



OPSOMMING

Objektiwiteit in stratifisering, monsterneming

en klassifisering van plantegroei

deur

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PHILOSOPHIAE DOCTOR (PLANTKUNDE)

Die doelwitte van hierdie studie was om waarnemers bevooroordeelings in die stratifiserings-, monsternemings- en klassifiseringsprosesse van plantegroei-wetenskap te verminder, om sodoende herhaalbaarheid en voorspelbaarheid, in hierdie prosesse te verbeter, asook om die geldigheid van plantegroei-klassifikasies te verbeter.

Die doelwitte is bereik deur: stratifiserings-, monsternemings- en klassifiseringsprosesse met skaal in verband te bring, deur middel van skaal-gedefiniëerde plantegroei-stande; die verbetering van klein-skaal stratifisering en dus plantegroei kartering deur middel van skaalverwante, plantegroei-versterkte, satelliet-beelde; die ontwikkeling van verbeterde metodes vir plant bedekkingsbepalings; plantegroei-klassifikasie deur minimum entropie; en die bepaling van plantegroei status deur spesie samestelling volgens bedekking-tot-frekwensie-verhoudings, binne groeivorms. 'n



Rekenaarpakket om objektiwiteit by plantegroei-analise te verbeter en om tyd van analyses te verminder, is ontwikkel.

Die resultate van hierdie studie het tot 'n vermindering in visuele volgorde-bepaling, van plantegroei-matrikse, veral van opnames teen 'n klein-skaal, gelei. Daar is ook 'n ooreenstemmende afname in tyd wat vir klassifikasie benodig word. Die plantegroei-stand, volgens skaal gedefiniëer, verseker buigbaarheid ten opsigte van metodes wat toegepas kan word. Aanbevelings sluit die noodsaaklikheid vir bevestiging van 'n klassifikasie in, en verskeie bevestigingstegnieke word beskryf. Afgeleide toepassings, voortspruitende uit klassifikasies sluit spesies-samestellings-analise ter bepaling van spesiesverhoudings op 'n plantgemeenskaps basis, bepaling van sleutelspesies op spesies kompetisievermoë gebaseer asook stand fase-analise vir die monitering van veranderings in plantegroei-stande, in. Behalwe plantegroei klassifikasie en afgeleide toepassings sluit die rekenaarpakket fasiliteite vir veld indentifikasie van plantspesies, statistiese dataverwerking, plantgemeenskap en omgewing korrelasie en 'n floristiese databank in.

Hierdie werk beklemtoon die belangrikheid van plantegroei-klassifikasies en beveel dat die hoogste nasionale prioriteit aan die hulpbron plantegroei toegeken word omdat korrekte plantegroei-bestuur die bewaring van grond en grondwater ook kan verseker.



SUMMARY

Objectivity in stratification, sampling
and classification of vegetation

by

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in the

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The aims of this study were to reduce observer bias in the stratification, sampling and classification processes in vegetation science so as to improve repeatability and predictability, as well as to increase the relevancy of vegetation classifications.

The aims were achieved by: relating the stratification, sampling and classification processes to scale by means of scale-defined vegetation stands; improving small-scale stratification and hence vegetation mapping by the use of scale-related vegetation-enhanced satellite imagery; developing a method for improved plant cover estimations; vegetation classification by minimum entropy; and assessing vegetation state through species composition according to cover-to-frequency ratios, within growth forms. A computer program package was developed to facilitate objectivity in the analysis of vegetation data and reduce time spent on analyses.



The results of this study have lead to a reduction in visual sequencing of vegetation matrices, especially those involving small-scale work, with a corresponding decrease in time required for classification. The vegetation stand, defined according to scale, introduces greater flexibility in the sampling methods that can be applied. Recommendations include the necessity for verifying a classification and several methods of verification techniques have been described. Classification derivatives include species composition analysis for determining species relationships on a community basis, as well as determining key species based on species competitive ability, and stand phase analysis for monitoring changes in vegetation stands. Apart from vegetation classification and derivatives the computer program package includes facilities for field identification of plant species, statistical treatment of data, community and habitat correlations and a floristic data bank.

