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STUDIES IN THE GENUS EULOPHIA R.Br.

— BY —

A. V. HALL.

Being a thesis submitted  
for the Degree of Master  
of Science.

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## SUMMARY.

Detailed variation studies of 23 species of the genus Eulophia R. Br. (Orchidaceae) indicate that six taxa may be upheld as distinct species, together with two or possibly three infraspecific taxa, whose status can only be assessed on the basis of further field work. It is considered highly likely that the remaining 17 taxa should be relegated to the synonymy of the six species upheld, possibly together with a further eight doubtfully distinct species of which only descriptions were available.

Of the remaining 57 previously accepted South African species of Eulophia, preliminary studies indicate that 29 may have to be regarded as synonymous to a probable 22 species, among which it may be possible to distinguish about six infraspecific taxa.

Cytological studies of fourteen species of Eulophia indicate the presence of three series of gametic chromosome numbers, approximating to 28, 36 and 56 respectively. The correlation of these chromosome numbers with morphology is discussed. Inter-chromosome linkages recorded by previous workers for other Orchid genera were found to be rather common in the species examined.

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## INTRODUCTION.

The first monograph of South African species of the genus *Eulophia* (Orchidaceae) appeared in 1912, under the authorship of R. A. Rolfe, in *Thistleton-Dyers Flora Capensis*. Previous to that date a considerable number of the more distinctive species had received recognition, and had been described and published by such authors as Sprengel, Lindley, Reichenbach the younger, R. Schlechter, Sonder and H. Bolus. A number of these authors had collected and travelled in South Africa, and had acquired first-hand experience of the rather high degree of population variation in *Eulophia*. Such experience is of considerable importance in assessing the latitude of species concepts, and in the authors opinion it was unfortunate that circumstances did not permit Rolfe to visit South Africa. Partly due to this, and also perhaps because of the haste with which the later volumes of *Dyers Flora Capensis* had to be compiled, it appears that Rolfe was led to include a rather large number of unnecessary names in his treatment of the genus. A revision of South African species of *Eulophia* has thus been required for some time.

It was previously held that members of the present concept of *Eulophia* constituted two closely allied genera, *Lissochilus* R.Br. and *Eulophia* R.Br., which were distinguished as follows:--

### *Eulophia*

Sepals and petals more or less equal, concolorous or the petals paler; Sepals and petals subconnivent, or sepals occasionally reflexed. Labellum crests rarely stout and fleshy, often much dissected.

### *Lissochilus*

Petals larger and differently coloured from the sepals. Sepals generally strongly reflexed; Petals erect to suberect. Labellum crests stout, fleshy, rarely finely dissected.

However, the significantly high frequency of forms intermediate in these characters has led several workers of wide experience

to conclude that the distinctions do not warrant recognition of the taxa at genus level (Hooker, Oliver and Brown in Bolus, 1918; Summerhayes, 1936; Schlechter, 1895; Perrier, 1935.). To quote Summerhayes (1936) :- "The genus (*Lissochilus*) rather consists of the end members of a number of series starting from different basic points within the genus *Eulophia* and evolving along parallel lines of development". This opinion is in accordance with that of the present author, although a lack of experience with inter-generic distinctions in the Orchidaceae suggests that it would be unwise to enter into such a controversy. The present work is therefore chiefly concerned with relationships between taxa at and below species level.

Affinities between such minor taxa in *Eulophia* are often complex, and elaborate methods have to be used to place their assessment on as objective a basis as possible. However, once these affinities had been established, considerable difficulty was experienced in expressing the rather complex variations patterns in terms of the conventional categories Species, Sub-species and Variety.

Throughout the literature, criteria for the application of these categories are astonishingly vague. One may concede the fact that one is attempting to lay down a system of categories over the products of a wide range of evolutionary processes, with the implication that the taxonomic treatment may vary considerably from group to group. Nevertheless there is no call for the existing laxity in defining at least the general conditions for use of a particular category. Some examples of the conflicting nature of the various meanings attributed to Subspecies and Variety are given overleaf (from Lawrence, 1951).

- Subspecies :** (1) Forms distinguished by less obvious or less significant morphological features than are more obvious species within the same genus.
- (2) Major morphological variants of a species exclusively occupying distinct parts of the distribution range.
- (3) Forms whose distributional, ecological and morphological characteristics suggest that they may constitute a distinct ecotype.

- Variety :** (1) A morphological variant of the species without regard for distributional characteristics.
- (2) A variant exclusively occupying a distinct part of the distribution range of a species.
- (3) A colour variant.
- (4) A variant whose form is the result of influence of special local habitat conditions.

It is a recognised dictum that no two taxonomists may reach the same conclusions about the status of groups within a complex. Lack of uniformity in the concepts of minor taxa may largely contribute to this aberration.

In the present work, the criteria for application of categories have been selected as follows, being based largely on du Reitz's concepts (du Reitz, 1930) :-

**Species :** The smallest natural populations invariably separated from each other by a major discontinuity in the series of biotypes.

**Subspecies :** A variant whose characteristics are minor in relation to those distinguishing the Typical form of a species from its nearest allies, the variant exclusively occupying a specific part of the distribution range.

**Variety :** A variant similar in nature to the Subspecies, but not exclusively occupying a specific part of the distribution range.

It is not considered necessary to recognise Forms, as extremely detailed analysis would be required for their rigorous demonstration.

METHODS OF EXAMINATION OF HERBARIUM SPECIMENS: Previous workers on the genus *Eulophia* have found considerable difficulty in treating dried and pressed flowers to render them suitable for dissection. Subjecting dried flowers to boiling is generally unsatisfactory as the agitation may lead to considerable damage to the thin and initially brittle perianth. Soaking in hot water was found to be far too lengthy for practical purposes, largely due to the formation of protective air bubbles on the slightly waxy epidermal surfaces.

On the suggestion of Professor J. H. O. Day of the Zoology Department, University of Cape Town, a method was tested that involved soaking the dried flowers in a 5 % solution of tri-sodium phosphate for 2-3 hours at 60° C. This proved to be extremely satisfactory, the flowers in many cases being restored to very nearly their original 3-dimensional shape. Flowers left in the solution for longer periods tended to become too soft and pulpy for dissection. This could be corrected by immersion in 70% Ethyl alcohol for 5-10 minutes.

To record floral morphology with maximum precision for comparative purposes, a photographic enlarger was used to project the images of the various flower parts onto a drawing board. The parts were laid out in water on a glass plate or in a shallow trough, and covered by a microscope slide. This could then be fitted into the film gate of a 2½ x 3½" enlarger for projection. Drawings of flower parts were set down in a standard pattern (see drawings in Section on Variation). From the top of a set of drawings downwards, the parts were arranged as follows:—

- (1) Ovary, column and spur.
- (2) Petals.
- (3) Labellum, usually with side view of the crests drawn next to it. The crest drawings were usually numbered according to the position of the nerve above which they lie (1 for crests above central nerve, 2 for crests above adjacent nerves). Crest 2 drawn alone is un-numbered.

(4) Sepals. A lateral sepal is drawn with the apex below, the odd sepal with the apex directed upwards.

Unless otherwise stated, all drawings were made on a scale four times natural size.

Recording crest morphology at first presented some difficulty, until it was found that by far the greater number of such emergences lay in lines above the larger nerves on the labellum. A needle, tipped with a small longitudinal cutting edge, could be used to sever the tissue between crested nerves, which could thus be removed and the crests laid flat on a slide for projection and drawing. It is considered that this technique, together with refined methods of reconstitution of dried material, represents a significant advance over previous work, where in many cases it had not been possible to examine the often quite important crest morphology of herbarium specimens.

In selecting material for dissection and drawing, it was found that mature flowers from distal parts of the inflorescence tended to be a little smaller than those produced below. As it was considered best for the purpose of this thesis to have the variation analysis encompassing all possible developments of floral morphology, no effort was made to use flowers from comparable levels on the inflorescences.

Details of floral morphology were recorded in this way for material of all *Eulphia* species represented in the collections at the Bolus Herbarium, University of Cape Town, together with part of the collection from the National Herbarium, Pretoria. Greater emphasis was laid on floral morphology in this survey, as vegetative characters tended to be of rather less taxonomic significance. Even distant relatives of a given form may have closely similar morphology in the vegetative organs, which may further show dimensional variation of a high order as a result of the

influence of habitat conditions. This survey of morphological variation in the genus was carried out to demonstrate likely affinities among as many South African species of *Eulophia* as possible, so that in the detailed treatment of a limited number of complexes, no allied forms should be omitted.

TERMINOLOGY: All terms used to describe the shapes of various organs are based on the drawings and definitions in the Glossary of John Lindley's Introduction to Botany, Third Edition, London 1839. In addition, it is necessary to draw attention to the terms in current use in orchid systematics (e.g. Adams, in <sup>W</sup>Wimber, 1959).

