two items. Whether this can be considered a useful distinguishing character has not yet been determined, as the key is untested.

The major subgroups derived from the key do not appear to correlate with the dendogram sub-groups.

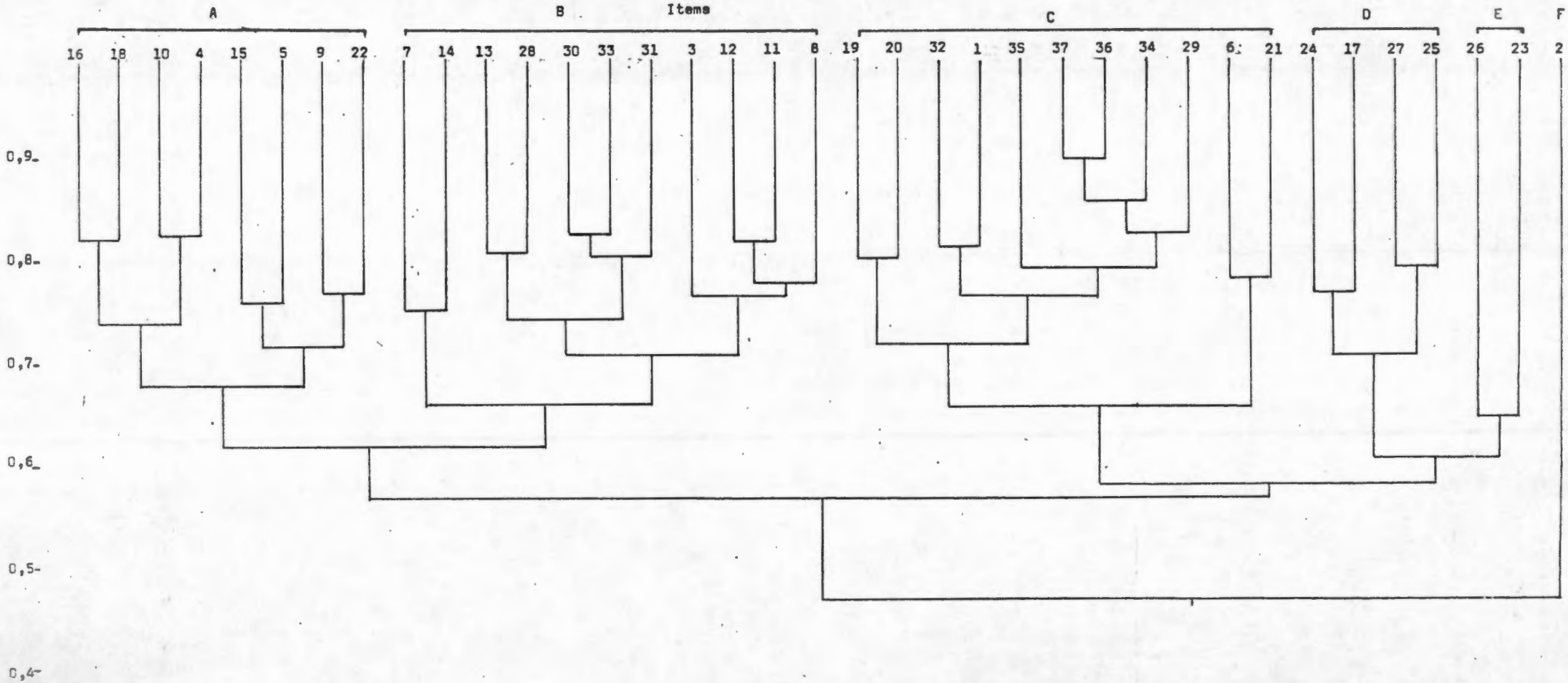


Figure 2: Dendogram illustrating similarity levels at which items are clustered. A - F refer to the six major subgroups.

Figure 3: Key to the genus THAMNOCHORTUS.

(Based on vegetative and floral characters).

This is an unweighted-character key.

1a. Sheath margins non-membranous.

2a. Bracts of female inflorescence oblong-lanceolate; and bracts of male inflorescence usually pale.

3a. Apex of outer perianth segments of female inflorescence acute-acuminate; and outer perianth segments of male inflorescence have distinct keel.