This work emphasizes the importance of vegetation classifications and recommends that the vegetation resource be given the highest national priority because correct vegetation management can also ensure conservation of soil and soil water.



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CURRICULUM VITAE

Robert Howard Westfall was born on the 17th December, 1944 in Kokstad, Cape Province. He completed high school at Fish Hoek, Cape Province in 1962. In 1976 he obtained a B.Sc. degree at the University of Pretoria with Botany and Zoology as major subjects.

In 1977 he was appointed as a Professional Officer at the Botanical Research Institute (Department of Agricultural Technical Services) in Pretoria. He was seconded, for completion of the B.Sc. (Hons.) degree, to the University of Pretoria in 1978 with ecology and taxonomy as major subjects. An M.Sc. degree was awarded to him in 1981 by the University of Pretoria on submission of a thesis entitled "The plant ecology of the farm Groothoek, Thabazimbi district.

In 1989 he was transferred to the Grassland Research Centre, which became the Roodeplaat Grassland Institute within the Agricultural Research Council in 1992, where he occupies the post of Principal Agricultural Researcher. During his period of service he has been engaged in ecological research and has concentrated on South African savanna vegetation and methodology in vegetation research.

Mr Westfall is a member of several scientific societies such as the South African Association of Botanists, the Grassland



Society of southern Africa and the South African Institute of Ecologists. He has been an active member of these societies, presenting papers at congresses and serving on the Northern Transvaal Branch of the South African Association of Botanists. He has served as treasurer for several years on this committee. He also serves on Departmental committees and was the convenor of the National Task Group for monitoring and evaluating vegetation change. He is registered as a natural scientist with the South African Council for Natural Scientists. The following is a list of published papers:

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APPENDIX I

ILLUSTRATED MORPHOLOGY FOR PLANT IDENTIFICATION IN THE FIELD

The character and character states used for field identification are sequenced in three main groups, namely, stemless or pseudo-stem, leafless and stems and leaves, from general to particular. This sequence is used for both encoding and identifying plants, as it was found that a set sequence facilitates encoding and identification. The program PHYTO 00 therefore, only sequences species to form dichotomies. Poaceae characters include those that are applicable to other plants as well as a group (numbers 187-224) which are exclusive to the Poaceae. Certain character states such as the presence of tendrils are redundant in the concept of climbing plants, in which they are implicitly included.

In field identification it was found that the efficiency of allocating a character state to a character of a plant is inversely proportional to the number of character states used. Fewer character states generally imply fewer problems with transitions between character states. The formula x gives the number of plants that can be differentiated where $x = \text{number of character states per character and } y = \text{the number of characters}$. For example, 4 character states per character for 8 characters provides 65 536 combinations. It is unlikely that so few characters and character states could be selected to differentiate



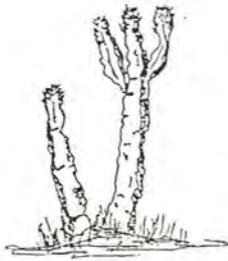
all the species in southern Africa. Nevertheless, this illustrates that judicious selection of characters and character states could be far more efficient, with further research, than those used at present.

Tables 4.4 to 4.9 show the results of the application of the character and character states, listed in this appendix, for field identification of plants.



