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Information available within the PRÉCIS data bank of the National Herbarium, Pretoria, with examples of uses to which it may be put

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ABSTRACT

The contents of the computerized information storage and retrieval system (PRÉCIS) of the National Herbarium, Pretoria (PRE) are described at length mainly by means of frequency histograms of descriptor codes. The frequency distributions found are discussed in the light of the history of the herbarium, the geography of the area and the habits of plant collectors. Two uses of PRÉCIS are illustrated by example. Firstly, the flowering phenology of *Eragrostis capensis*, *Themeda triandra* and *Heteropogon contortus* is plotted and, secondly, the route followed by Dinter in South West Africa/Namibia from December 1933 until March 1935 is described. It is concluded that the system should be of particular use in revisionary studies, regional floras and biogeographic research.

RÉSUMÉ

INFORMATION DISPONIBLE DANS LE DÉPOT DE DONNÉES PRECIS *DE L'HERBARIUM NATIONAL DE PRETORIA, AVEC DES EXEMPLES D'UTILISATION AVEC LAQUELLE IL PEUT ÊTRE EMPLOYÉ*

*Les contenus d'un dépot d'informations sur ordinateur et un système de recouvrement (PRECIS) de l'Herbarium National de Pretoria (PRE) sont décrits tout au long, principalement au moyen d'histogramme de fréquence de codes de description. Les distributions de fréquence trouvées sont discutées à la lumière de l'histoire de l'Herbarium, la géographie de la région et les habitudes des collectionneurs de plantes. Deux utilisations du PRECIS sont illustrées par des examples. Premièrement la phénologie de la fleur d'*Eragrostis capensis, Themeda triandra *et* Heteropogon contortus *est située et, deuxièmement, la route suivie par Dinter au Sud-Ouest africain/Namibia, de Décembre 1933 jusqu'a Mars 1935 est décrite. On tire la conclusion que le système devrait être particulièrement utile pour des études de révision, les flores régionales et la recherche biogéographique.*

INTRODUCTION

Over the past eight years a computerized data banking system for the National Herbarium (PRE) has been designed, programmed and data have been loaded. The entire project has been completed recently and this communication is intended to describe the scope of the information contained in the data base, attempt to account for its shortcomings and to give examples of results that can be derived from it. A knowledge of what is available will enable prospective users to design their enquiries efficiently and will indicate what can and cannot be extracted from the data bank. It is not our intention to present new taxonomic, floristic or ecological results, based on this information, but merely to summarize it for the benefit of future users and to highlight a few of the possible uses of the system through examples.

The aim of the project was to encode all the information from the approximately half million herbarium specimens collected in the Flora of Southern Africa Area and housed in the National Herbarium, Pretoria, and to produce a flexible information retrieval system by means of which the data could be made available in a number of useful forms. A systems analysis (Morris, 1974), progress reports (Morris & Leistner, 1975; Morris & Glen, 1978) and a description of the backlog encoding task (Morris, 1980) have traced the development of the system.

The frequency of occurrence of each descriptor on herbarium specimens, i.e. how many specimens had an indication of flower colour or notes on habitat, was unknown when this data bank was designed. The net was thrown extremely wide with the intention that as much data as possible would be captured in retrievable form. Of great use to the designers of future systems will be knowledge of the frequency of occurrence of descriptors in a herbarium of the size and scope of ours. It is a great waste of computer disk storage space if provision is made on every specimen record for a particular descriptor which has a low frequency, i.e. is missing or absent most times, and more efficient storage procedures can be used in those cases. Frequency of occurrence of descriptors for specimens housed in the National Herbarium are summarised below, together with brief comments on the distributions found.

Many uses of this and other such computerized herbarium data banks have been proposed (see e.g. Crovello, 1972). Two uses which are particularly suited to this approach are countrywide phenological studies and the reconstruction of routes followed by early collectors. We present a preliminary account of the flowering times of three widespread grass species and notes on the probable route followed by Dinter in South West Africa/Namibia on his last visit to the territory as examples of the kind of information that is now available from PRÉCIS.

CONTENTS OF THE DATA BANK

General

At the time when the statistics given below were extracted, 496 909 backlog specimens had been loaded into the data bank. Although the system makes provision for the continuous addition of new collections (see Morris & Glen, 1978) and about 10 000 are being accessioned annually, those that had been added by means of the new plant collection form were deliberately excluded from this analysis. Some 4 100 additional backlog specimens, still to be loaded at the

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time, have since been accessioned. We consider it unlikely that these omitted specimens will significantly alter the results presented.

A complete list of descriptors and codes is given in Morris (1980). This list should be consulted in conjunction with this paper.

Geographical distribution of specimens

(a) *Region*

The distribution of specimens by region is given in Fig. 1. All specimens from the Flora of Southern

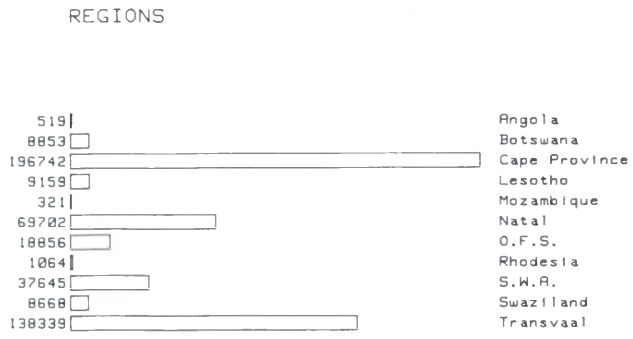

FIG. 1.—Distribution of specimens by region. Numbers in the left-hand column indicate numbers of specimens in each region and bars represent proportion, scaled by the maximum, of specimens in each region. Similar conventions are used in all following figures of this kind.

Africa area as well as all type specimens in the herbarium were encoded, explaining the relatively small number of specimens from Angola, Mozambique and Rhodesia/Zimbabwe in the herbarium. It is surprising that there are more Cape specimens housed in the herbarium than there are Transvaal ones as the herbarium is situated in the Transvaal and another three large herbaria serve the Cape Province. Although the Cape has a longer botanical history than the Transvaal, it is only during the latter parts of this century that large numbers of specimens have been collected so that this cannot be advanced as a reason for this disproportionate distribution of specimens. Natal and South West Africa/Namibia are better represented than the Orange Free State and neighbouring independent countries (Swaziland, Lesotho and Botswana).

An indication of the intensity of collection may be obtained from a study of the number of specimens collected per square km of each region. In Fig. 2 pie charts are used to indicate the number of specimens

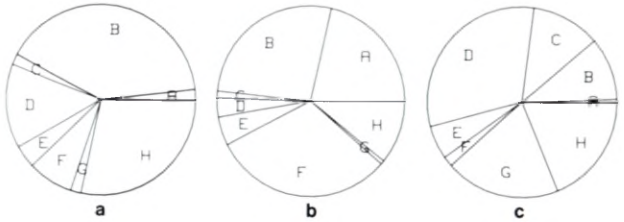

FIG. 2.—Pie charts of: a, number of specimens per region; b, areas of regions; c, number of specimens per square km of each region. (A = Botswana, B = Cape Province, C = Lesotho, D = Natal, E = Orange Free State, F = South West Africa, G = Swaziland and H = Transvaal.)

per country and province of South Africa falling within the Flora of Southern Africa Area (Ross *et al.*, 1977), the area of that geographic unit and the number of specimens collected per unit area of the region. The largest regions, Botswana, Cape Province and South West Africa, are less collected on the basis of number of specimens per unit area than Transvaal, Natal and Swaziland, the last two being very small in area compared with most other regions. Botswana, South West Africa and the Orange Free State are particularly undersampled by this criterion.

(b) *Grid references*

Grid references have only been given to specimens on a regular basis since the development of the quarter degree grid reference system by Edwards & Leistner (1971) and thus we anticipated that a large proportion of the collection would be without this useful geographic identifier. Of the total, 10,5% had codes when they were accessioned. Many more specimens with grids have been collected in the Transvaal than in any other region. An attempt is being made at present to automatically assign grids to the specimens without grids on the basis of region and major and minor locations.

(c) *Major and minor locations*

A total of over 41 300 major and minor locations have been used by collectors. A page of examples of localities is given in Table 1. It is our intention to remove synonymous names and correct spelling mistakes in the collector and locations files in due course.

Curatorial information

(a) *Year collected*

The dramatic, almost linear, increase in the number of specimens accessioned annually after 1880 is illustrated in Fig. 3. Factors contributing to the rapid increase include the appointment of J. Burtt Davy as Government Botanist in Pretoria in May 1903 and the establishment of the Botanical Survey Advisory Committee by I. B. Pole Evans during 1918 (Dyer, 1977). The former lead to the foundation of what is now known as the National Herbarium (PRE) and the latter to the appointment of ecologists who have collected widely as part of their brief. The effect of World War II on collections is clearly shown by the drop in accessions from 1936 to 1945. During the five-year period before encoding began (1971–1975) about 9 600 specimens were collected and accessioned annually. The decrease in the last period plotted (1976–1980) is attributed to curatorial activities being concentrated on the preparation of the herbarium for encoding rather than on the accessioning of new material.