In contrast to allied Monocotyledonous families, the term Tepal is not often used in referring to the perianth segments, owing to their high degree of differentiation. The outer whorl of three segments are generally known as sepals, two of which are placed laterally in relation to the plane of symmetry of the flower (Lateral Sepals). The remaining segment of this whorl is called the Odd Sepal. The three segments of an inner whorl are inserted alternately in relation to the sepals, and are usually clearly differentiated from them by distinctive size, shape and colouring. The inner whorl segment lying in the plane of symmetry is usually of rather more complex structure than the other segments, and is called the Labellum. The two remaining segments are referred to as Petals.

In *Eulophia*, an erect Column bears an anther and stigmatic surface near its apex, as in *Cattleya* (see Darwin, 1904). The labellum is attached to the frequently extended foot of the column, such an extension being known as a Mentum. In many species a Sac or hollow Spur may be produced at the base of the labellum.

The three-lobed labellum of *Eulophia* can be arbitrarily divided into three sectors, as follows:-

(1) Middle lobe: That part of the labellum limb

extending from the labellum apex to a line joining the points of insertion of the distal margins of the side lobes.

(2) Lateral (side) Lobes: Tissue lying outside a line joining the base of the notch between middle and side lobes, and the point of junction of the labellum margin to the lower part of the column.

(3) Basal portion, to which the lateral and middle lobes are attached.

This description of the lateral lobes is of rather greater significance than previous concepts, where undue attention was given to the highly variable free distal apex of the lateral lobes. It is likewise not considered satisfactory to use the term disc for the areas of the inner labellum surface bearing appendages or Crests. Crests may be distributed in varying degrees of development over the greater part of the labellum, and may occur in a reduced condition near the distal margin of the lateral lobes. The term disc is thus of very little descriptive significance.

CITATION OF SPECIMENS AND OTHER CONVENTIONS: As this thesis is not of the nature of a taxonomic monograph, it is not considered necessary to cite all details on herbarium labels, and the data has been reduced to the Province, Division and local name of the place of collection, together with the name of the collector and the specimen reference number. The location of specimens in herbaria are given in terms of the abbreviations of Lanjouw and Stafleu (1959).

The species are arranged in approximately the same sequence as in Dyer's Flora Capensis. As the work was primarily concerned with taxa at and below species level, no attempt has been made to group the species into categories such as those of Perrier (in Humbert, 1939).

## VARIATION.

**(1). EULOPHIA PETERSII COMPLEX:** Preliminary inspection reveals the presence of three groups in this complex, their characteristics being as follows:—

**Form I:** Inflorescence axis unbranched and rather stout, frequently pale brown in the dried state. Labellum side lobes expanded at the base, tapering distally to merge gradually into the middle lobe. Flowers generally rather large. (See p.13)

**Form II:** Inflorescence axis showing first order branching, invariably dark brown in the dried state, frequently more slender in the distal parts than form I. Labellum side lobes a little broadened about the middle, rounded distally, usually with a distinct notch at the point of junction with the middle lobe. Flowers generally slightly smaller than those of Form I. (See page 15).

**Form III:** Inflorescence axis showing second order branching, dark brown in the dried state, as slender in the distal parts as Form II. Flowers a good deal smaller than those of Form I or II. Labellum side lobes oblong, rounded distally with a distinct notch at the point of junction with the middle lobe.

Reference to Map 1 shows that the expression of the chief distinguishing characteristics, inflorescence branching and side lobe morphology, is correlated with geographical distribution. Specimens of the affinity of Form I are recorded almost exclusively from the coastal parts of Natal and Portuguese East Africa, whereas those from inland localities in the Northern Transvaal and Southern Rhodesia exhibit the characteristics of Form II to a marked degree.

Specimens from the South Eastern Transvaal however, while clearly having either branched or unbranched inflorescences, tend to be intermediate in floral characters (see drawings on page 14). The labellum side lobes closely resemble those of Form I

in available specimens from this area. Studies of variation in populations in this district would be extremely profitable, and it is unfortunate that the author was unable to find any material of E. petersii on collecting trips in that part of the country.

However, judging from (the authors) observations near Salisbury, Southern Rhodesia, it appears that first order branching occurs consistently throughout a population typically representing Form II. Further, Dr. E. A. Schelpe (of the Botany Department, University of Cape Town,) has reported that the unbranched characteristic of plants representing Form I was constant through several seasons of cultivation (private communication).

While this evidence lends weight to the importance of branching as a distinguishing character, it should be borne in mind that there are several reservations concerning its application and reliability. In 35% of the specimens examined, it was impossible to determine branching characteristics owing to partial or complete absence of the inflorescence axis. Further, juvenility or adverse ecological conditions could conceivably lead a normally branched form to produce a flowering axis that is unbranched.

It seems best therefore to await further evidence, principally from field observations, before coming to any conclusions regarding taxonomic status. The relatively minor nature of the distinguishing features, together with the marked correlation of variation with geographical distribution, suggests that subspecific status would be applicable to such taxa, if they were shown to be justifiable.

A similar problem is presented by Form III, of which unfortunately only one specimen was available. The form again differs in the branching of the inflorescence, and appears to have rather smaller flowers than those of its nearest ally in Southern Rhodesia (compare drawings of Form III - Smuts 1521, and

Form II - Greatrex 63, on page 16). Unfortunately, the only flowers available of Form III came from distal parts of the inflorescence, where they are usually a little smaller than those produced below. Nevertheless, it was considered pertinent to assess the degree of such differences in flower size statistically.

This was carried out by comparing variance ranges of frequency distributions of measurements of a suitable character. Measurements of petal length were compiled from material of all three forms and their respective variances calculated from the formula

$$\sigma^2 = \frac{\sum fu^2 - \frac{(\sum fu)^2}{n}}{n - 1} \dots\dots\dots(1),$$

where  $\sigma^2$  = variance,

$\sum fu^2$  = sum of the squares of petal measurements,

$(\sum fu)^2$  = sum of the petal measurements squared,

and  $n$  = number of measurements used from each form.

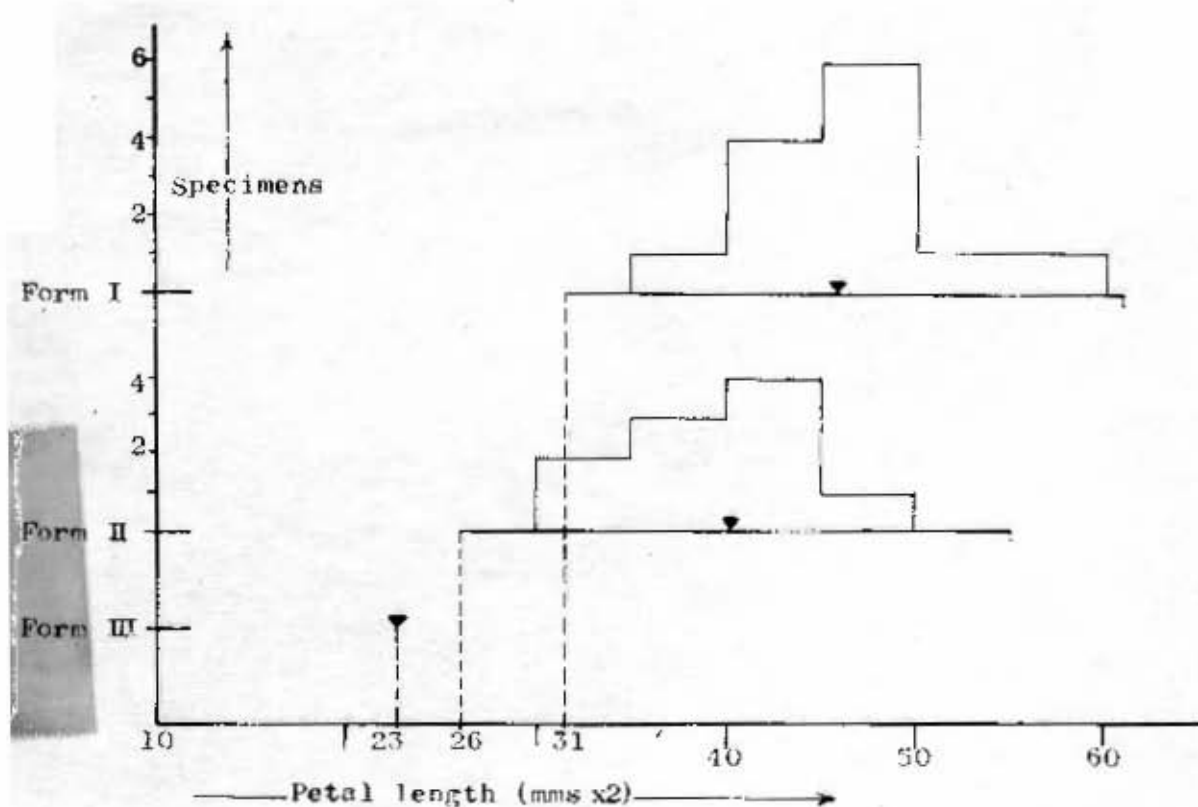
The extent of the range with a 99.75% probability of encompassing all measurements likely to be obtained from Forms I and II was calculated from  $m_I \pm 3\sigma_I$  and  $m_{II} \pm 3\sigma_{II}$  respectively,  $m$  being the mean of observations of each set.