* NOT MUTUALLY EXCLUSIVE
PHOTOSYNTHESIZING ORGANS PRESENT (REDUNDANT)

MAIN AXIS SHAPE



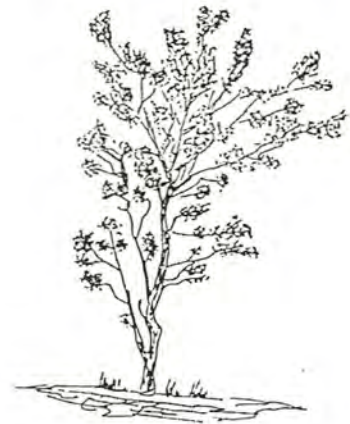
1. LEAFLESS (main axis photosynthetic)



2. STEMLESS OR PSEUDOSTEM
(main axis formed by separate
photosynthetic organs)



3. STEMS AND LEAVES (photosynthetic organs separate from main axis)





MAIN AXIS ORIENTATION



4. ERECT



4. ERECT



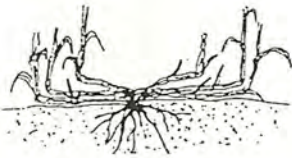
5. GENICULATE (abruptly bent)



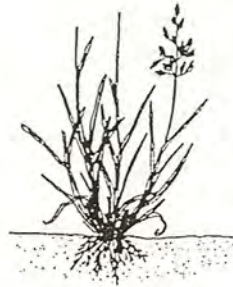
6. TWINING



7. CLIMBING (tendrils/hooks redundant)



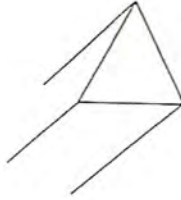
8. DECUMBENT



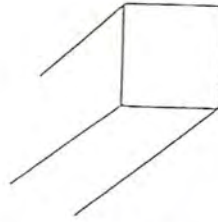
9. TUFTED/CLUMPED



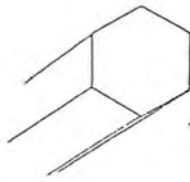
MAIN AXIS OUTLINE IN TRANSVERSE SECTION



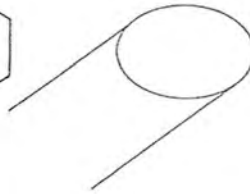
10. TRIANGULAR



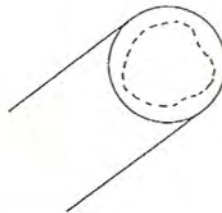
11. QUADRANGULAR



12. HEXAGONAL



13. ELLIPTIC/FLATTENED

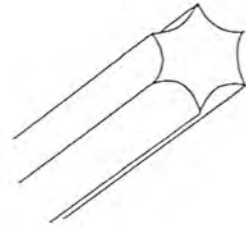


14. ROUND/IRREGULAR

MAIN AXIS SURFACE FEATURES *



15. SMOOTH



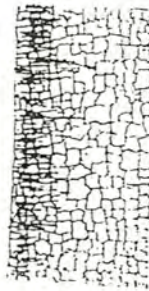
16. RIDGED



17. STICKY



18. FISSURED (longitudinal)



19. FISSURED (rectangular)



20. STRIPPED/PEELED/FLAKY (bark)

MAIN AXIS APPENDAGES (trunk) *



21. KNOBS



22. THORNS SINGLE
CURVED



23. THORNS SINGLE
RETROSE



24. SPINES SINGLE
STRAIGHT



25. THORNS AND SPINES PAIRED OR SINGLE, CURVED AND STRAIGHT



26. THORNS PAIRED
CURVED



27. SPINES PAIRED
STRAIGHT



28. THORNS IN THREES
CURVED



29. PRICKLES (short straight
or curved non-woody,
protuberances)



30. KNOTS
(Poaceae)

THORN/KNOB ARRANGEMENT
(trunk)



31. SCATTERED



32. IN ROWS

BRANCHING FROM MAIN AXIS



33. UNBRANCHED



34. OPPOSITE

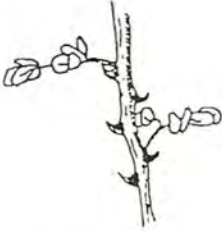


35. RECTANGULAR



36. SCATTERED

BRANCH/BRANCHLET APPENDAGES



37. THORNS SINGLE CURVED



38. THORNS SINGLE RETRORSE



39. SPINES SINGLE STRAIGHT



40. THORNS AND SPINES PAIRED OR SINGLE, CURVED AND STRAIGHT



41. THORNS PAIRED CURVED



42. SPINES PAIRED STRAIGHT



43. THORNS IN THREES CURVED



44. PRICKLES (short straight or curved,
non-woody protuberances)



45. SPINESCENT BRANCHLET

SAP (at stem, petiole or if succulent, leaf)