The oldest specimens housed in the herbarium include about 150 collected by Burchell between 1810 and 1815. Ecklon, Zeyher and Drège are responsible for the relatively high peak in collecting from 1825 to 1830 and the continuation of activity until 1840 (Fig. 3). These three collectors are represented by a total of 8 000 specimens in the herbarium, spanning the years 1826 to 1850. Alexander, who later changed his name to Prior, collected 1 100 specimens (housed in PRE) from 1846 to 1850. The collections of Wahlberg account, in part, for the peak during the five-year period 1856–1860.

TABLE 1.—Examples of localities from PRECIS. The columns on the right give the number of times the name is used as a major and minor location, respectively

Locality	Province/Country	As major location	As minor location
Lusikisiki Div.	Cape Province	1	1
Lusikisiki For. Dist.	Cape Province	1	0
Lusikisiki Dist.	Cape Province	1	0
Lusizi	Cape Province	0	1
Luslington Mt	Cape Province	0	1
Lusoti Hill	Swaziland	3	3
Lusthof	O.F.S.	0	4
Lusthof Ou 243 Farm	S.W.A.	0	1
Lusthof 707 Farm	O.F.S.	2	2
Lustorville Dist.		1	0
Lutambasee		0	3
Lutembure	Transvaal	1	1
Lutembwe	Transvaal	1	1
Lutembwe Aansluiting	Transvaal	1	1
Luther Peak	Cape Province	0	1
Lutheran Mission Sta.	Natal	0	12
Luthle	Botswana	1	2
Lutindi		1	1
Lutombi	Angola	1	1
Luttig	Cape Province	0	2
Lutzputs	Cape Province	3	8
Lutzville	Cape Province	5	2
Luve	Swaziland	0	2
Luvimbi	Transvaal	1	1
Luvuvhu	Transvaal	0	2
Luwinga Dist.	Rhodesia	2	1
Luxillo	Angola	0	1
Luyengo	Swaziland	0	2
Luyengo College of Agriculture Farm	Swaziland	4	5
Luyengo College of Agriculture Farm	Swaziland	0	1
Luyengo College of Agriculture Farm	Swaziland	0	1
Lwamondo Location	Transvaal	0	1
Lwandle	Swaziland	0	2
Lwandle Township	Cape Province	0	1
LWS Farm	S.W.A.	0	1
Lydenburg	Transvaal	1	0
Lydenburg Dist.	Transvaal	0	1
Lydenburg	Transvaal	1 234	1 086
Lydenburg Dist.	Transvaal	340	115
Lydenburg Dist.	Transvaal	2 990	1 063
Lydenburg Dist.	Transvaal	74	34
Lydenburg Dist. Sekukuniland	Transvaal	2	0
Lydenburg Div.	Transvaal	2	1
Lydenburg Div.	Transvaal	9	10
Lydenburg East Dist.	Transvaal	1	0
Lydenburg Town	Transvaal	2	3
Lydenburg	Transvaal	0	1
Lydenburgpas		0	0
Lydiana	Transvaal	0	9
Lyds Pass	Cape Province	1	1

(b) *Contributions from the Cape and Transvaal to the herbarium*

It has been shown above that there are more Cape Province specimens in the herbarium than Transvaal ones, even though the herbarium is situated in, and primarily serves, the Transvaal. In Fig. 3, the proportions of Cape and Transvaal specimens to the total over five-year periods are plotted. Until 1915 there are proportionally far more Cape specimens than Transvaal ones in the herbarium. At that time the proportions from both provinces stabilize at about 0,4 each and then decrease slightly to between 0,2 and 0,4 at the present time. For nearly all periods after 1915 the proportion of Cape specimens still remains higher than that of Transvaal specimens. Exceptions are from 1916–1920 and 1941–1945, both times of world war. The gradual decreases in both proportions in recent years suggest the increasing accession of specimens from other regions. The relatively low proportion of Cape specimens during 1871–1875 is partly due to active collection by Rehmann in Natal during that period. It is not known who was active in the Transvaal during the period 1886–1890 and responsible for the large proportional contribution of Transvaal specimens during that period, but the collections of Galpin from Barberton (Phillips, 1930) will undoubtedly contribute to the total.

(c) *Month of collection*

A clear summer peak in collecting activity is seen from the distribution of specimens by month of col-

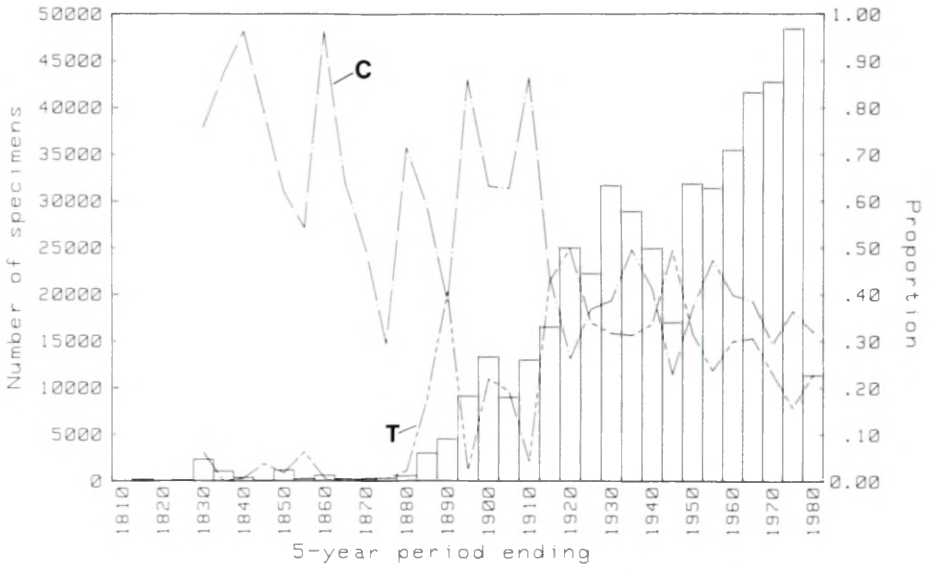

FIG. 3.—Histogram of number of specimens accessioned during successive five-year periods from 1806. The proportions of Cape (C) and Transvaal (T) specimens to the total are also indicated for each period.

lection (Fig. 4a). Slightly fewer collections than expected during February may be caused by there being fewer days for collecting during that month. Holidays during December may have influenced the number of collections during that month. The pattern in the Transvaal is similar with a maximum in January and very little collecting activity from May until September (Fig. 4b). In the Cape, on the other hand, where most collecting has been done in the winter-rainfall part of the Province, a more equable distribution of specimens by month of collection is found with a clear peak in September (Fig. 4c).

(d) *Distribution of types*

A type code is assigned to 2% of the specimens in the data bank. Nearly half of these specimens are types (46%), while 26% are isotypes, 15% holotypes and the other 12% are syntypes, paratypes and lectotypes (Fig. 5). Only 36 specimens received a neotype code. It is likely that more type specimens are housed in the herbarium. Those reflected here are those identified as such on labels and exclude those that have not yet been annotated.

(e) *Duplicates*

When more than one sheet of a specimen (i.e. of the same collection) was found together by the encoders, the number of duplicates was recorded. This information is required by the curator so that he will know how much space in cabinets is taken up by duplicates. Two percent of the collection have more than one sheet filed. Eighty-one percent of these specimens have two duplicates and very few specimens are represented by more than three duplicates.

(f) *State of specimen*

Ninety-seven percent of the specimens received a flower code for state of specimen. Seventy-three percent of these specimens had mature flowers, 15% were coded with flowers present, 11% with flowers absent and only 1% of the specimens had immature flowers (Fig. 6a). A surprisingly large proportion of specimens have flowers (89% including both immature or mature flowers). Ninety-five percent of the specimens have a code for fruit (Fig. 6b). Immature fruit occur on 57% of the specimens, 15% of the specimens are coded with fruit present and 20% of the specimens have mature fruit. Only 8% of the

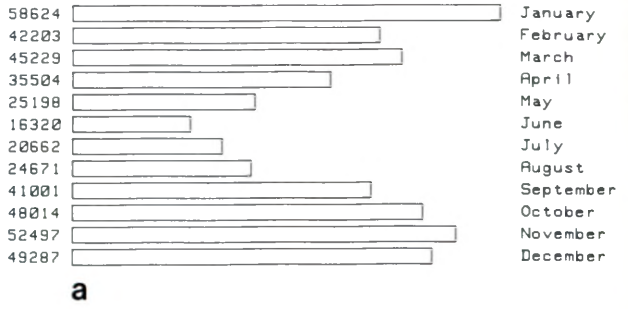

FIG. 4.—Distribution of specimens by month of collection: a, all regions; b, Transvaal; c, Cape Province.