4a. Culms devoid of shoot growth; and sheath apex generally obtuse . . . . . T. papyraceus (25).

4b. Culms possess slight degree of shoot growth; and sheath apex generally mucronate . . . . . T. gracilis (20).

3b. Apex of outer perianth segments of female inflorescence acute-apiculate; and outer perianth segments of male inflorescence have only slight degree of keeling.

5a. Culm stems glabrous; and culms have some shoot growth . . . . . T. dumosus (14).

5b. Culm stems pubescent; and culms possess much shoot growth . . . . . T. fruticosus (1).

2b. Bracts of female inflorescence oblong; and bracts of male inflorescence usually light-brown to red-brown.

6a. Bracts of male inflorescence light-brown; and outer perianth segments of female inflorescence not winged.

7a. Apex of outer perianth segments of male inflorescence generally obtuse; and base of spikelets of female inflorescence rotundate .. . . . . T. comptonii (27).

7b / -

7b. Apex of outer perianth segments of male inflorescence acute; and base of spikelets of female inflorescence cuneate . . . . . T. platypteris (15).

6b. Bracts of male inflorescence red-brown; and outer perianth segments of female inflorescence winged.

8a. Culm stems glabrous; and culms devoid of shoot growth . . . . . T. scabridus (7).

8b. Culm stems slightly pubescent; and culms possess much shoot growth .. . . . . T. acuminatus (24).

1b. Sheath margins membranous.

9a. Culm stems devoid of yellow speckling.

10a. Sheaths non-cartilaginous.

11a. Bracts of female inflorescence not red-brown.

12a. Sheath apex obtuse.

13a. Culms do not possess shoot growth; and attachment of perianth of female inflorescence slightly stipitate . . . . . T. muticus (29).

13b. Culms possess shoot growth; and attachment of perianth of female inflorescence stipitate.

14a. Apex of bracts of male inflorescence generally acuminate; and bracts of male inflorescence red-brown . . . . . T. plumosus (35).

14b. Apex of bracts of male inflorescence generally

acute / -

acute; and bracts of male inflorescence usually light-brown . . . . . T. similis(36).

12b. Sheath apex mucronate.

15a. Perianth segments of male inflorescence non-cartilaginous; and outer perianth segments of male inflorescence lanceolate.

16a. Outer perianth segments of female inflorescence have slight degree of keeling; and attachment of perianth of female inflorescence slightly stipitate.

17a. Culms devoid of shoot growth; and sheaths non-striate . . . . . T. spicigerus (23).

17b. Culms possess some shoot growth; and sheath veins nervose striate . . . T. nervosus (30).

16b. Outer perianth segments of female inflorescence devoid of keel; and attachment of perianth of female inflorescence distinctly stipitate.

18a. Culms devoid of shoot growth; and apex of bracts of male inflorescence generally obtuse.. . . . . T. muirii (6).

18b. Culms possess much shoot growth; and apex of bracts of male inflorescence generally mucronate . . . . . T. glaber (3)

15b. Perianth segments of male inflorescence cartilaginous; and outer perianth segments usually oblanceolate.

19a / -

19a. Culms devoid of shoot growth; inner perianth segments of male inflorescence usually oblong.

20a. Apex of bracts of male inflorescence generally obtuse; and perianth of male inflorescence slightly stipitate . . . . . *T. pi ketbergensis* (34).

20b. Apex of bracts of male inflorescence generally acuminate; and perianth of male inflorescence stipitate. . . . . *T. nutans* (5).

19b. Culms possess much shoot growth; and inner perianth segments usually linear-oblong.

21a. Sheath veins closely striate; and apex of outer perianth segments of male inflorescence usually acute. . . . . *T. lewisiae* (28).

21b. Sheath veins nervose striate; and apex of outer perianth segments of male inflorescence acute-apiculate. . . . . *T. sporadicus* (37).

11b. Bracts of female inflorescence red-brown.

22a. Sheaths closely convolute.

23a. Culm stems glabrous; shoot growth absent / some present; and sheaths glabrous.

24a. Culms devoid of shoot growth; and sheath apex mucronate . . . . . *T. papillosus* (32).

24b. Culms possess some shoot growth; and sheath apex oristate . . . . . *T. obtusus* (31).

23b. / -

23b. Culm stems distinctly pubescent; shoot growth present; and sheaths pubescent . . . . . T. argenteus (2).