46. CLEAR



47. YELLOW/
RED



48. MILKY

LEAF ARRANGEMENT (separate photosynthetic organs)



49. OPPOSITE



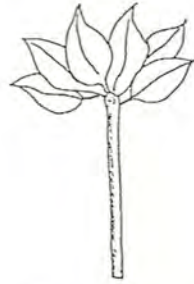
50. DECUSSATE



51. SPIRAL/ALTERNATE



52. WHORLED



53. CLUSTERED TERMINALLY ON
BRANCHES



54. CLUSTERED ON ABBREVIATED
BRANCHLETS/STEMS



55. DISTICHOUS (two rows)

LEAF ATTACHMENT



56. SESSILE (petiole less than 0,5 mm)



57. AMPLEXICAUL (enlarged base, petiole, stipule embracing stem)



58. PERFOLIATE (stem appears to pass through leaf base)



59. DECURRENT (leaf base runs down stem)

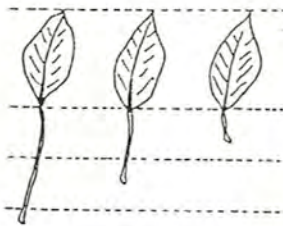


60. SHEATHING (lower part of leaf \pm encircles stem)



61. PELTATE (leaf attached by lower surface not margin)

- 62. PETIOLE GREATER THAN LAMINA LENGTH
- 63. PETIOLE HALF TO LAMINA LENGTH
- 64. PETIOLE LESS THAN HALF LAMINA LENGTH



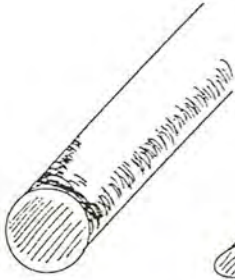
62.

63.

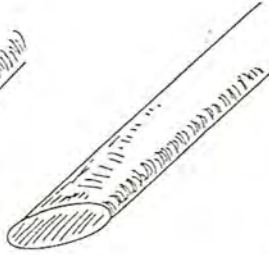
64.



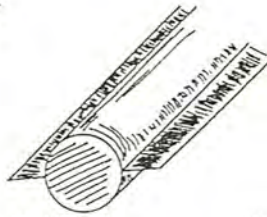
PETIOLE SHAPE



65. CYLINDRICAL



66. FLATTENED (one or both sides)

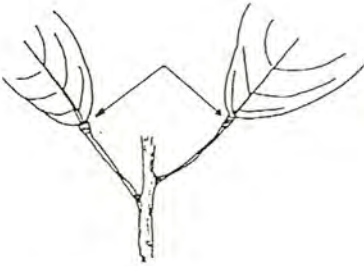


67. WINGED

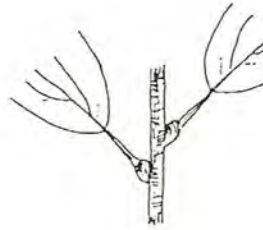


68. CHANNELED ABOVE (grooved)

PETIOLE APPENDAGES *



69. APEX SWOLLEN



70. BASE SWOLLEN



71. SINGLE BASAL GLAND



72. PAIRED BASAL GLANDS



LIGULES



73. ABSENT/INCONSPICUOUS



74. FRINGE OF HAIRS



75. MEMBRANE STRAIGHT



76. MEMBRANE ROUNDED



77. MEMBRANE POINTED



78. MEMBRANE NOTCHED



STIPULES (unmodified - young growth or stipular scar)