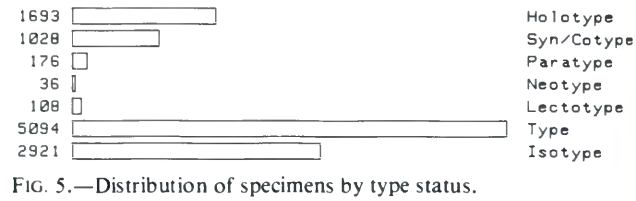

FIG. 5.—Distribution of specimens by type status.

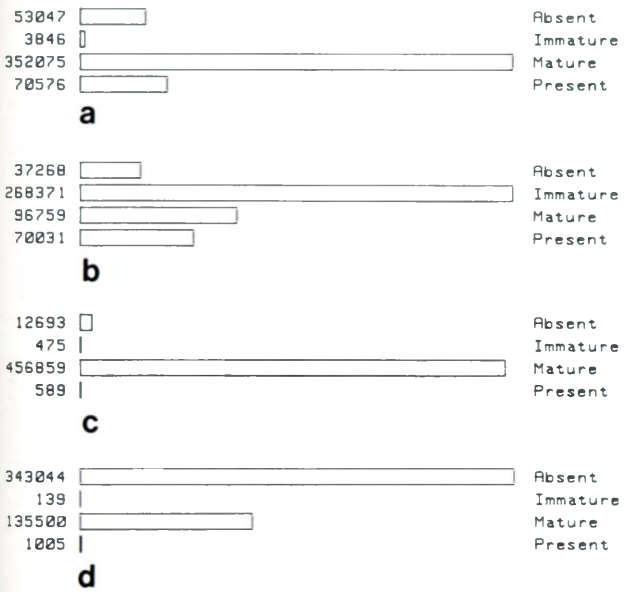

FIG. 6.—Distribution of specimens by state of specimen: a, flower; b, fruit; c, leaf; d, root.

specimens have fruit absent. A leaf code is assigned to 97% of the specimens, of which, again 97% have mature leaves. Leaves are absent from only 3% of the specimens (Fig. 6c). Ninety-seven percent of the specimens have a code for presence of roots. Seventy-two percent of these specimens have no roots and 28% have mature roots.

(g) *Language used on label*

Eighty-six percent of all the collections have labels in English in comparison with the 6% which are in Afrikaans (Fig. 7). Even higher percentages of the

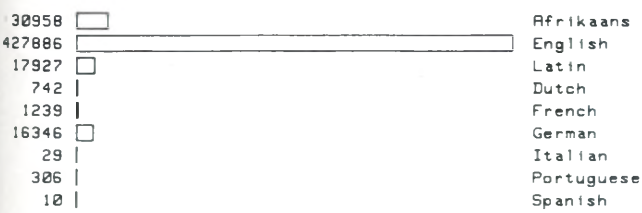

FIG. 7.—Distribution of specimens by label language.

collectors use English in Natal (95%), Botswana (96%), Lesotho (98%) and Swaziland (98%). Thirty-two percent of the collectors in South West Africa use German.

Plant descriptors

(a) *Abundance and distribution*

Twenty percent of the specimens have an abundance code. Over 50% of these are common, 17% are very rare and rare, 18% occur occasionally and 12% of the specimens are abundant (Fig. 8). A distribution code (i.e. widespread/local) is assigned to 20% of all specimens collected. Eighty-six percent of these specimens are coded as widespread and 14% have a local occurrence.

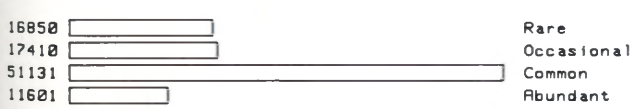

FIG. 8.—Distribution of specimens by abundance code.

(b) *Flower and fruit colour*

Thirty percent of the specimens have a flower colour code and nearly 30% of these have yellow flowers (Fig. 9a). Twenty-seven percent of the specimens have white or cream flowers, 13% mauve or purple flowers and 10% have pink flowers. There are very few specimens with grey, orange or brown flowers and only 138 specimens are recorded with black flowers. A flower code is given to over 50% of the specimens collected in Lesotho (52%) and 50% of the Swaziland specimens have a flower colour code. Both these percentages are significantly higher than the overall average.

A fruit colour code is assigned to only 1% of the total number of specimens. Thirty percent of these specimens have red fruits while 24% have green fruits (Fig. 9b). Only 80 specimens were recorded with blue fruits and 57 specimens have grey fruits. The fact that red fruit occurs more frequently than any other colour fruit can probably be explained by the way that many seeds and fruit are distributed. Birds and small mammals are attracted by brightly coloured fruits, red in particular. Another consideration in connection with fruit colour is that collectors are apt not to record usual colours, such as green and brown, and only note unusual colours.

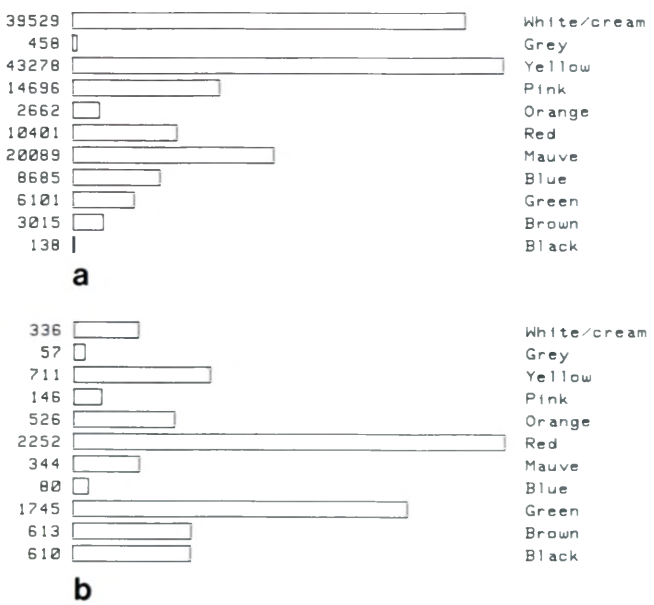

FIG. 9.—Distribution of specimens by: a, flower colour code; b, fruit colour.

(c) *Life form*

A life form code is given on 25% of the specimens. Of these, 36% are shrubs (Fig. 10a), 27% herbs and 19% trees. Distribution by life form for specimens from the Transvaal is similar to that of the total sample but that for the Cape suggests, as one would expect, the presence of fewer trees and many more shrubs in the Cape than in the country as a whole (Fig. 10b).

(d) *Annual/perennial code*

Four percent of the specimens have an annual/perennial code. Over 60% of the specimens are perennial while 37% are indicated as being annual. Very few specimens had either ephemeral or biennial codes. Relatively high percentages of the specimens are perennial in Natal (86%), the Orange Free State (82%), Lesotho (81%) and Swaziland (92%). In

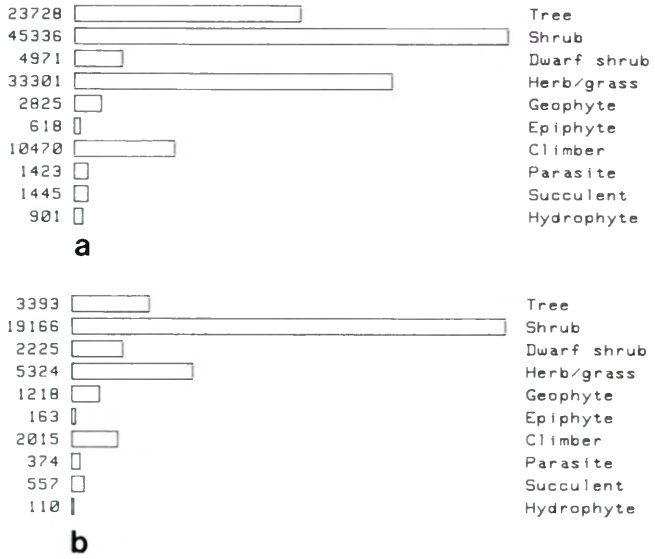

FIG. 10.—Distribution of specimens by life form code: a, entire collection; b, Cape specimens only.

comparison with this, 64% of the specimens in South West Africa are annual, compared with 36% which are coded as perennial.

(e) *Woody/herbaceous code*

A woody/herbaceous code is assigned to only 1% of the specimens. Seventy-eight percent of these specimens are woody and 22% are herbaceous. No specimens are coded as half-woody although there is a code assigned for such a descriptor.

(f) *Evergreen/deciduous code*

An evergreen deciduous code is given to only 1 214 of the specimens. Of these, 53% are evergreen, 44% deciduous and only 2% are coded as semi-deciduous. In Lesotho, 100% of the specimens with this descriptor are evergreen while 100% of the specimens in Botswana are deciduous.