The results are presented in Diagram 1. It can be seen that the measurement of petal length of the Form III specimen lies just outside the variation limits of Form II. In other words the probability that Form III is a member of the Form II population rates at rather less than 0.25%. (The diagram also supports the observation that flowers of Form I tend to be on the average a little larger than those of Form II).

This rather large dimensional difference, together with the probably distinctive second order branching of Form III should next be considered in relation to geographical distribution.

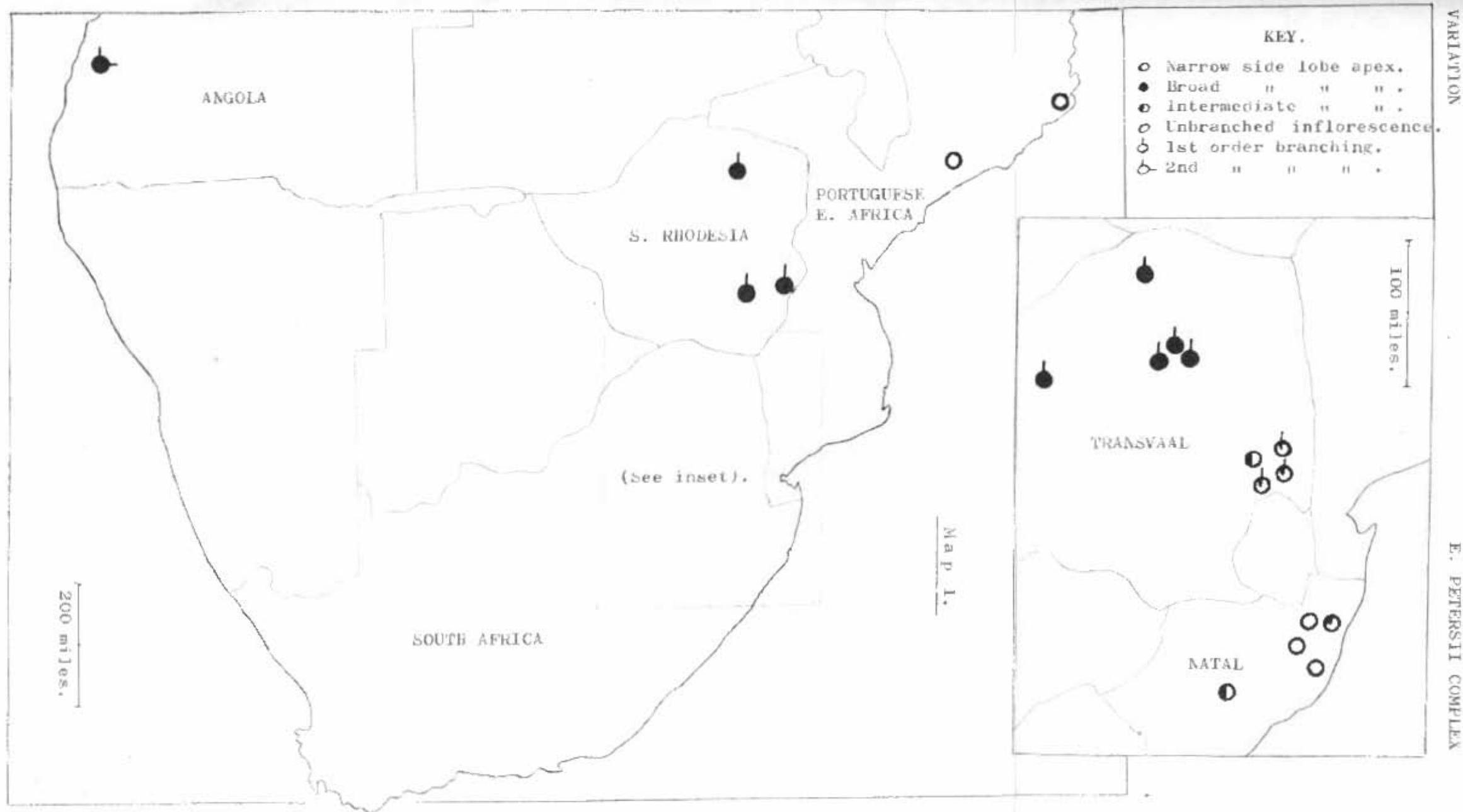
Form III was collected near the coast of Angola, nearly 1000 miles from the nearest locality recorded for material of other forms (MARU)

It appears that Form III represents a further development of the somewhat topoclinal changes noted between Forms I and II, that involved a modification of inflorescence morphology and a reduction in flower size, on passing a relatively short distance inland from the East African coast. The high degree of dimensional difference between Form III and its nearest ally may be interpreted as a result of an extension of the topocline between Forms I and II over a very much greater geographical range. It is considered highly likely that intermediate forms may be found in the intervening parts of Angola and Northern Rhodesia. Until such material is available, it seems best to retain the existing status of a separate species for Form III, on the basis of the distinctions detailed above.

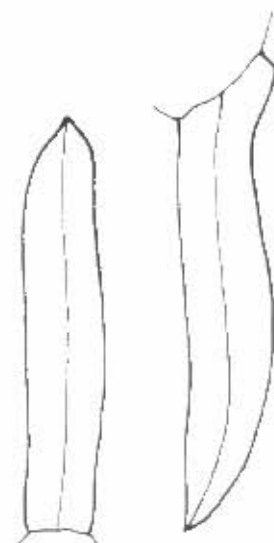
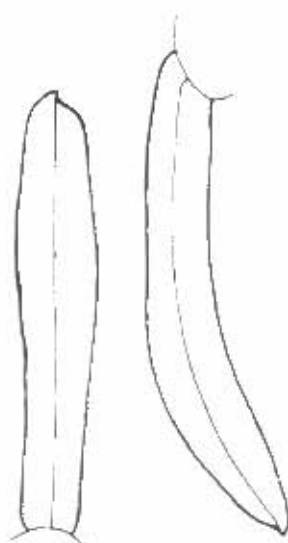
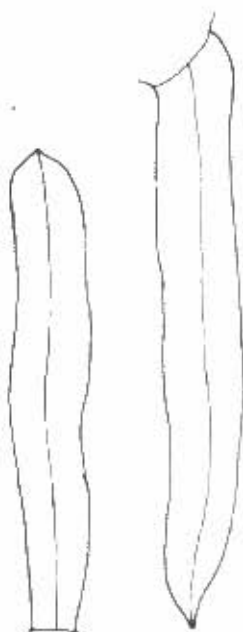
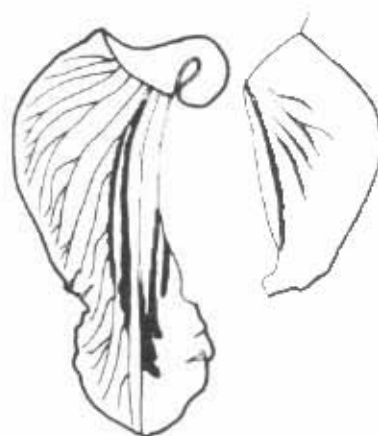
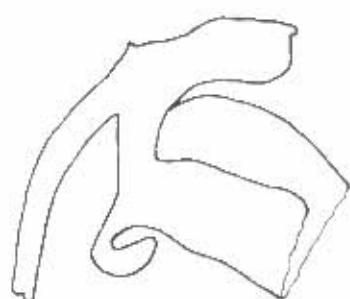
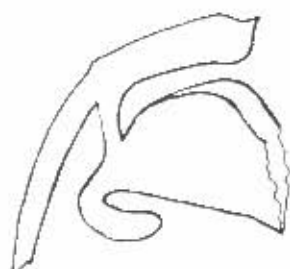


**Diagram 1:** Showing frequency distributions of specimens of the *E. Petersii* complex with unbranched scapes (Form I), first order branching (Form II) and second order branching (Form III), in relation to their measurements of petal length. The values of  $m_{III}$ ,  $m_{II} - 3\sigma_{II}$  and  $m_I - 3\sigma_I$  are shown by dotted lines,  $\sigma^2$  representing the variance and  $m$  the mean in each set.

MAP 1: DISTRIBUTION OF THE E. PETERSII COMPLEX (COMPLETE SPECIMENS ONLY).