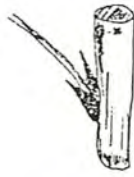
79. EXSTIPULATE



80. SINGLE



81. INTERPETIOLATE



82. PAIRED - FREE



83. PAIRED - JOINED



84. PAIRED - UNEQUAL



85. LOBED

LEAF FORM

petiolules greater than or equal to 0,5 mm
for compound leaves



86. SIMPLE



87. TWO



88. THREE



89. ONCE DIGITATE/PALMATE



90. TWICE DIGITATE/PALMATE



91. ONCE PINNATE



92. TWICE PINNATE



93. PARIPINNATE



94. IMPARIPINNATE

LEAFLET ATTACHMENT*



95. SESSILE



96. PETIOLATE



97. SESSILE/TERMINAL
PETIOLATE

LATERAL LEAFLET ARRANGEMENT (excluding terminal leaflet)



98. ALTERNATE LEAFLETS



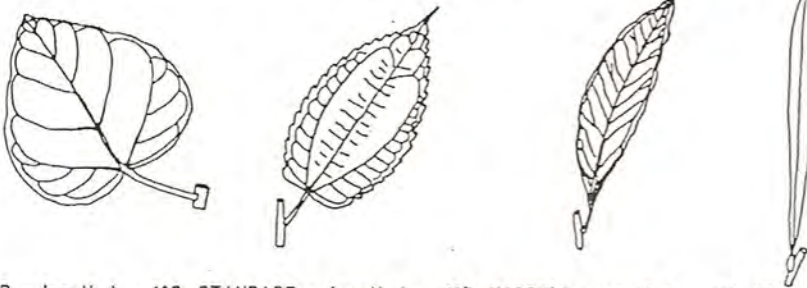
99. OPPOSITE LEAFLETS



100. ALL INSERTED AT ONE
POINT



LEAF SHAPE RATIO (compound leaves - entire lamina)

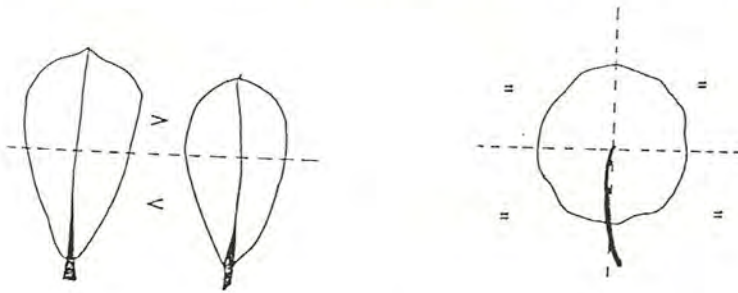


101. BROAD - length to width equal to or less than 1
 102. STANDARD - length to width greater than 1 to 3
 103. NARROW - length to width greater than 3 to 9
 104. LINEAR - length to width greater than 9

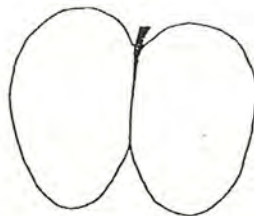
LEAF SHAPE (folded transversely with apex on base - lamina)