(g) *Weed status code*

Only 1% of the specimens have a weed code. Ninety-eight percent of these specimens are encroachers and only 13 specimens are coded as exotic plants. This latter information is usually obvious from the name of the plant, accounting for the very low frequency with which the information was recorded separately on the label.

(h) *Height and diameter at breast height*

A height code is assigned to 18% of all the specimens. Forty-four percent of these specimens are in the range of 0–0,5 m (0–1,6 ft). Another 45% (Fig. 11a) of the specimens occur with a steep and then gradual decrease in numbers to 3,5 m (11,5 ft). The remaining 11% are higher than 3,5 m. An interesting fact is that specimens are clustered at certain heights, indicating rounding off by the collectors of the heights of the plants that they collect. Peaks in the number of specimens occur at 4,5 m (about 14 ft), 6 m (20 ft), 7,5 m (25 ft), 9,0 m (30 ft), 10,5 m (35 ft), 12,25 m (40 ft), 13,75 m (45 ft), 15,25 m (50 ft), 17,0 m (55 ft), 18,5 m (60 ft) and at 20,0 m (65 ft). As most specimens were collected before metrication, the heights in feet given above possibly indicate the midpoints of common height estimation ranges used by collectors.

Nineteen percent of all plants coded as being 'woody' have a height code and 22% are in the range 0–0,25 m (0–0,8 ft) and 25% are in the range of 0,26–0,5 m (0,8–1,6 ft). Once again, there is a sharp drop in the number of specimens higher than 0,50 m up to about 3 m (Fig. 11b). In the case of woody plants, even sharper peaks occur at certain heights than with all specimens together.

In Lesotho, where 17% of the specimens have a code for height, 73% are in the range 0–0,5 m and 19% in the range 0,51–1,00 m. Only 28 specimens of height 1,01–1,5 m, 31 of height 1,51–2,0 m and 13 of height 2,01–2,5 m have been collected (Fig. 11c). Almost no specimens had a height code greater than 2,5 m in Lesotho where, anyway, only 60 specimens are given a code of 'tree' for life form.

Diameter at breast height (DBH) is recorded on only 1 901 specimens, all of which are also coded as woody. Most specimens have a DBH of less than 0,5 m (Fig. 12) with additional peaks at 1,2–1,3 m (about 4 ft) and 1,8–1,9 m (6 ft). There are 158 specimens with a DBH greater than 2,0 m.

Habitat and vegetation features

(a) *Substrate*

Only 24% of the specimens have an indication of substrate type and 88% of these specimens are collected from either soil or stony soil. Bare rock, cliff faces and beach dunes are equally well represented (3% each) and in water is recorded for 2 040 specimens (2%). In South West Africa, desert dunes are recorded on 5% of the specimens and in Natal cliff face is recorded on 6% of specimens and beach dunes on 7%.

(b) *Moisture regime*

Only 12% of the specimens have a moisture regime code. From the distribution of codes, it is clear that

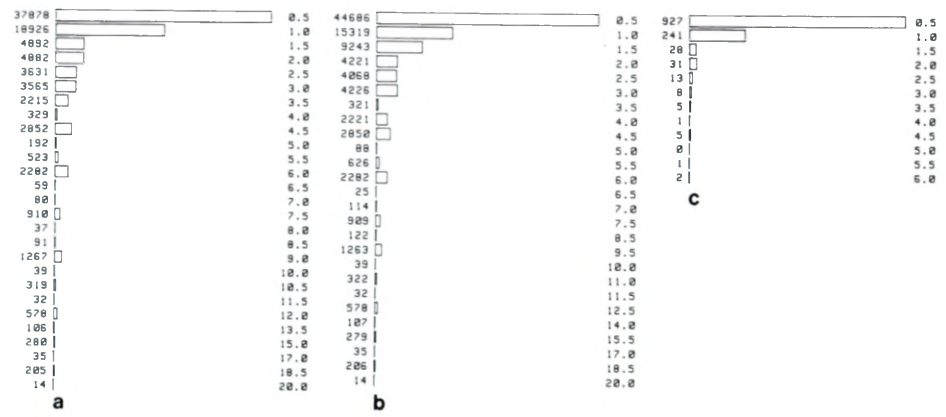

FIG. 11.—Distribution of specimens by height class. Numbers on right indicate ends of 0,5 m class intervals. a, all specimens; b, only specimens with a code for woody; c, for all specimens from Lesotho.

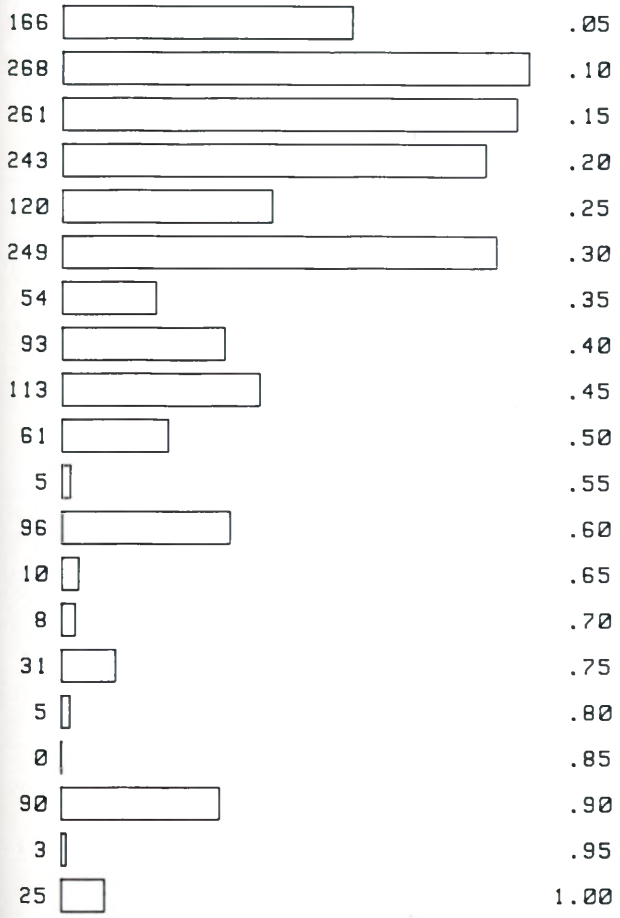

FIG.12.—Distribution of specimens by diameter at breast height (DBH). Numbers on right indicate ends of 0,05 m class intervals.

only unusual situations, e.g. stream banks, marsh/swamp and pan/depression are recorded by collectors. Dry river beds in South West Africa are well sampled in this category.

(c) *Soil type and soil colour*

A soil type code is assigned to only 4% of the specimens. Of these, over half (56%) are collected from sandy soil. Other categories with over 5% representation are gravel (7%), loam (13%), clay (9%) and calcrete (8%).

A disappointing 3% of specimens have soil colour of the A-horizon codes and only 99 specimens have B-horizon soil colour codes. Fifty percent of the A-horizon soil colours are red.

(d) *Biotic effects*

Biotic effects codes are assigned to only 2% of the specimens. The distribution gives an insight into the plant collecting habits of botanists. Nearly half the specimens with codes (44%) are collected alongside roads and railway lines while 19% are from gardens (Fig. 13). Eleven percent of the specimens are from recently burnt areas. Encoders were specifically told not to encode 'on road to . . .' as a biotic effect (Morris, 1980) and that 'collected near road' or a similar statement was needed before code 06 could be assigned and it can therefore be concluded from these statistics that roadside collecting is a major activity of plant collectors. Other favourite collecting sites appear to be gardens, recently burnt veld and disturbed areas (Fig. 13).

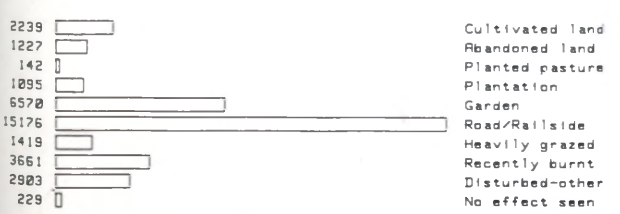

FIG. 13.—Distribution of specimens by biotic effects code.

(e) *Aspect*

It was expected that compass points would be equally represented. The results, however, show that many more specimens are collected from south-facing habitats than any others (Fig. 14) and that the four cardinal points are far better represented than the four intermediate points. The distribution is even more exaggerated in the Orange Free State (Fig. 14b). The results indicate guessing by collectors to the nearest 90°, and often to the nearest 180°. It is not known why south is the most commonly-collected aspect but it is thought that south-facing slopes, with more mesic conditions and often forest patches, will have higher species diversities and therefore have more species to be collected from them. The bias is particularly marked in the Cape (Fig. 14c). Most even distribution by aspect is shown by specimens from Natal and South West Africa. Relatively few specimens are, however, collected from NE- and NW-facing slopes in South West Africa.