22b. Sheaths tightly convolute.

25a. Apex of outer perianth segments of male inflorescence acute; and attachment of perianth of female inflorescence distinctly stipitate.

26a. Sheaths veins closely striate; and attachment of perianth of male inflorescence subsessile . . . . T. paniculatus (9).

26b. Sheath veins nervose striate; and attachment of perianth of male inflorescence stipitate . . . . . T. fraternus(10).

25b. Apex of outer perianth segments of male inflorescence obtuse-apiculate; and attachment of female inflorescence sub-sessile . . . . . T. insignis (22).

10b. Sheaths cartilaginous.

27a. Apex of inner perianth segments of female inflorescence obtuse; and bracts of female inflorescence generally lanceolate.

28a. Culms do not possess culm growth; and sheath apex generally aristate . . . . . T. pulcher (26).

28b. Culms possess much shoot growth; and sheath apex generally mucronate . . . . . T. pellucidus (33).

27b. Apex of inner perianth segments of female inflorescence generally sub-obtuse; and bracts of female inflorescence usually oblanceolate.

29a. Culms devoid of shoot growth; and sheath veins nervose striate . . . . . T. ellipticus (8).

29b. / -

29b. Culms possess slight amount of shoot growth; and sheaths non-striate . . . . . T. stokoei (17).

9b. Culm stems yellow-speckled.

30a. Perianth of female inflorescence elliptic.

31a. Apex of outer perianth segments of male inflorescence sub-acute - acute; and bracts of female inflorescence red-brown.

32a. Sheaths veins closely striate; and attachment of perianth of male inflorescence subsessile . . . . . T. bachmanni (16).

32b. Sheath veins nervose striate; and attachment of perianth of male inflorescence stipitate . . . . . T. levynsiae (4)

31b. Apex of outer segments of perianth of male inflorescence obtuse-apiculate; and bracts of female inflorescence not red-brown.

33a. Culms devoid of shoot growth; and apex of bracts of male inflorescence generally acuminate . . . . T. schlechteri (13)

33b. Culms possess much shoot growth; and apex of bracts of male inflorescence acute-mucronulate. . . . . T. guthriae (12).

30b. Perianth of female inflorescence rotundate-orbicular.

34a. Bracts of female inflorescence non-coriaceous; and bracts of male inflorescence generally ovate-lanceolate.

35a. Sheath veins nervose striate; and apex of inner perianth segments of male inflorescence generally obtuse . . . . . T. pluristachyus (11).

35b. / -

35b. Sheath veins closely striate; and apex of inner perianth segments of male inflorescence generally acute . . . . _T. erectus_ (21).

34b. Bracts of female inflorescence coriaceous; and bracts of male inflorescence oblanceolate-lanceolate.

36a. Culms devoid of lateral shoot growth; and sheath apex usually aristate . . . . _T. punctatus_

36b. Culms possess some shoot growth; and sheath apex usually mucronate . . . . _T. dichotomus_ (19).

6. CONCLUSIONS AND SUGGESTIONS FOR FURTHER WORK.

A phenetic (Cain and Harrison, 1960; Sneath, 1976) numerical taxonomic study of the Restionaceous genus Thamnochortus, Berg. was attempted.

A dendrogram and comprehensive key were produced using BOLAID sub-routines. The genus was demonstrated to be fairly closely linked. Modifications with respect to the data base and key are suggested.

It may be possible to utilize the key obtained in this study for further work. Keys for identification of the male and female plants separately could be produced by de-weighting out female and male inflorescence characters respectively. In addition, it would be useful to attempt to obtain keys for the identification of Thamnochortus species in a particular area; for example: a key to the Thamnochortus spp. of the Cape Peninsula.

In this manner, it is to be hoped that the information obtained in this study may eventually contribute usefully to the taxonomy of the Restionaceae.

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A P P E N D I X

GLOSSARY I - taxonomic terms used by N.S. Pillans in his description of the genus.

GLOSSARY II - numerical taxonomic terms.

CODED DATA INPUT.

GROUP FORMING MATRIX.

KEY FORMING MATRIX.

GLOSSARY I: Descriptive terms employed by Pillans.

ACUMINATE - having a gradually diminishing point.