105. ELLIPTIC
 106. LINEAR (parallel sided - grasslike)
 107. OVATE (broadly/narrowly)



108. OBOVATE (broadly/narrowly)
 109. ORBICULAR (round)



110. BUTTERFLY



111. ASYMMETRIC

LEAF OR LEAFLET MARGINS *



112. ENTIRE



113. ENTIRE/UNDULATE



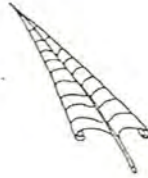
114. CILIATE



115. CONVOLUTE (rolled upon itself)



116. INVOLUTE (rolled inwards)



117. REVOLUTE (rolled down and back)



118. CRENATE (scalloped /rounded teeth)



119. SERRATE (sharp forward pointing teeth)



120. DENTATE (sharp outward pointing teeth - middle of lamina)



121. TOOTHED ENTIRE MARGIN



122. TOOTHED APEX ONLY



123. TOOTHED BASE ONLY



124. LOBED, UP TO HALFWAY TO MIDRIB



125. CUT, GREATER THAN HALFWAY TO MIDRIB



NERVATION, LAMINA



126. OPAQUE (nerves not visible)



127. PARALLEL



128. PINNINERVED (feather-like - major side veins parallel towards margin)



129. PINNATE/NET (side veins diminish to form net pattern)



130. LOOPED (major side veins joined by loops near margin)

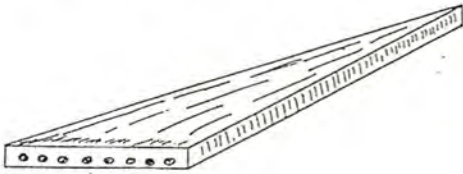


131. TRIPLINERVED (midrib with two major side veins originating from base of blades)

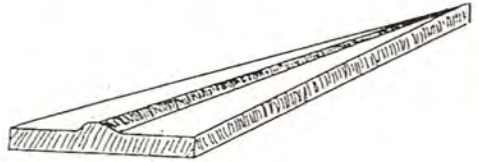


132. DIGITATELY NERVED (midrib with more than two major side veins originating from base of blade)

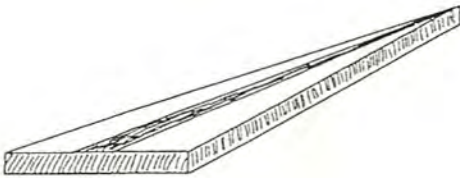
NERVATION RELIEF OF MIDRIB - PRINCIPAL RIB, DISTINCTLY THICKER THAN SIDE VEINS *



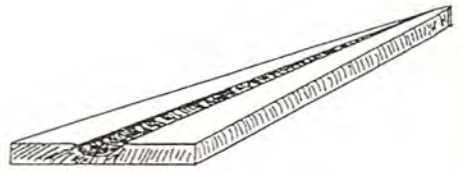
133. NO DISTINCT MIDRIB



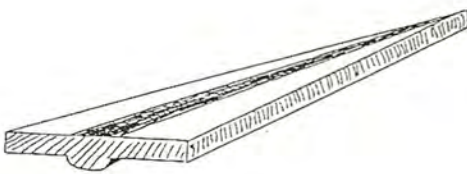
134. UPPER RAISED



135. UPPER LEVEL



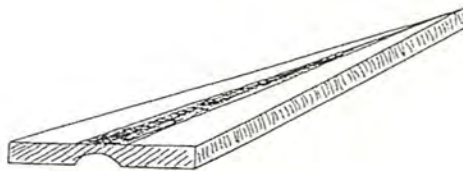
136. UPPER DEPRESSED



137. LOWER RAISED (keeled)

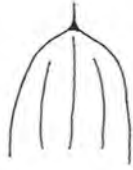


138. LOWER LEVEL

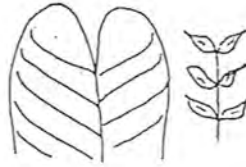


139. LOWER DEPRESSED

LEAF APEX (ENTIRE LAMINA)