(f) *Slope*

Four percent of the specimens have a code for slope, over 60% of which are level. A further 25% are recorded from steep slopes and 10% from gentle slopes. Specimens from South West Africa (96%), Botswana (93%) and the Orange Free State (75%) are virtually all collected from level sites, whereas about 50% of the Natal specimens, 55% of Lesotho specimens and 55% of Swaziland specimens are from steep slope sites, as would be expected from a knowledge of the topography of these areas.

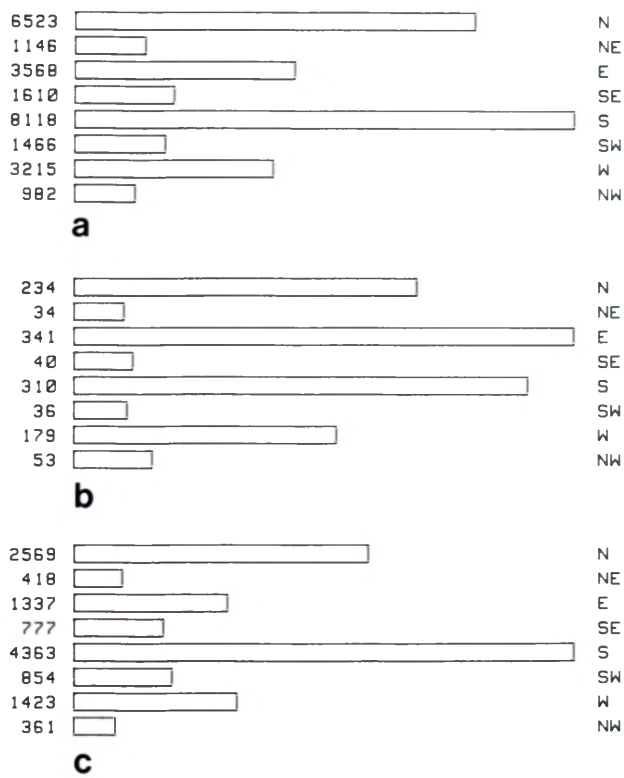

FIG. 14.—Distribution of specimens by aspect: a, all specimens; b, specimens from the Orange Free State; c, from the Cape Province.

(g) *Altitude*

Nearly 40% of the specimens have an altitude, indicating the importance attached to altitude by plant taxonomists. As expected, close agreement between known geographic altitude ranges of the provinces and altitude at which plants are collected is found. Overall, there is evenly-spread collecting from sea level to 1 500 m (Fig. 15a) and then a sharp decrease in collecting intensity. In the Cape the decrease is more gradual but starts at 600 m (Fig. 15b). In the Transvaal, collecting decreases on either side of the 1 400 m contour (Fig. 15c), a pattern also shown by the Orange Free State, only in a more extreme form. In Natal, 52% of specimens have altitudes. A number of small peaks are shown, possibly corresponding with the altitudes of botanical survey areas (Fig. 15d) or towns with active collectors. Collecting continues in the Drakensberg to at least 3 200 m although the distribution is only plotted as far as 2 300 m. Collecting at high altitudes is a feature of mountainous Lesotho (Fig. 15e).

(h) *Vegetation and veld type*

A vegetation code is given to 21% of the specimens. Of these specimens, nearly half are coded as grassland. Taken together, woodland, savanna and scrub/thicket formations account for a further 30% and forest for 20% (Fig. 16). Desert, with only 363 specimens, karoo (including semi-desert) and fynbos are particularly undersampled. Bearing in mind the large area covered by karoo vegetation in South Africa, it has been poorly collected. On the other hand, as habitat and species diversities are lower in the drier parts of the country, a lower sampling intensity is to be expected there.

In Table 2 a representation of specimens by veld types (Acocks, 1975) for the four provinces of South Africa is given. The sample is small as only 3,1% of the specimens are assigned veld types. In the table the number of specimens from each province and the total for the country are given for each veld type and then the number of specimens collected per 100 km^2 of that veld type is given as a measure of collecting intensity. Veld type areas were obtained from Edwards (1974). Eleven veld types (Kalahari Thornveld, Mixed Bushveld, Sourish Mixed Bushveld, Karroid Broken Veld, Arid Karoo, Succulent Karoo, Orange River Broken Veld, False Upper Karoo, Highland Sourveld, *Cymbopogon—Themeda* Veld and Dry *Cymbopogon—Themeda* Veld) cover half the area of South Africa and yet only 14% of the specimens with veld types were collected from them indicating again the uneven distribution of collection effort. Five of the large veld types listed above are either Karoo or False Karoo types, whereas the largest, Kalahari Thornveld, is an arid region tropical bush and savanna type. Therefore the under-collection of the more arid parts of South Africa, shown from an analysis of codes assigned to vegetation, is confirmed by this analysis of specimen distribution by veld type.

Macchia and Coastal Macchia have the greatest number of specimens collected from them and also the highest collection frequency. The high collection

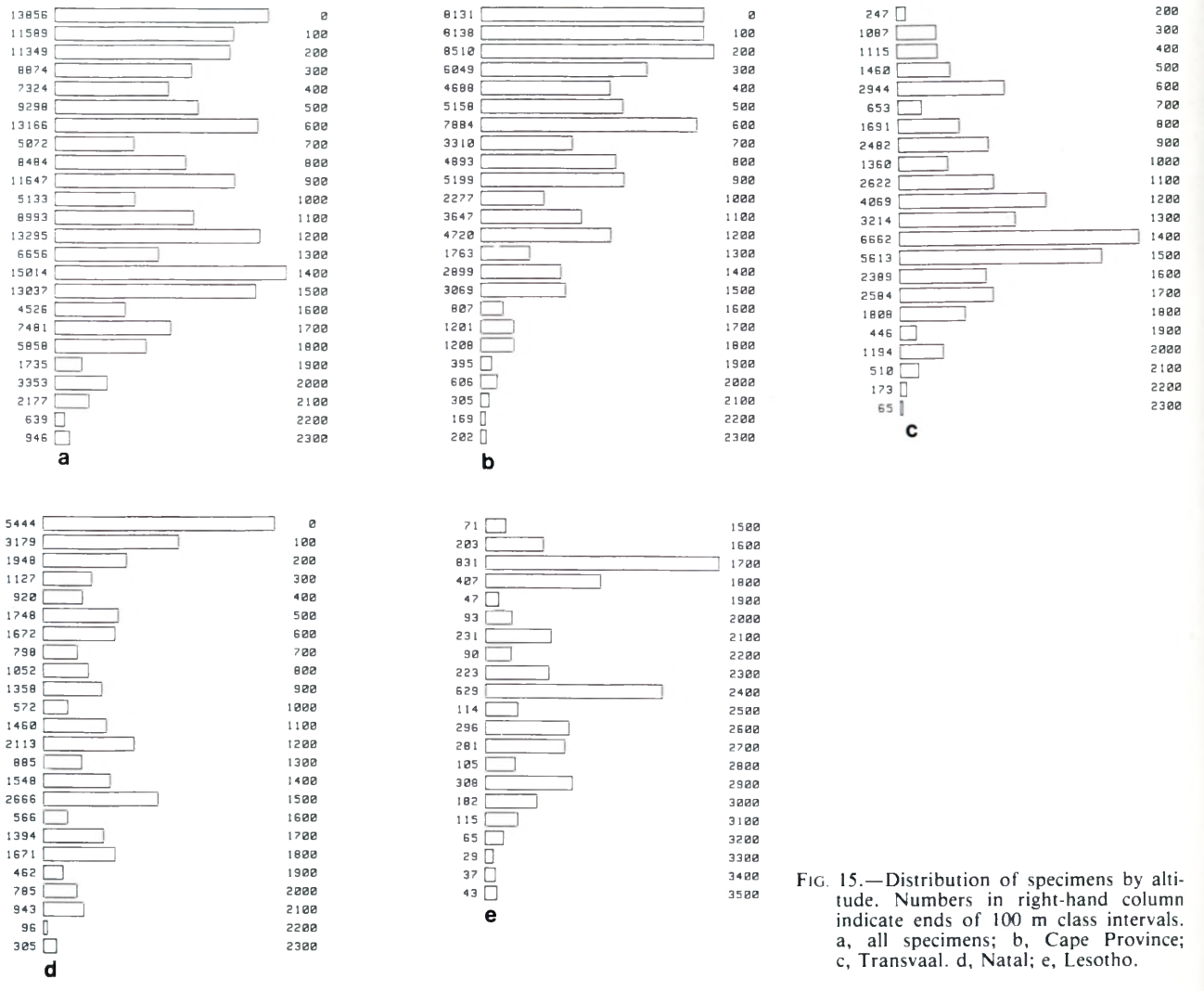

FIG. 15.—Distribution of specimens by altitude. Numbers in right-hand column indicate ends of 100 m class intervals. a, all specimens; b, Cape Province; c, Transvaal. d, Natal; e, Lesotho.