ACUTE - distinctly and sharply pointed but not drawn out.

APICULATE - short, sharp not a stiff point.

ARISTATE - awned.

ATTENUATE - narrow, tapered.

CAESPITOSE - growing in tufts like grass.

CARINATE - keeled.

CARTILAGINOUS - hard and tough.

CERNUOUS - nodding.

CHARTACEOUS - papery.

CONVOLUTE - one part wholly rolled up in another.

CORIACEOUS - leathery.

CULM - stem of grass/sedge.

CUNEATE - wedge-shaped, triangular.

CYMOSE - flower cluster of determinate type.

DECLINATE - bent/curved downwards.

DECURRENT - of a leaf, having the base extending down the stem as two wings.

DELTOID - shaped like an equatorial triangle.

DENTATE - toothed.

ELLIPTIC - oval shaped, with narrowed ends.

EXCURRENT - said of a vein which runs out beyond the lamina of the leaf.

FERRUGINOUS - rust coloured.

FILIFORM - thread shaped.

GEMINATE - in pairs.

GLABROUS - destitute of hairs.

GLUMACEOUS - resembling glumes of grasses.

HIRSUTE - hairy, with long tolerably distinct hairs.

HISPIDULOUS / -

HISPIDULOUS - minutely set with rough hairs/bristles.

HYALINE - colourless, translucent.

IMBRICATE - overlapping - as in roof tiles.

INFLORESCENCE - any arrangement of more than one flower, e.g. raceme, cyme, capitulum, umbel.

LACERATE - torn, irregularly cleft.

LANCEOLATE - flattened, 2 or 3 times as long as broad, widest in middle and tapering to a pointed apex.

LAX - loose, distant.

LINEAR - narrow, several (4-5 times) longer than wide, with parallel sides.

MEMBRANOUS - thin and semi-transparent.

MUCRONATE - possessing a short straight point.

MUTICOUS - pointless, blunt, awnless.

NAVICULAR - boat shaped.

NERVES - simple, unbranched vein, simple rib.

NERVOSE - full of nerves.

OBLANCEOLATE - lanceolate, tapering, but towards base.

OBLONG - much longer than broad, with nearly parallel sides.

OBLONG - ELLIPSOID - having long side almost parallel, and the ends almost hemispherical.

OBOVATE - having the outline of an egg, with broadest part in middle and attached at narrow end.

OBOVOID - obovate solid, distal end broader.

OBTUSE - rounded or blunt at end.

ORBICULAR - of a flat body with a circular outline.

PANICLE - strictly a branched raceme with each branch bearing a further raceme of flower. More loosely, it applies to any complex, branched inflorescence.

PANICULATE - loose flower cluster.

PAPILLOSE - covered with soft, superficial hairs.

PENDULOUS - hanging down.

PLUME - feather like.

PUBESCENT - covered in short, soft hairs.

PUNCTICULATE / -

PUNCTICULATE - minutely marked with dots, depressions.

QUINQUEFARIS - in five ranks.

RACEMOSE - inflorescence capable of indefinite prolongation, having lateral and auxillary flowers.

RACHILLE - axis in centre grass spikelets.

ROTUNDATE - outline is rounded, inclined oblong.

RUGULOSE - somewhat wrinkled.

SCABRID - somewhat rough.

SECUND - parts/organs directed to one side only (result of torsion).

SESSILE - destitute of stalk.

SETACO - pointed (bristle like).

SPATHELLAE - spatula-like.

SPATHES - large bract enclosing flower cluster.

SPATULATE - spoon-shaped.

SPICIFORM - spike-like (spicate).

SPORADIC - widely dispersed, scattered.

STIPITATE (STIPULATE) - having stipe or special stalk.

STRIATE - marked with fine, longitudinal, parallel lines.

SUBSESSILE - almost devoid of stalk.

SUBORBICULAR - nearly circular.

SUBTRIGONOUS - rather triangular.

SUBULATE - awl shaped.

SULCATE - grooved, furrowed.

TERETE - circular in T.S. Cylindrical usually tapering.

TRIGONOUS - 3 angled, with plane faces.

TRUNCATE - as though cut off at end.

TUBERCULED - covered in warty excrecences.

TURBINATE - shaped liked a top.

(from Jackson, 1905; Usher, 1965; Heywood, 1978).