140. MUCRONATE



141. EMARGINATE



142. OBTUSE/ROUNDED



143. ACUTE/POINTED

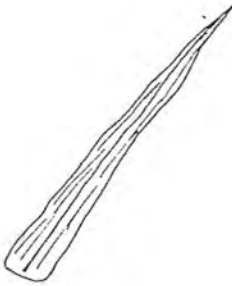


144. JUTTING/TWISTED



145. HOODED (emarginate when flattened)

LEAF BASE



146. TRUNCATE



147. OBTUSE/ROUNDED



148. AURICULATE



149. SAGITTATE



150. CORDATE (heartshaped)

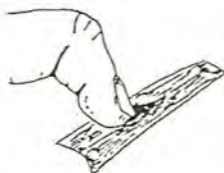


151. ACUTE/TAPERING

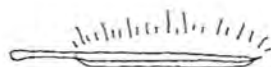
LEAF BLADE (lamina) COLOUR/TEXTURE *



152. FLESHY



153. GLAUCOUS (wax/powder bloom on bluish green)



154. GLOSSY



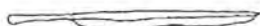
155. DISTINCTLY BICOLOROUS



156. WHITE SILVERY BELOW



157. RUSSET BROWN BELOW



158. GLABROUS (both surfaces)



159. STELLATE/TUFTED HAIRS



160. BRISTLY/SCABRID



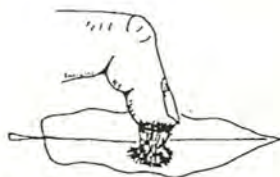
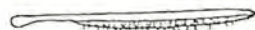
161. WOOLLY/FELTED



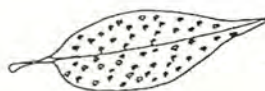
162. SPARSELY HAIRY



163. HAIRS ON SINGLE SURFACE



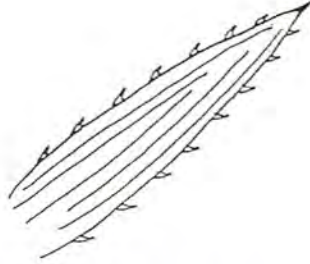
164. STICKY (viscid)



165. SCALY



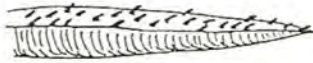
LEAF APPENDAGES *



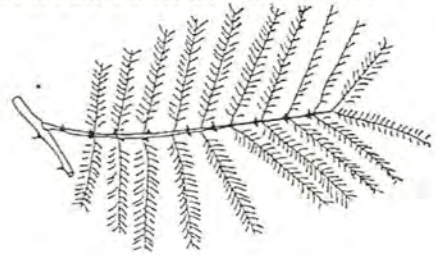
166. SPINES/THORNS ON MARGINS



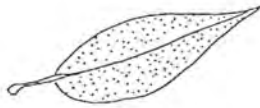
167. SPINES/THORNS ON LOWER SURFACE



168. SPINES/THORNS ON UPPER SURFACE



169. SPINES/THORNS ON RACHIS



170. SPOTS/GLANDS



171. DOMATIA

LEAF SMELL



172. NEUTRAL



173. AROMATIC



174. FOETID



SHOOT APEX



175. SMALL INCONSPICUOUS



176. COVERED BY SCALES

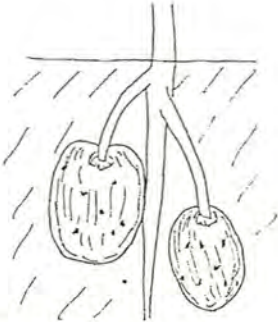


177. COVERED BY VELVETY/RUSSET
BROWN HAIRS



178. COVERED BY LEAF PRIMORDIA

ROOTS/UNDERGROUND STRUCTURES



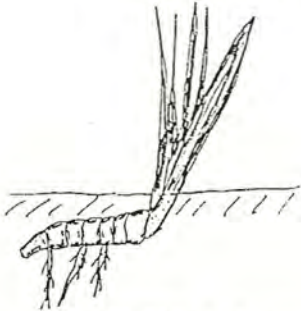
179. TUBER (abrupt swelling
- vertical, starch)



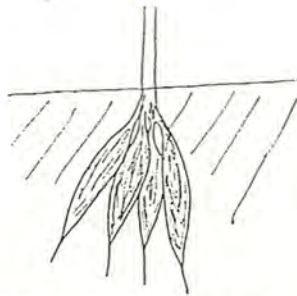
180. CORM (fibrous leaf
bases)