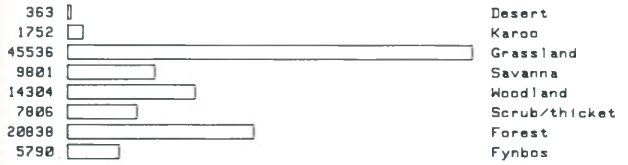

FIG. 16.—Distribution of specimens by vegetation type.

frequency for *Themeda* Veld to Highland Sourveld Transition in Natal is due to the small area covered by this veld type (52 km²) and the relatively large number of specimens collected from it (25). The high collection frequencies for Pondoland Sourveld in Natal (14 specimens/104 km²), *Themeda* Veld to *Cymbopogon—Themeda* Veld transition in Transvaal (54/419) and Highland Sourveld to *Cymbopogon—Themeda* Veld in Natal (20/104) can be similarly explained. In the Cape, other well-represented veld types are from the smaller Karoo, Karroid Bushveld, False Karoo and temperate and transitional forest and scrub types. In the Transvaal, bushveld and the tropical bush and savanna types are well collected. There are few specimens with veld types from the Orange Free State and most are from False Upper Karoo, Highland Sourveld and pure grassveld types. In Natal, well-represented veld types include Coastal Tropical Forest types, Valley Bushveld, Highland Sourveld and Pure grassveld types.

A small amount of mis-coding of specimens is bound to occur in a project of this magnitude. Thus seven specimens of Coastal Forest and Thornveld, coded as being from the Orange Free State, were obviously given either the wrong Region code or the wrong veld type code. Similarly, Mopani Veld (4 specimens) does not occur in Natal. Where a veld type does not occur in a province, specimens recorded for that veld type in the province were omitted in Table 2. A total of 602 specimens (3,9% of specimens with veld type codes) was excluded in this way. Presence of such errors in the data bank should not prevent users from deriving valuable information from it. General trends should be sought and not exceptions or obvious errors.

Encoding rules and collector's biased knowledge can explain some of the results presented above. Some veld types are inherently easier to identify than others (e.g. Mopani Veld, Macchia) and they will, therefore, tend to be noted on collecting labels more often than small, obscure ones, identifiable by specialists alone. The close correspondence between the number of specimens coded as vegetation: fynbos and veld type: Macchia is not surprising because the encoders were taught that the terms are synonymous, and where one code was used, the other was normally also encoded.

Economic botany data

(a) *Actual-potential use*

An actual-potential use code is given to only 2% of the specimens. Ninety-three percent of these specimens are actually used, whereas 7% of them have a potential use.

(b) *Utilized by*

A disappointing 8 702 specimens have a utilized by code. Forty-six percent of these specimens are utilized by man while stock utilizes 27% of the specimens (Fig. 17). Relatively high percentages of specimens are utilized by man in Swaziland (63%), Botswana (68%) and Lesotho (68%). Stock utilizes 41% of the

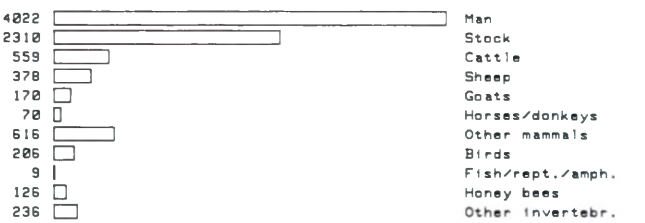

FIG. 17.—Distribution of specimens by utilized by code.

TABLE 2.—Distribution of specimens by veld type and province. See text for further explanation

VELD TYPE	Number of specimens					Specimens/100 square km				
	Cape	Tvl	OFS	Natal	Total	Cape	Tvl	OFS	Natal	Total
I COASTAL TROPICAL FOREST TYPES										
1 Coastal Forest and Thornveld	267	0	0	349	616	5.23	.00	.00	2.33	3.07
2 Alexandria Forest	5	0	0	0	5	.25	.00	.00	.00	.25
3 Pondoland Coastal Plateau Sourveld	27	0	0	14	41	4.31	.00	.00	13.46	5.62
4 Knysna Forest	26	0	0	0	26	.69	.00	.00	.00	.69
5 'Ngongoni Veld	30	0	0	117	147	1.13	.00	.00	1.38	1.32
6 Zululand Thornveld	0	3	0	9	12	.00	1.91	.00	.28	.35
7 Eastern Province Thornveld	36	0	0	0	36	.58	.00	.00	.00	.58
II INLAND TROPICAL FOREST TYPES										
8 North-eastern Mountain Sourveld	0	14	0	1	15	.00	.16	.00	.16	.16
9 Lowveld Sour Bushveld	0	66	0	0	66	.00	.59	.00	.00	.59
III TROPICAL BUSH AND SAVANNA TYPES (BUSHVELD)										
10 Lowveld	0	434	0	17	451	.00	5.91	.00	.15	2.41
11 Arid Lowveld	0	0	0	0	0	.00	.00	.00	.00	.00
12 Springbok Flats Turf Thornveld	0	4	0	0	4	.00	.12	.00	.00	.12
13 Other Turf Thornveld	0	0	0	0	0	.00	.00	.00	.00	.00
14 Arid Sweet Bushveld	0	254	0	0	254	.00	1.34	.00	.00	1.34
15 Mopani Veld	0	727	0	0	727	.00	3.51	.00	.00	3.51
16 Kalahari Thornveld and Shrub Bushveld	26	5	1	0	32	.02	.07	.01	.00	.02
17 Kalahari Thornveld invaded by Karoo	5	0	0	0	5	.03	.00	.00	.00	.03
18 Mixed Bushveld	0	518	0	0	518	.00	1.20	.00	.00	1.20
19 Sourish Mixed Bushveld	3	78	0	0	81	.08	.26	.00	.00	.24
20 Sour Bushveld	0	276	0	0	276	.00	1.51	.00	.00	1.51
IIIa FALSE BUSHVELD TYPES										
21 False Thornveld of Eastern Cape	26	0	0	0	26	1.09	.00	.00	.00	1.09
22 Invasion of Grassveld by Thorn	2	0	0	0	2	.04	.00	.00	.00	.04
IV KAROO AND KARROID TYPES										
23 Valley Bushveld	324	0	0	70	394	2.03	.00	.00	.84	1.62
24 Noorsveld	15	0	0	0	15	.55	.00	.00	.00	.55

(Continued overleaf)