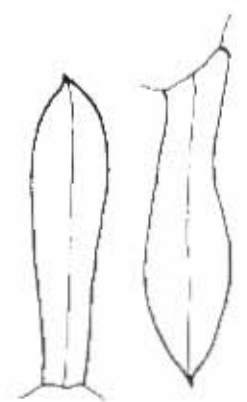
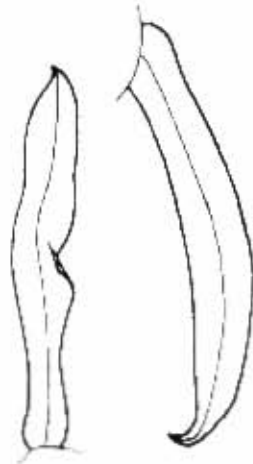
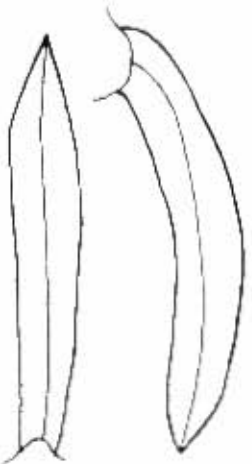
All drawings  
twice natural  
size.



Bolus Herb. 15717.  
Natal.  
Unbranched infl.

Harrison 35.  
Natal.  
Unbranched infl.

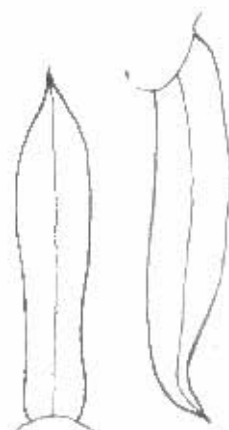
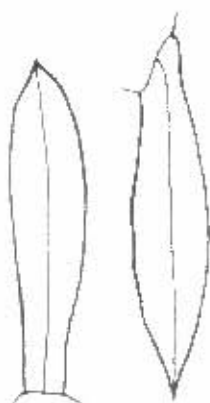
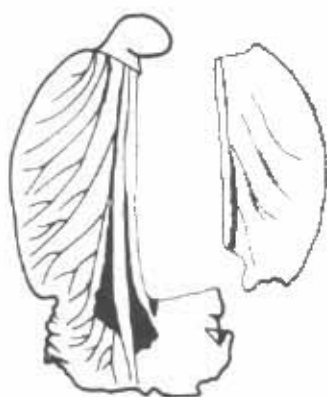
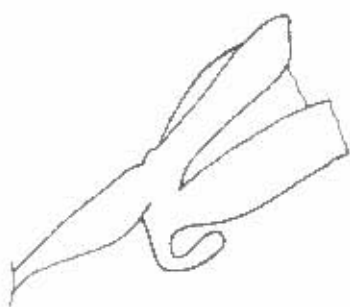
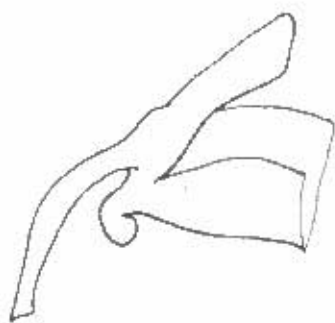
Gomes e Sousa 3500.  
Port. E. Africa.  
Unbranched infl.



rogers 204912.  
E. Transvaal.  
Unbranched infl.

v.d. schijff 1265.  
E. Transvaal.  
Branched infl.

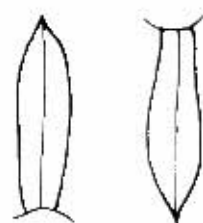
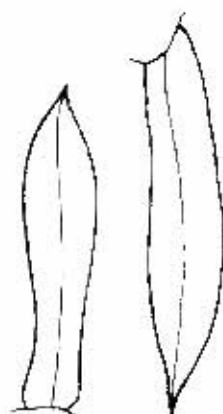
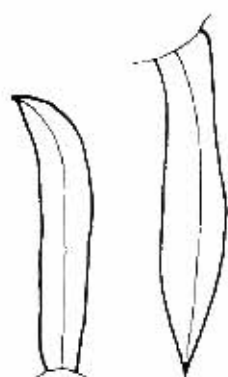
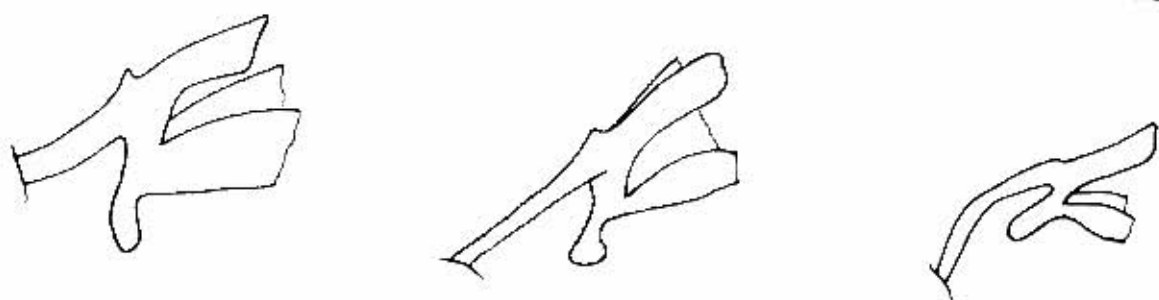
Pole Evans 5920.  
E. Transvaal.  
Branched infl.



Kies & Bruce 33.  
N. Transvaal.  
branched infl.

Nat. Herb. 24475.  
N. Transvaal.  
Branched infl.

Nat. Herb. 28745.  
N. W. Transvaal.  
Branched infl.



Nat. Herb. 29042.  
S. Rhodesia.  
Branched infl.

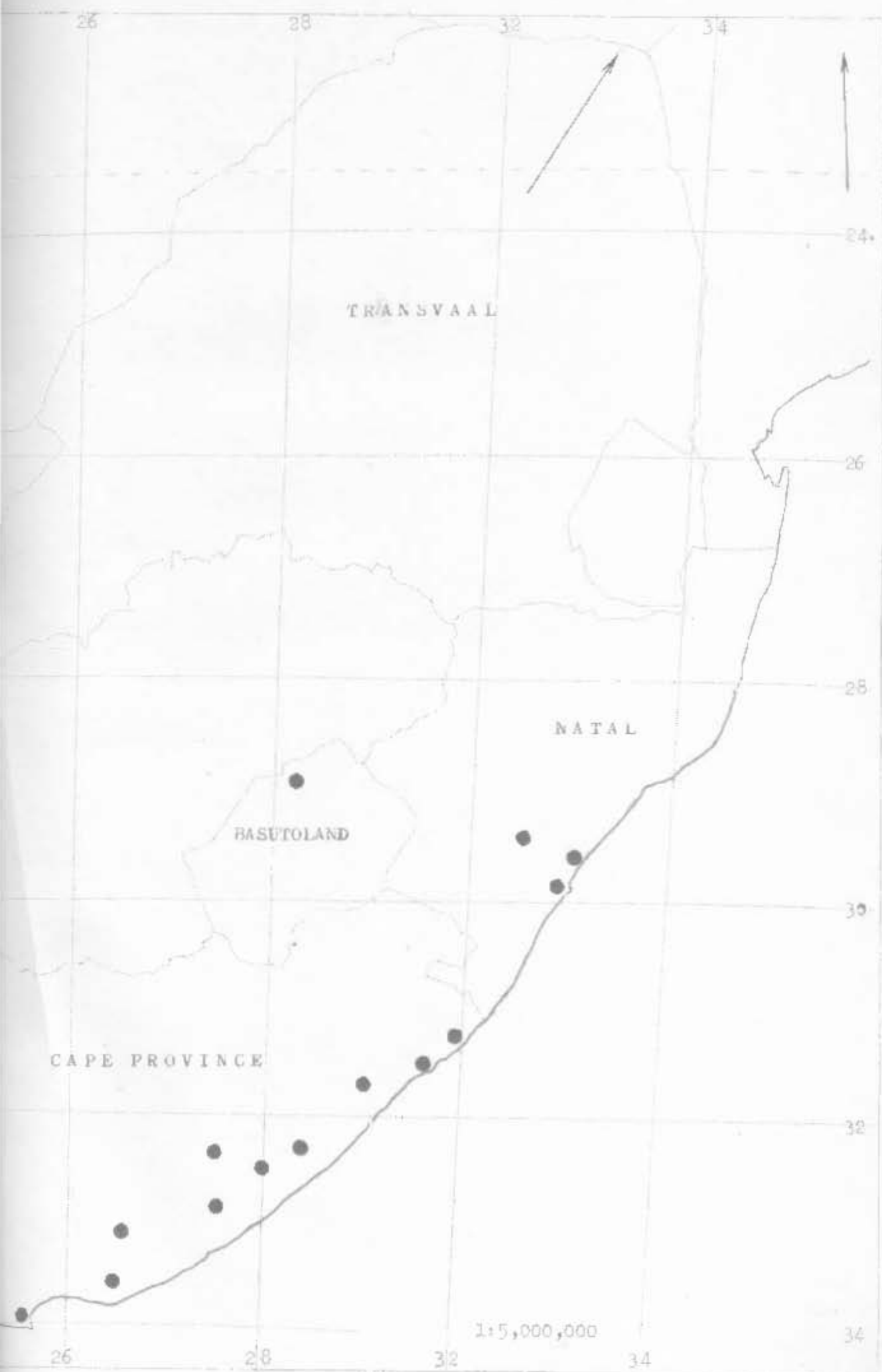
Greatrex 63.  
S. Rhodesia.  
Infl. not seen.