181. BULB (fleshy leaf
bases)



182. ROOTSTOCK (horizontal)

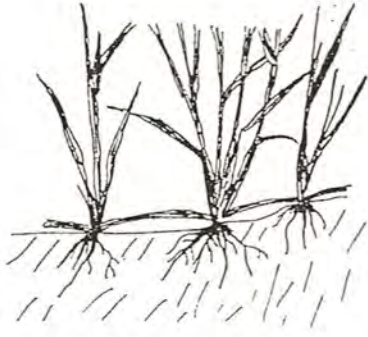


183. SWOLLEN ROOT (gradual
swelling)



184. RHIZOMES

ABOVEGROUND STRUCTURES



185. STOLONS



186. ROOTING FROM NODES/KNOTS

OTHER CHARACTERS FOR GRASS IDENTIFICATION
CULM *



187. CULMS WITH HAIRS
ABOVE NODES



188. CULMS WITH HAIRS
ON NODES



189. CULMS TUBEROUS AT
BASE



190. LEAVES MAINLY ON CULMS (leafy culms)



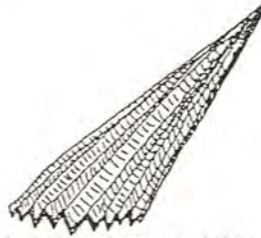
191. LEAVES MAINLY BASALLY AGGREGATED



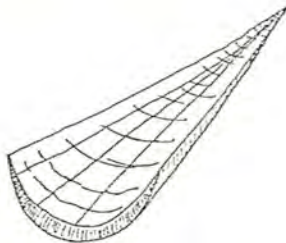
SHEATH/LAMINA *



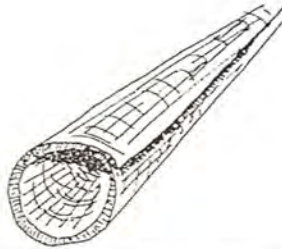
192. LAMINA FLAT



193. LAMINA FOLDED - Plicate



194. LAMINA CURVED



195. LAMINA ROLLED ± TUBULAR



196. LAMINA BASE
BEARDED



197. LAMINA BASE WITH
TWO TUFTS OF HAIRS



198. HAIRS BELOW
LAMINA BASE



199. BASE GREATER
THAN SHEATH



200. BASE EQUALS
SHEATH



201. BASE LESS
THAN SHEATH



202. SHEATH MARGINS JOINED
(at least one quarter
of length)



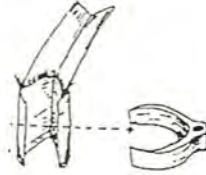
203. FREE SHEATH
MARGINS



FRESH SHEATH *



204. FLABELLATE AT BASE
 (fan shaped)



205. KEELED



206. GLABROUS



207. ENTIRE EXTERIOR
 HAIRY



208. BASE HAIRY



209. APEX HAIRY



210. ENTIRE EXTERIOR
 TINGED PURPLE/RED



211. BASE PURPLE/RED



212. APEX PURPLE/RED



OLD LEAF SHEATH



213. GLABROUS



214. ENTIRE EXTERIOR
HAIRY



215. BASE HAIRY



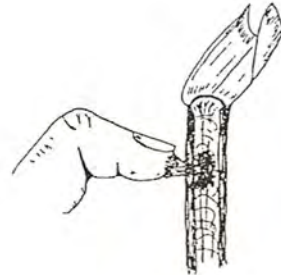
216. APEX HAIRY



217. INTERIOR TINGED
SHINY ORANGE BROWN



218. INTERIOR TINGED
PURPLE



219. INTERIOR VISCID (sticky)



OLD DEAD LEAVES



220. ABSENT



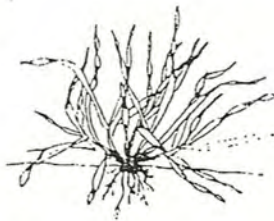
221. LOOSLEY CURLED WAVY



222. A FEW DISTINCT CURLS



223. TIGHTLY CURLED



224. OLD BLADES TWISTED
INTO CORKSCREWS