VELD TYPE	Number of specimens					Specimens/100 square km				
	Cape	Tvl	OFS	Natal	Total	Cape	Tvl	OFS	Natal	Total
25 Succulent Mountain Scrub (Spekboomveld)	133	0	0	0	133	1.52	.00	.00	.00	1.52
26 Karroid Broken Veld	232	0	0	0	232	.69	.00	.00	.00	.69
27 Central Upper Karoo	62	0	0	0	62	.32	.00	.00	.00	.31
28 Western Mountain Karoo	389	0	0	0	389	1.97	.00	.00	.00	1.97
29 Arid Karoo	84	0	0	0	84	.12	.00	.00	.00	.12
30 Central Lower Karoo	29	0	0	0	29	.29	.00	.00	.00	.29
31 Succulent Karoo	215	0	0	0	215	.65	.00	.00	.00	.65
32 Orange River Broken Veld	128	0	0	0	128	.38	.00	.00	.00	.38
33 Namaqualand Broken Veld	478	0	0	0	478	1.68	.00	.00	.00	1.68
34 Strandveld of West Coast	339	0	0	0	339	5.37	.00	.00	.00	5.37
IVa FALSE KAROO TYPES										
35 False Arid Karoo	34	0	0	0	34	.27	.00	.00	.00	.27
36 False Upper Karoo	377	0	61	0	438	.97	.00	.23	.00	.67
37 False Karroid Broken Veld	72	0	0	0	72	.77	.00	.00	.00	.77
38 False Central Lower Karoo	11	0	0	0	11	.82	.00	.00	.00	.82
39 False Succulent Karoo	10	0	0	0	10	.09	.00	.00	.00	.09
40 False Orange River Broken Veld	8	0	3	0	11	.15	.00	1.51	.00	.20
41 Pan Turf Veld invaded by Karoo	0	0	1	0	1	.00	.00	.09	.00	.09
42 *Merxmuellera* Mountain Veld replaced by Karoo	33	0	0	0	33	1.63	.00	.00	.00	1.63
43 Mountain Renosterbosveld	510	0	0	0	510	4.56	.00	.00	.00	4.56
V TEMPERATE AND TRANSITIONAL FOREST AND SCRUB TYPES										
44 Highland Sourveld and Dohne Sourveld	182	0	36	210	428	.74	.00	.99	1.88	1.08
45 'Ngongoni Veld of Natal Mist Belt	0	0	0	17	17	.00	.00	.00	.46	.46
46 Coastal Renosterbosveld	744	0	0	0	744	5.10	.00	.00	.00	5.10
47 Coastal Macchia	898	0	0	0	898	10.72	.00	.00	.00	10.72
VI PURE GRASSVELD TYPES										
48 *Cymbopogon–Themeda* Veld (sandy)	5	9	23	0	37	.16	.06	.10	.00	.09
49 Transitional *Cymbopogon–Themeda* Veld	0	0	13	0	13	.00	.00	.09	.00	.09
50 Dry *Cymbopogon–Themeda* Veld	20	27	24	0	71	.55	.19	.09	.00	.16
51 Pan Turf Veld of Western Free State	0	0	4	0	4	.00	.00	.15	.00	.15
52 *Themeda* Veld (Turf Highveld)	0	95	0	0	95	.00	.87	.00	.00	.87
53 *Themeda* Veld to *Cymbopogon–Themeda* Veld Transition	0	54	41	0	95	.00	12.89	.36	.00	.81
54 *Themeda* Veld to Highland Sourveld Transition	0	0	4	25	29	.00	.00	.67	48.08	1.05
55 *Themeda* Veld to Bankenveld Transition	0	6	0	0	6	.00	.88	.00	.00	.88
56 Highland Sourveld to *Cymbopogon–Themeda* Veld	21	0	16	20	57	.87	.00	.22	19.23	.58
57 North-eastern Sandy Highveld	0	1	0	0	1	.00	.01	.00	.00	.01
58 *Themeda–Festuca* Alpine Veld	7	0	0	10	17	.10	.00	.00	1.01	.21
59 Stormberg Plateau Sweetveld	16	0	0	0	16	.65	.00	.00	.00	.65
60 Karroid *Merxmuellera* Mountain Veld	247	0	0	0	247	1.73	.00	.00	.00	1.73
VIa FALSE GRASSVELD TYPES										
61 Bankenveld	0	314	4	0	318	.00	1.37	.62	.00	1.35
62 Bankenveld to Sour Sandveld Transition	0	11	0	0	11	.00	.95	.00	.00	.95
63 Piet Retief Sourveld	0	7	0	0	7	.00	.11	.00	.00	.09
64 Northern Tall Grassveld	0	0	0	0	0	.00	.00	.00	.00	.00
65 Southern Tall Grassveld	0	0	0	5	5	.00	.00	.00	.04	.04
66 Natal Sour Sandveld	0	0	0	5	5	.00	.00	.00	.09	.09
67 Pietersburg Plateau Grassveld	0	0	0	0	0	.00	.00	.00	.00	.00
68 Eastern Province Grassveld	27	0	0	0	27	4.50	.00	.00	.00	4.50
VII SCLEROPHYLLOUS BUSH TYPES										
69 Macchia (Fynbos)	4 270	0	0	0	4270	23.93	.00	.00	.00	23.93
VIIa FALSE SCLEROPHYLLOUS BUSH TYPES										
70 False Macchia	640	0	0	0	640	3.58	.00	.00	.00	3.58

specimens in the Cape Province and 61% in the Orange Free State in comparison with the 29% and 13% which are utilized by man in the Cape and Orange Free State respectively.

(c) *Economic property*

Only 1% of the specimens have an economic property code, of which 59% are stated as being eaten (Fig. 18). Other economic properties which occurred with a frequency of more than 5% were poison (7%), general medicine (13%) and structural purposes (6%). Another 78 specimens are used for magic or ritual purposes, 121 specimens are used as beverage, 80 as fuel, 74 as sand binders, 61 as ground covers and 216 as ornamental plants in gardens.

Thirty-six percent of the specimens with economic property codes in Lesotho are used as medicine compared with 34% which are used as food. In Swaziland a relatively high 14% of the specimens are used for structural purposes.

Examples of the specimens which have magic as an economic property are listed in Table 3. From an examination of the entire set of specimens with this code it is clear that such attributes are given to plants from diverse taxa but that relatively few collectors regularly noted such attributes. Most specimens with this property were collected by J. Gerstner (Natal) and W. G. Barnard (Transvaal).

(d) *Special record*

A special record code was used to indicate plants collected for a specific purpose or survey. A total of 9 288 specimens have such a code. Of these, 34% are for SKF alkaloid studies, 25% for anatomy studies, 19% for a cancer research project, 9% for pollen studies (UOFS) and 5% for the 'Stijfsiekte' survey.

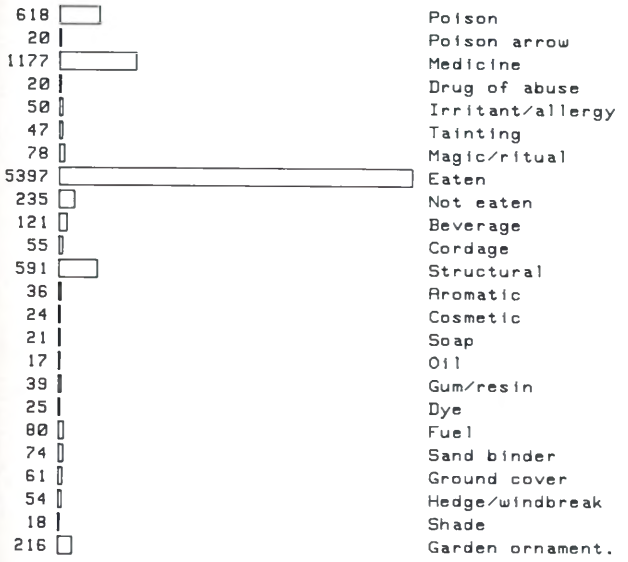

FIG. 18.—Distribution of specimens by economic property code.

PHENOLOGY

It is likely that phenological studies, i.e. the relationships between climatic factors and periodic phenomena in organisms (Daubenmire, 1959), will be facilitated in future through the use of PRÉCIS. Many plants, as an example of phenology, are known to flower in response to some change in the environment (Salisbury, 1963). It is possible to find all the specimens of a particular species that were either flowering or fruiting at the time of collection (from the state of the specimen codes) and to sort these by month of collection (and day, if necessary) in order to study the march of phenological development over a large geographic range.

To illustrate our contention that PRÉCIS can be of use in this way, the flowering patterns of three widespread indigenous grass species were obtained. Printouts were made of all specimens, from South Africa only, with flowers present or mature, sorted by month and day of collection. With the aid of these printouts as well as computer-generated distribution

TABLE 3.—Examples of specimens coded with 'magic' economic property code

Name	Use—as described on label	Region	Surname of collector	Year
Kyllinga erecta K. Schum. var. *intricata* C.B.Cl.	Used by doctor himself before throwing bones	Botswana	Curson	—
Tulbaghia natalensis Bak.	Planted by natives before hut doors to ward off snakes	Natal	Gerstner	1939
Asparagus buchananii Bak.	Used for calling the rain	Transvaal	Barnard	1935
Celtis africana Burm. f.	Magical stick placed across footpath	Transvaal	Barnard	1934
Silene bellidioides Sond.	Love charm	Natal	Gerstner	1943
Cadaba termitaria N.E.Br.	Natives believe that pursuers can be warded off by carrying	Transvaal	Louw	1946
Cassia floribunda Cav.	Warding off snakes	Natal	Gerstner	1944
Eriosema psoraleoides (Lam.) G. Don	Natives burn to protect against lightning	Swaziland	Pierce	1920
Trichilia emetica Vahl.	Muti gatherers use bark	Natal	Edwards	1964
Berchemia discolor (Klotzsch) Hemsl.	Natives think they can allure with bark	Natal	Gerstner	1944
Asclepias meliodora Schltr.	Love charm	Natal	Gerstner	1948
Withania somnifera (L.) Dun.	Used by bushmen for charm purposes in lion hunting	S.W.A.	Maguire	1953
Rhigozum obovatum Burch.	If you have lost something, carry a stick of this and you will find the lost item	S.W.A.	Rodin	1973
Gardenia spatulifolia Stapf & Hutch.	Magical	Transvaal	Barnard	1934
Pentanisia prunelloides (Klotzsch ex Eckl. & Zeyh.) Walp.	Charm	Natal	Brandwyk	1930
Vernonia mespilifolia Less.	Famous love charm	Natal	Gerstner	1948
Psiadia punctulata (DC.) Oliver & Hiern ex Vatke	Put under pillow to prevent dreaming	Transvaal	Barnard	1934
Gnaphalium luteo-album L.	Use in bathing water to remove witchcraft spell	Botswana	Curson	—
Senecio microglossus DC.	A branch is placed beneath pillow to inhibit dreaming in sleeper thereon	Transvaal	Mogg	1936
Senecio pleistocephalus S. Moore	Used for medicinal and magical purposes	Transvaal	Barnard	1934

maps of those specimens with quarter degree grid references, the distributions of *Eragrostis capensis* (Fig. 19), *Themeda triandra* (Fig. 20) and *Heteropogon contortus* (Fig. 21) were drawn. All three species are widespread in the Transvaal, Orange Free State and Natal and occur along the southern Cape coast as far as Cape Town. The general distribution patterns based on the computer data base are remarkably similar to those given by Chippindall (1955) for the same species even though only about two-thirds of the specimens in the data base could be plotted (those specimens flowering at other times of year, without date of collection, collected without flowers or with localities that could not be converted to grid references were excluded). In all three species, early flowering (August to October) is clearly restricted to the eastern and southern coastlines and to a less marked extent to the midlands of Natal. Later flowering (October to February, depending on the species concerned) is found inland in the Cape and throughout the distribution ranges of the species. Where three flowering periods are plotted there is a clear progression of flowering from the coast to the interior.