Smuts 1521.  
Angola.  
Branched infl.

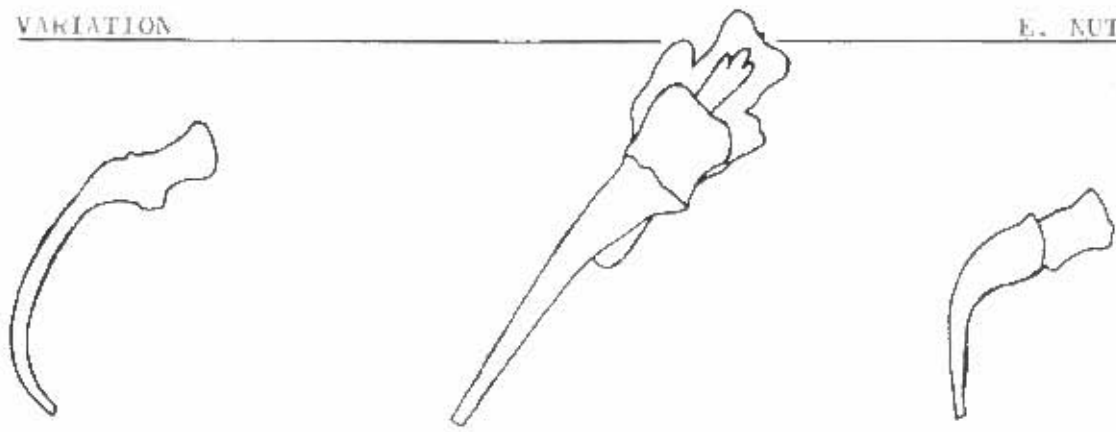
(2) EULOPHIA NUTANS: While there appears to be a certain amount of minor variation in this group, only one case has been recorded of an apparently significant variant.

The minor variation is most apparent in the shapes of the lateral and middle lobes of the labellum (see drawings on pages 19, 20). However, a wide and continuous range of such forms was found to occur within a single dense population near Grahams-town in the South Eastern Cape. (See page 21). This evidence suggests that it would be extremely difficult to delimit taxa, even of very low status, within these forms. It is notable that a specimen from Southern Rhodesia, apparently isolated by a distance of some 600 miles, showed a morphology lying well within the limits of South African material (see map 2, and drawings of Hall 340 on page 19).

An important variant was found in specimens of Miss Pegler's collection no. 290, from Kentani in the S. E. Cape. (See page 22). The specimens are characterised by unusually broad bases to the labellum side lobes, perceptibly larger flowers, and vegetative parts about 40-50% larger than the average for other specimens. However, there are no important structural innovations, and the modifications chiefly express an increased luxuriance of development. There is no evidence to suggest that the form was growing in a habitat likely to induce luxuriant growth, the herbarium label reading "Valleys, rare". However, if the modifications had an ecological basis, one might expect to find a continuous range of intermediates among other specimens, and not the rather marked discontinuous variation, which suggests an inherent genetical difference. It is clear therefore that further population studies are required before the status of this variant can be assessed.



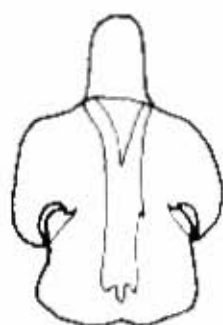
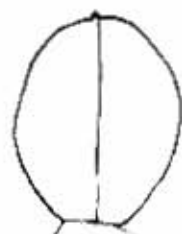
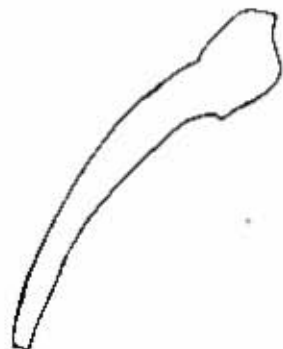
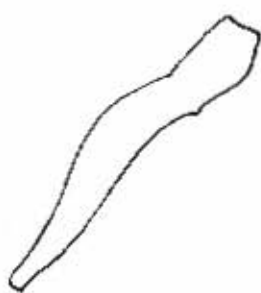
Map 2: Distribution of *E. nutans* Sond. Arrows point towards the locality in Southern Rhodesia.



Bolus 10291.  
Stutterheim Dist.  
E. Cape Province.

Hall 340.  
Melsetter Dist.  
S. Rhodesia.

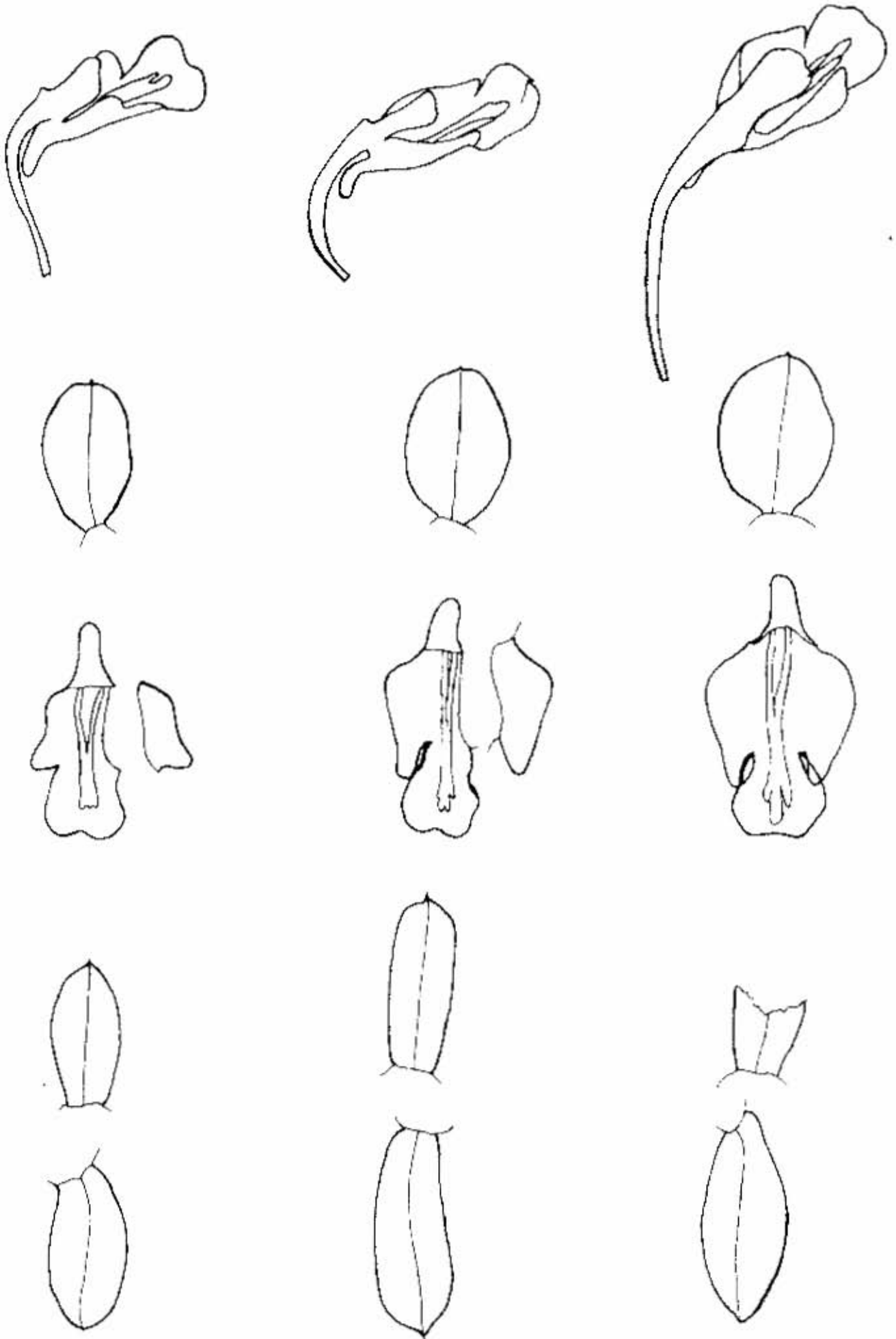
Gueinzus s.n.  
? -  
Natal.



Acocks 15269  
Lusikisiki Dist.  
E. Cape Province.

Schreell s.n.  
Kingwilliamstown  
E. Cape Province.

Bolus 7366  
Grahamstown  
E. Cape Province.



Hall 606.  
Grahamstown  
E. CAPE Province.

Fegler 290.  
Kentani District.  
E. Cape Province.