GLOSSARY II: Numerical taxonomic terminology used in study.

ACCESSORY CHARACTER: A character not necessary for the identification of some taxon, yet useful for verifying or confirming the identification (also called auxilary or confirmatory character).

ALGORITHM: A finite series of logical steps or instructions by which a specific type of problem can be solved.

ATTRIBUTE: See character.

BINARY CHARACTER: See Two-state character.

CHARACTER: A particular feature or other way in which organisms may differ; a particular basis for comparing two organisms, populations or taxa. The possible alternative expressions of a character are called the states, values or levels of the character. Also defined as 'a taxonomic character of two or more states which within the study at hand cannot be subdivided logically except for subdivision brought about by the method of coding' (Sneath and Sokol, 1973 : p.74). See also Michener and Sokal (1957).

CHARACTER CODING: The steps involved in converting the data into a form suitable for computation, whilst still preserving the kind of information the taxonomist wishes to consider in making a classification. Character states are concisely and unambiguously labelled or recorded with a particular system of numbers, letters, or other symbols.

CHARACTER STATE: One of two or more possible alternative expressions of a character.

CHARACTER WEIGHTING: A numerical or other indication or estimation of different importance values for the various characters used in some application. (The typical 'unweighted' case is really an assumption of equal

character / -

character weights).

In identification, unlike classification, it is generally agreed that character weighting is important in giving preference to unambiguous, easily observed characters readily studied in the material to be identified. Another use of character weighting in identification is in producing identification systems for different purposes, such as separate keys for flowering, fruiting, and vegetative plant material.

In this study, the contribution to overall similarity of chosen properties can be reduced by a deweighting factor in the group studies (Hall, 1973).

DATA MATRIX: A rectangular table presenting the data for numerical taxonomy in the form of an n x t matrix. The t columns represent the t OTU'S to be grouped on the basis of resemblances and whose n rows are n unit characters. Each entry X_{ij} in such a matrix is the score of OTU j for character i. (Sokal and Sneath, 1973 : p. 114).

Characters	OTU's			
	1	2	⋯	t
1	X_{11}	X_{12}	⋯	X_{1t}
2	X_{21}	X_{22}	⋯	X_{2t}
⋮	⋮	⋮		⋮
n	X_{n1}	X_{n2}	⋯	X_{nt}

GROUP: An informal term for a set of related taxa which is subject of a particular study.

INDENTED KEY: A printed dichotomous key in which each lead of a couplet is immediately followed by all couplets subordinate to it. In such a key, each subordinate couplet is usually indented one unit farther to the right than its predecessor, giving a stepped outline to the left-hand side of the key.

ITEMS: An item is an object or concept being classified. It is sometimes called an operational taxonomic unit or O.T.U. (Hall, 1973).

MODAL CHARACTER: A model character must at least have the potential for a range, with an imaginable mode, over a set of items. Measurements, or scored degrees of development of a phenomenon, are examples (Hall, 1973).

MULTI-STATE CHARACTER: Like binary, multi-state characters must have no existing or likely intermediates between the states (Hall, 1973).

O.T.U. (OPERATIONAL TAXONOMIC UNIT): In NT, taxonomic units of different categorical ranks are employed as the entities to be grouped into more inclusive aggregates during classification. Therefore, we cannot speak of fundamental taxonomic units, but shall refer to operational taxonomic unites (OTU'S) (Sokal and Sneath, 1973).

PROPERTY: See character.

SPACE CONSERVATION: This gives the degree of departure from maximum compactness in a group-study. The values range from 0 (no space-conservation : compact) to 100 (maximum space-conservation : least possible compactness). Least compactness is needed for studies where any single item may represent a distinct population : classification space must be left around it to show its possible importance, and to allow for likely insertion of future allies. Zero space-conservation is used for strictly finite populations where a very compact classification is wanted (Hall, 1967, 1969c, 1973).

STATE: See character state.

TWO-STATE CHARACTER: A character having two distinct and mutually exclusive states. There should be no existing or likely intermediates between the states. (all-or-none characters, binary characters, presence-absence characters).

WEIGHTING / -

WEIGHTING OF CHARACTERS: See character weighting.

Definitions from Morse, Pankhurst and Rypka (1975, except where otherwise stated.