It is not our intention to provide a detailed explanation for the phenomenon described above. We consider that photoperiodism (Salisbury, 1963) is unlikely to be accounting for the observed pattern, as the pattern is not directly related to latitude, and that temperature is likely to be playing a major role. It has been shown by Schulze & McGee (1978) that isotherms run parallel to the coasts of South Africa with decreasing values with distance inland, reflecting the effects of continentality. Thus we expect that the coast is warmer earlier in the growing season than the interior at a given latitude, accounting for a more rapid phenological development on the coast. Although temperatures in the far northern Transvaal are as high, if not higher, than those on, say, the Natal coast, soil moisture as an interacting factor is probably limiting growth early in the season in the Transvaal.

With the aid of PRÉCIS, the phenology of a large number of species can be investigated rapidly. In this way, it would be possible to ascertain how general the pattern found with these three grasses is, as a first step towards explaining the phenomenon in detail. From preliminary studies of this kind with tree species, *Acacia karroo* Hayne, *Erythrina lysistemon* Hutch. and *Apodytes dimidiata* E. Mey. ex Arn., it appears that not all widespread species respond to the same environmental triggers in the same way as these species appear to have synchronized flowering and fruiting throughout their range within South Africa.

DINTER'S COLLECTING ROUTE

According to Dr L. E. Codd (pers. comm.) the last route followed by Dinter, an important collector in South West Africa, is not as well known as those of his earlier visits, accounts of which he published. As an example of the use to which PRÉCIS could be put for this purpose, a printout of Dinter's specimens collected from December 1933 until he finally left the country was made with specimens sorted according to date of collection. The following reconstruction is based on that printout of specimens housed in the National Herbarium.

From December 1933 until mid-March 1934 Dinter collected extensively in the Karibib district. His specimen numbers ran from 6721 to about 7474 and com-

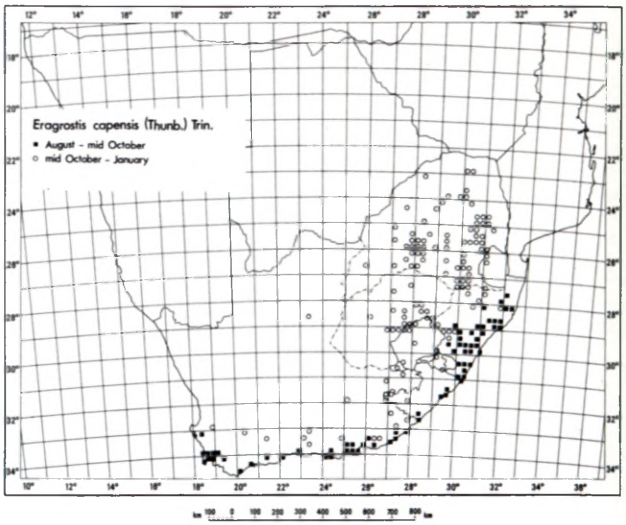

FIG. 19.—Distribution of flowering in *Eragrostis capensis* within South Africa.

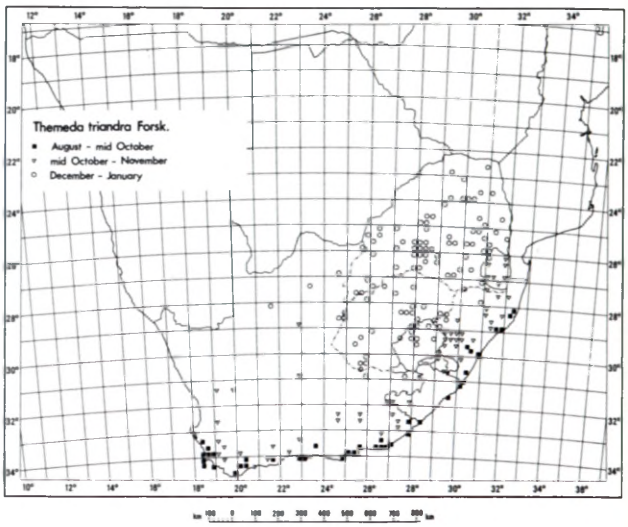

FIG. 20.—Distribution of flowering in *Themeda triandra*.

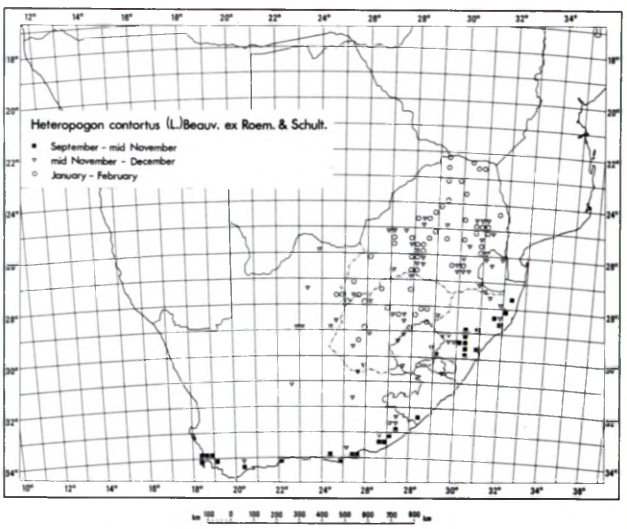

FIG. 21.—Distribution of flowering in *Heteropogon contortus*.

mon collecting localities included Kalkhugel, Kalkbuschsteppe, Okongava, Amusema, Ameib, Erongo and Unduas. In mid-March he moved north-east to Grootfontein, collecting on the way, and on the 18th March started collecting in the Tsumeb district. He remained in that area until mid-July, collecting specimens 7497 to 7703. Localities included Heidelberg, Bobos, Neitsas and Guchab. During this period he also collected occasionally at Karakowisa, east of Grootfontein. During August he returned to the Karibib district where he collected a few specimens near Okahandja. Dinter then travelled south to Windhoek where he collected specimens on the 10th October. A few days later he collected south-west of Windhoek at Lichstenstein, Friedental, Weissenfels and in the Hakos Mountains. He stayed in this area until about the 20th December, collecting numbers 7889 to 8054. During late December he travelled further south to Buchholzbrunn, near Aus, where he collected numbers 8264 to 8307. From this area he travelled to Swakopmund, collecting specimens at Helmeringhausen and Nudaus on the way. In March 1935 he collected at Swakopmund, with the last specimen to be collected in the territory apparently being *Hypertelis caespitosa* Friedr. (no. 8471) on the 15th March 1935.

We have shown above that a fairly detailed account of a collector's route can be obtained from a study of his specimens in such a data bank. Without selection and sorting by computer, of course, and a good collection of his material in the herbarium, it would not have been feasible to undertake such a task. Other factors contributing to the success of this particular exercise were the presence of dates, sequential collecting numbers and localities that could be identified on most labels. Absence of one or more of these items would have made reconstruction far more difficult, if not impossible.

CONCLUSION

In this paper we have presented an account of what information is contained within the PRECIS data bank and have given two examples of the kinds of information that may be extracted from it. In some areas, e.g. economic botany and habitat information, there is far less information available on herbarium sheets than had been expected. Also, it has become clear that collectors note abnormal characteristics and situations far more regularly than normal ones, leading to an apparent bias in some categories. On the other hand, we consider that particularly valuable information has already been extracted and should continue to be extracted from PRECIS for the benefit of the botanical community in South Africa. Obviously, the information presented in this paper has limited value in itself but the data bank should be of particular use in revisionary studies, regional floras and biogeographic research.

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UITTREKSEL

Die inhoud van die gerekenariseerde inligting berging en onttrekking stelsel (PRECIS) van die Nasionale Herbarium, Pretoria (PRE) word breedvoerig bespreek, hoofsaaklik by wyse van frekwensie histogramme van beskrywingskodes. Die frekwensie verspreidings wat gevind is, word in die lig van die geskiedenis van die herbarium, die geografie van die gebied en die gewoontes van plantversamelaars bespreek. Twee gebruike van PRECIS word deur voorbeelde geillustreer. Eerstens, word die blomfenologie van Eragrostis capensis, Themeda triandra *en* Heteropogon contortus *geplot en, tweedens, word die roete wat deur Dinter in Suidwes-Afrika vanaf Desember 1933 tot Maart 1935 gevolg is, beskryf. Daar is tot die gevolgtrekking gekom dat die stelsel van besondere nut in hersienings studies, streeks floras en biogeografiese navorsing kan wees.*

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