(3, 4 and 5.) EULOPHIA HIANS - E. LAXIFLORA COMPLEX:

Preliminary inspection of a little over 200 sets of specimens revealed not much more than general trends in the greater part of the complex. It seems likely that the variation pattern is what may be described as 'nodal', with large numbers of specimens falling into one of several groups, and varying percentages tending to form continuous series between such groups. It is extremely difficult to fit a workable system of taxonomic categories to this kind of variation pattern, and it was found that fairly elaborate statistical techniques were required for the resolution of taxa.

Scatter diagrams of measurements taken from organs appearing to show the most significant variation indicate that it is not possible to delimit taxa on the basis of such characters alone. (See diagrams 2-7). It thus seems likely that any delimitation must rest on particular sets of character combinations. In many parts of the complex, the subjective visual estimation of what combinations are most suitable tends to be a rather risky process. Accordingly, the author was led to seek a more objective method of demonstrating relationships.

Such a scheme must ultimately be based on numerical data, at once a drawback in that it is only possible to express shapes rather crudely in terms of measurements, without resorting to subjective systems of scoring. However, in this complex, it was found that most major developments could be reasonably well recorded using a set of thirteen measurements for each specimen. The system devised essentially involves comparison of these sets of measurements, leading to the construction of a chart showing the specimens linked by lines to their closest 'dimensional' allies.

in this way for a sample of 66 specimens representing most major developments of the complex, but excluding forms referable to the Type of E. brachystyla Schltr., which are readily distinguishable on characters difficult to express in terms of measurements.

The characters used were as follows :—

- A. Column length.
- B. Spur length
- C. Labellum length.
- D. Length of middle lobe of labellum.
- E. Broadest width of middle lobe of labellum
- F. Petal length.
- G. Broadest width of petal.
- H. Odd sepal length.
- I. Broadest width of odd sepal.
- J. Length of penultimate sheath on the scape.
- K. Length of the internode clothed by penultimate sheath.
- L. Scape length.
- M. Length of longest leaf.

Vegetative characters were included as they appeared to show considerable correlation with floral morphology variations in the preliminary survey. While generally speaking, their reflection of inherent relationships may be masked by their pronounced responses to habitat conditions, it was felt that the significance of such characters was too great in the complex for them to be omitted. A degree of simplification might have been achieved by the use of ratios between various measurements; however it was considered that such a practice would tend to reduce the strictly objective nature of the method.

The final diagram, presented on pages 39 and 40, was constructed primarily on the basis of first order 'relationships' (minimum compound dimensional difference values), which are shown as lines ('bonds') joining the specimens. Second and third best relationships were used to guide the positioning of specimens;

they are not shown however as their inclusion would have necessitated the construction of a 3-dimensional model.

The principal advantage of this procedure is that it achieves a simultaneous assessment of a considerable number of characters. In conventional taxonomic practice the number of characters assessed depends very largely on the perceptive capacity of the observer. However, the compounding of such differences has the somewhat unfortunate effect of not showing what are the chief constituents of the values. This is best carried out by examining the morphology of the specimens used, in relation to the affinities suggested in the diagram.

The diagram reveals the presence of two series, between which no primary, secondary or tertiary links exist. For convenience, the two major groups are named the Laxifloroid and the Hiansoid Series, after the two most common forms referable to the names E. laxiflora Schltr. and E. hians Spreng. Names were coined for other variants in a similar manner.

A cytological examination of a representative of the Hiansoid series revealed that it had approximately twice the chromosome number of two forms of the Laxifloroid series, the numbers being within the ranges 109 - 112 and 54 - 56, 50 - 56 respectively. In view of the similarity of the basic morphological developments in the two series, it is reasonable to suggest that the Hiansoid series originated as polyploids of the Laxifloroid series.

In this connection it is interesting to note that the chief differences between the two groups lie in the rather more bulky construction of parts in the Hiansoid series. From casual observation it seems likely that this bulkiness may be chiefly due to an increased cell size. This type of effect has been

recorded previously in several instances of polyploidy (eg. Gates 1909), although it is probably by no means as frequent as the popular conception suggests (Stebbins 1950).

It may also be significant that the putative polyploid Hiansoid series shows far greater morphological instability than the Laxifloroid series. Whereas a high frequency of malformed flowers was recorded in the Hiansoid group, slight irregularity was only found twice in the other group. Pollination experiments in a population of Hiansoid forms near Grahamstown (E. Cape) showed that these abnormal flowers were quite capable of setting fruit, although circumstances did not permit fertility tests on the seed produced.

Phenology of flowering can be of considerable use in distinguishing between members of the two groups, and it is unfortunate that owing to the frequent lack or imprecision of such data on herbarium labels, it must be regarded as being of secondary importance. The frequency distribution of precisely recorded dates of collection is shown in diagrams 9 and 10. Members of the Hiansoid series flower mostly during September, October and November when the leaves are not fully developed, whereas forms of the Laxifloroid series generally flower in the months December, January and February, with exceptional cases in September and October.

The principal morphological developments in the two series, deduced from an examination of specimens in conjunction with Diagram 8, are described below:—

#### LAXIFLOROID SERIES

Spur shorter than the column, except rarely in Section 3.  
Leaves fully developed at time of flowering. Penultimate scape sheath 0.5-1.4 times as long as the internode it clothes.

#### HIANSOID SERIES

Spur 1.0-1.3 times as long as the column except in some forms of Sect. 7. Leaves usually not fully developed at time of flowering. Penultimate scape sheath 0.3-0.5 (rarely 0.8) times as long as the internode it clothes.

LAXIFLOROID SERIES (CONTD.)

1. Purpurascents: Spur, including a short mentum, 0.6-0.8 times as long as the slender 0.5-0.7 cm column. Labellum narrow, up to 2 cm long, dense papillae on the middle lobe.

1a. Galpinoids: A serial development of section 1, culminating in forms with flower parts 50% smaller.

2. Aemuloids: Petals 1.0-1.7 cm long. Penultimate scape sheath 0.5-1.2 times as long as the internode it clothes. Crests of dissected blades. Spur 0.6-0.8 times as the 0.35-0.45 cm long column, lying closely beneath the ovary. Labellum suffused with pale pink or green

No equivalent of Section 5a in this series.

2-3. Similar characters to Section 2, but spur curved away from the ovary, longer.

3. Laxifloroids: Similar to Section 2, but spur set apart from the ovary by a distinct mentum, 0.8-1.1 times as long as the 0.40-0.55 cm column. Labellum suffused with yellow.

HIANSOID SERIES (CONTD.)

No equivalent of section 1 in this series.

No equivalent of section 1a in this series.

5. Hiansoids: Spur 1.0-1.3 times as long as the 4-6 mm long column, set apart from the ovary by a vestigial mentum. Leaves very rarely fully developed at time of flowering. Crests of dissected or subpapillose blades. Middle lobe of labellum much expanded distally. Equivalent to Section 2 and 2-3.

5a. Aberrant Hiansoids: A serial development of Sect. 5, the forms having petals, labellum and occasionally sepals variously distorted. Petals and labellum purplish like in Section 5.

6. Inaequaloids: Morphologically indistinct from Section 5. Mentum often prominent, middle lobe of labellum rarely expanded distally, side lobes seldom falcate-divergent. Petals and labellum yellow, rarely distorted. Equivalent to Section 3.

LAXIFLOROID SERIES (CONTD.)HIANSOID SERIES (CONTD.)

**4. E. brachystyla:** A distinct group based on the following characters; side lobes divergent, attached to less than half the length of the limb of the labellum. Cresting of low fleshy dissected ridges. Spur 0.6 - 0.8 times as long as the 0.25 - 0.30 cm column, lying closely beneath the ovary.

**7. Brachystylo - Hiansoids:** A serial development of Sect 5. Side lobes attached to less than half the length of the limb of the labellum. Spur 0.7 - 1.4 times as long as the 0.35 - 0.45 cm column. Crests usually of high, slightly dissected blades, often only above the three central nerves. Equivalent to Section 4.

Only brief synopses of the characters tending to distinguish groupings are given in the above Table. Drawings of representatives of each group may be found at the end of this article.

A feature of considerable significance in the taxonomy of complexes of this sort is the nature of the variation encountered within and between geographically distant populations. Assortments of forms from sections 1, 2 and 3 are seldom found under a given collectors number, in spite of great morphological similarities. Further, in the two populations of forms representing Sections 1 and 1a examined by the author, the characteristics peculiar to these groups were exhibited with little variation throughout each respective assemblage of plants. While these populations may probably be locally homogenous, there appears to be a high degree of continuity in the range of specimens assembled from various parts of South Africa. This is borne out by the 'chains' of closely related specimens in Diagram 8, as well as the sequences illustrated in Drawings 1 - 17. This concept of localised variants was not recognised in early work, and the limited material available led to the description of an unnecessarily large number of species.

The continuity of morphological developments suggests

that sections 1 to 3 should be combined to form a single variable taxon. The absence of restriction of any one of the constituent variants to a specific part of the distribution range indicates that this taxon may not be divisible into smaller units.

Representatives of section 4, while readily distinguishable from sections 2 and 3 by their peculiar side lobes to the labellum (see drawings on pages 64, 65), have considerable affinity with what is very likely an analogous development in the Hiansoid series (section 7; see drawings 21-32). While a series of intermediates may be found between sections 5 and 7 at the same locality (see drawings 21-23), limited information from collectors indicates that plants of section 4 tend to occur in locally isolated populations. This data, together with significant differences in cresting, size of floral and vegetative parts, and dissimilar phenology, points to a reasonable likelihood that section 4 may be recognised as a separate taxon, probably of species status.

In contrast to the variation pattern in sections 1 to 3, wide ranges of forms are encountered within populations representing sections 5, 5a and 7 (see drawings 18-35). The continuity of this variation, which encompasses a significant proportion of teratological forms (drawings 33-35), necessitates the incorporation of all three sections into a single taxon.

However the extent of the variability of this taxon occasionally obscures its distinctions from other parts of the complex. In diagram 8, two specimens considered to belong to section 5a by virtue of their rather long spurs, irregular petals and bladed crests, were <sup>found</sup> to be dimensionally closely related to a member of the Laxifloroid series. This apparent breakdown of otherwise diagnostic characters was found between several other specimens, in some cases the forms being distinguishable on

vegetative morphology alone (see drawings 49, 10, 15, and 48).

Accordingly, the author was led to seek a more objective appraisal of the distinctness of the groups involved. A method of testing differences was suggested by Professor Pollard of the Department of Mathematics, University of Cape Town, employing linear discriminant functions. The mathematical basis of this method is best described in a paper by its original author, R. A. Fisher (1936). The procedure for its application, as outlined by Professor Pollard, is given below.

Two groups of specimens were selected from each series, containing a range of doubtful forms. The principles of the method of evaluating their distinctions may be summarised as follows. Values of  $q$  are found in the equation

$$Z = q_1x_1 + q_2x_2 + q_3x_3 \dots \dots \dots q_kx_k$$

which weight the set of measurements  $x_1, x_2, x_3 \dots x_k$  of each specimen in such a way as to give values of the linear compound  $Z$  that afford maximum discrimination between the two groups. Values of  $q$  are in essence found by comparing measurements from each set of specimens. Finally, the degree of discontinuity in the range of values of  $Z$  is assessed statistically.

In solving equations for finding the values of  $q$ , determinants must be solved of an order proportional to the number of characters employed. As there is considerable labour involved in the solution of high order determinants, an attempt was made to restrict the number of characters to those most likely to be significant in distinguishing the two groups. <sup>Squares of</sup> Standard deviations were calculated for the ranges of measurements of both groups. The measured characters tested were the same as those used in the preparation of Diagram 8 (see page 25), and the groups consisted of 13 specimens from Sections 2 to 3, (set I) and 25 from Sections 5 and 5a. <sup>(Set I)</sup> The calculated standard deviations <sup>(squared)</sup> are given in Table 1.

**Table 1:** Means and standard deviations<sup>2</sup> of measurements in Sets I and II.

Charac- ters.	Set I.		Set II.	
	Means ( $\bar{X}$ )	Standard deviation <sup>2</sup>	Means ( $\bar{X}$ )	Standard deviation <sup>2</sup>
A	18.5	6.9	20.8	5.1
B*	16.2	8.9	23.6	11.6
C*	38.9	6.1	49.0	15.8
D*	17.2	4.6	27.2	7.5
E	19.8	4.7	25.7	21.6
F	39.9	8.4	49.2	25.7
G*	18.2	4.8	28.7	23.4
H	45.0	33.7	50.6	56.7
I*	11.8	1.2	16.5	1.9
J	45.7	97.9	31.6	34.9
K	53.9	171.5	67.9	488.0
L	36.0	196.7	28.9	41.1
M	22.5	21.1	12.4	30.4

Those characters marked with an asterisk in Table 1 have relatively little overlap in their ranges for  $\bar{X} \pm$  (standard deviation)<sup>2</sup> between the two sets, and are therefore considered most likely to be of significance in discrimination. The basic equation may then be written in the form

$$Z = q_B x_B + q_C x_C + q_D x_D + q_G x_G + q_I x_I \dots\dots(1)$$

Values of  $\underline{x}$  and  $\underline{Z}$  for substitution in equation 1 were obtained in the following manner. For set I, values of  $P_I$  were calculated from equation (2) for all cases of combinations of characters  $k_r$  and  $k_t$ .

$$P_{I, k_r, k_t} = \frac{\sum x_{I, k_r} + \sum x_{I, k_t} - \frac{(\sum x_{I, k_r})(\sum x_{I, k_t})}{n_I - 1}}{n_I - 1} \dots\dots(2)$$

where  $n_I$  = number of specimens in set I,

and  $\sum x_{I, k_r}$  = the sum of all measurements of character  $k_r$  in set I,

similarly for  $\sum x_{I, k_t}$ .

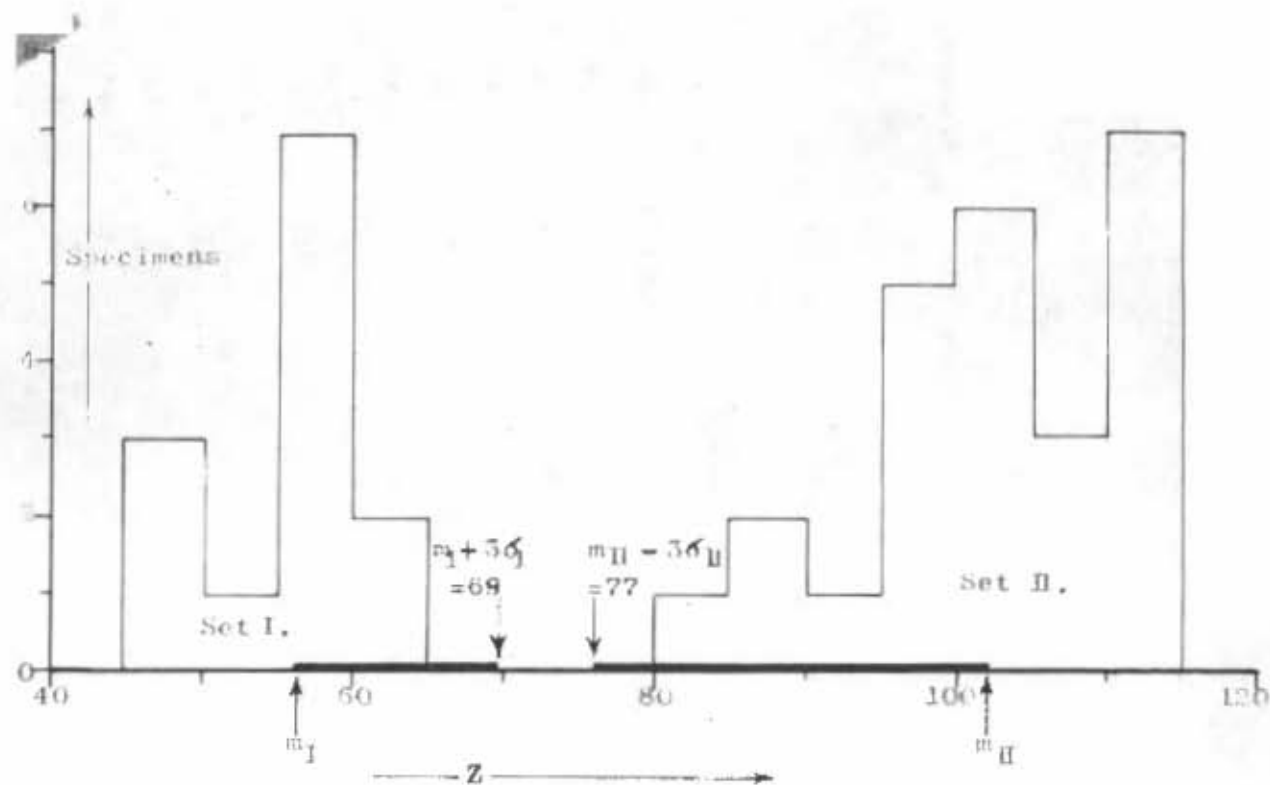


Diagram II: Showing the frequency distribution of specimens of the Laxifloroid series (Set I) and the Hiansoid Series (Set II), in relation to their values of the discriminating function  $Z$ .

It is at once apparent from Table II that the values of  $\bar{Z}$  for specimens of set I are consistently lower than those of set II, indicating that no misclassification had occurred in assigning these groups. The frequency distributions of values of  $\bar{Z}$  are presented in Diagram II. An analysis of frequency distributions in the two sets was carried out by the same method outlined

Set I.		Set II.	
Specimen	Z.	Specimen	Z.
1	52	1	114
2	60	2	112
3	57	3	111
4	50	4	114
5	49	5	109
6	59	6	103
7	48	7	101
8	61	8	101
9	55	9	97
10	55	10	101
11	56	11	99
12	60	12	97
13	62	13	102
14		14	104
15		15	103
16		16	105
17		17	107
18		18	104
19		19	107
20		20	104
21		21	104
22		22	104
23		23	104
24		24	107
25		25	86

Table II: Values of the discriminating function  $\bar{Z}$ .

whole number.

function  $\bar{Z}$  are presented in Table II, corrected to the nearest in equation (7). The resulting values for the discriminating

The sets of measurements of each specimen may now be substituted

$$Z = x_B + 0.016x_C + 1.194x_D + 0.020x_G + 1.534x_I \dots (7)$$

This data for q may now be substituted in equation (1), so that

$$\begin{aligned} \text{where } q_B &= 1, \quad q_C = 0.016 \\ q_D &= 1.194 \\ q_G &= 0.020 \\ \text{and } q_I &= 1.534. \end{aligned}$$

The values of q finally obtained are given below :-

on page 10. Assuming an approximate fit of a normal distribution curve, overlap between values of  $\bar{Z}$  between the two groups would possibly occur in rather less than 0.25% of the specimens.

Bearing in mind that this assessment chiefly applies to doubtful forms, it is considered that, together with all other evidence, Sections 1 to 3 and Sections 5, 5a, and 7 should be regarded as distinct at species level.

In passing, it should be mentioned that the weighting calculated for characters B, D, and I was much greater than that for C and G (see values of  $w$ , page 34). This was a result of some interest, as it had not been realised in preliminary surveys that characters D (length of middle lobe of labellum) and I (broadest width of odd sepal), were of such significance.

Section 6 of the Hiansoid series presents a case of some difficulty, as the morphological characters cited on page 28 for this section appear to be indistinct from those of section 5. (Compare drawings 43 and 51; 37 and 18; 39 and 21). Besides a colour difference and slightly modified morphology in the greater number of specimens, there is a little evidence on collectors labels to indicate that these forms occur in locally isolated populations. Unfortunately, no populations were found by the author for testing these propositions. Until evidence from field studies becomes available, the status of this group must remain in doubt. As the differences are relatively minor and there is no significant correlation with geographical distribution (see Map 3), it seems rather likely that on being recognised as a separate taxon, the group would receive varietal status.

It is therefore concluded that three species can be upheld in this complex, the valid names and the corresponding sections being as follows (see Taxonomy):- E. carunculifera Reichb.f. (Sections 1, 1a, 2, 2-3, 5); E. brachystyla Schltr. (Section 4); E. hians Spreng. (Sections 5, 5a, 6, 7).

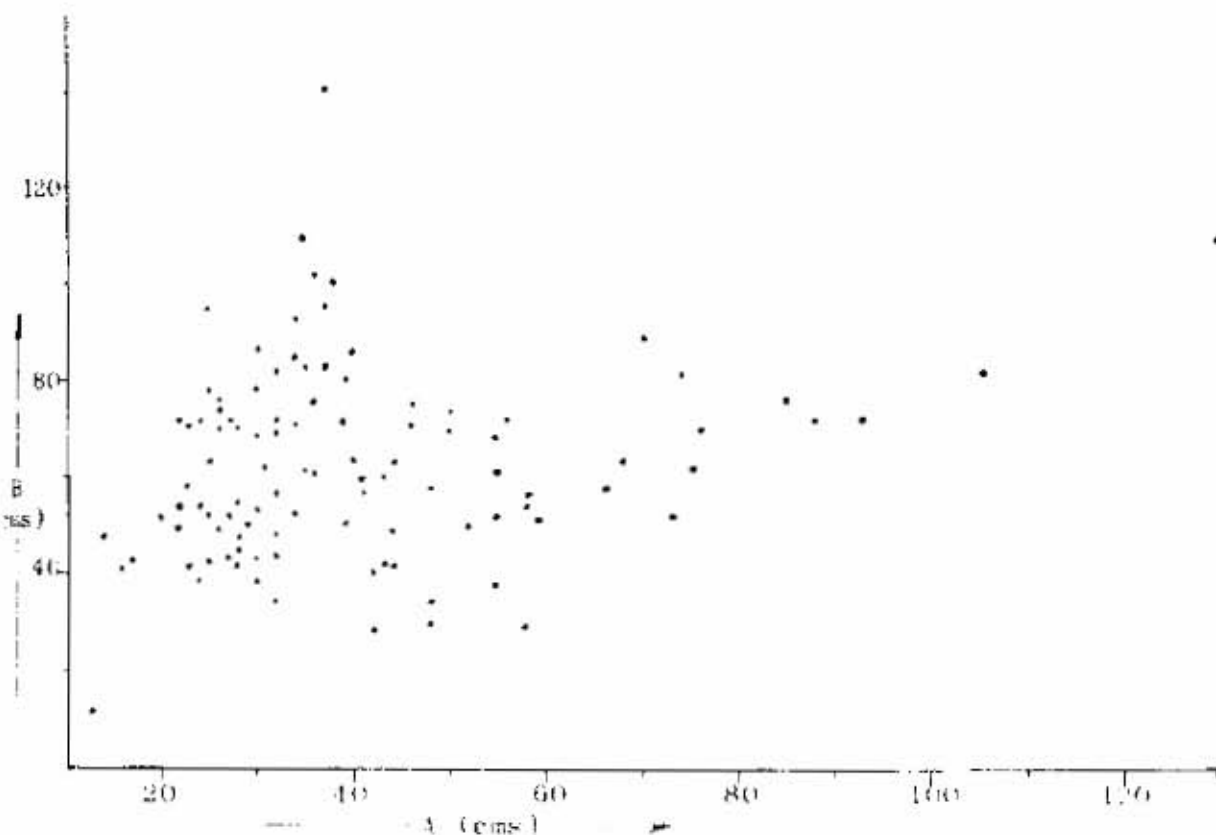


Diagram 2 : Scatter diagram of measurements of length of penultimate sheath on scape (A), plotted against length of the internode clothed by that sheath, (B).

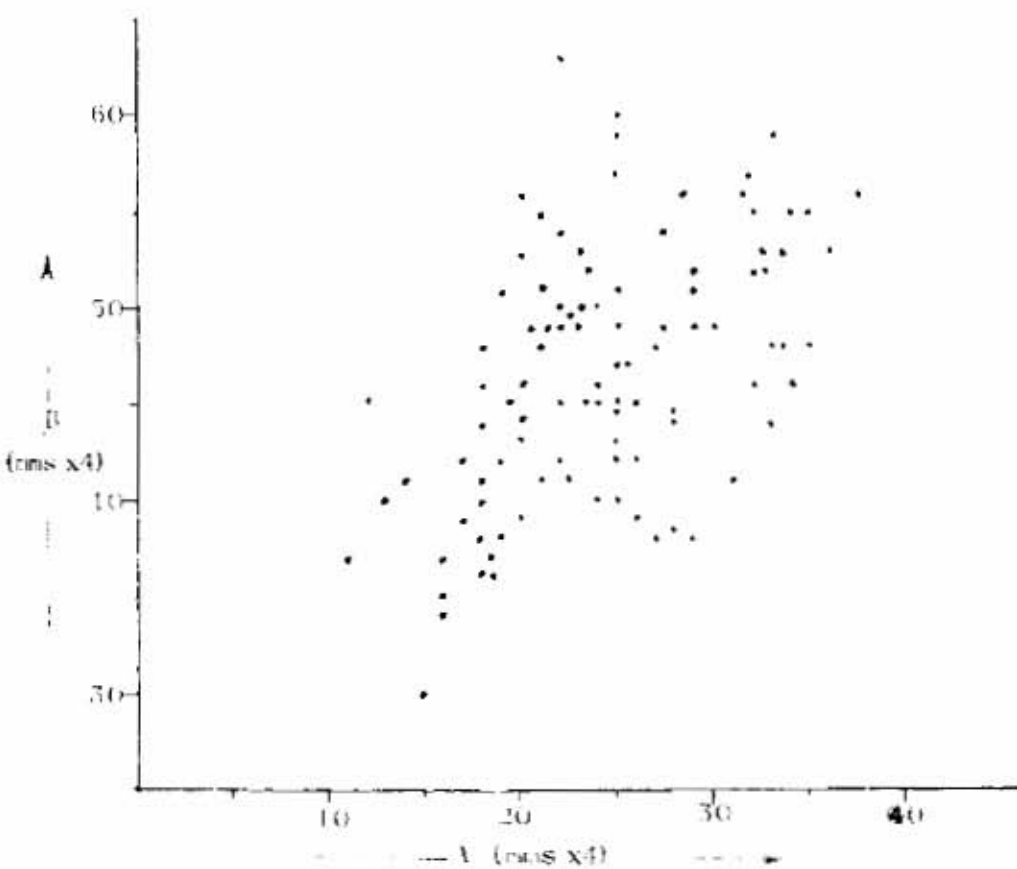


Diagram 3 : Scatter diagram of measurements of broadest width of petal (A), plotted against petal length (B).

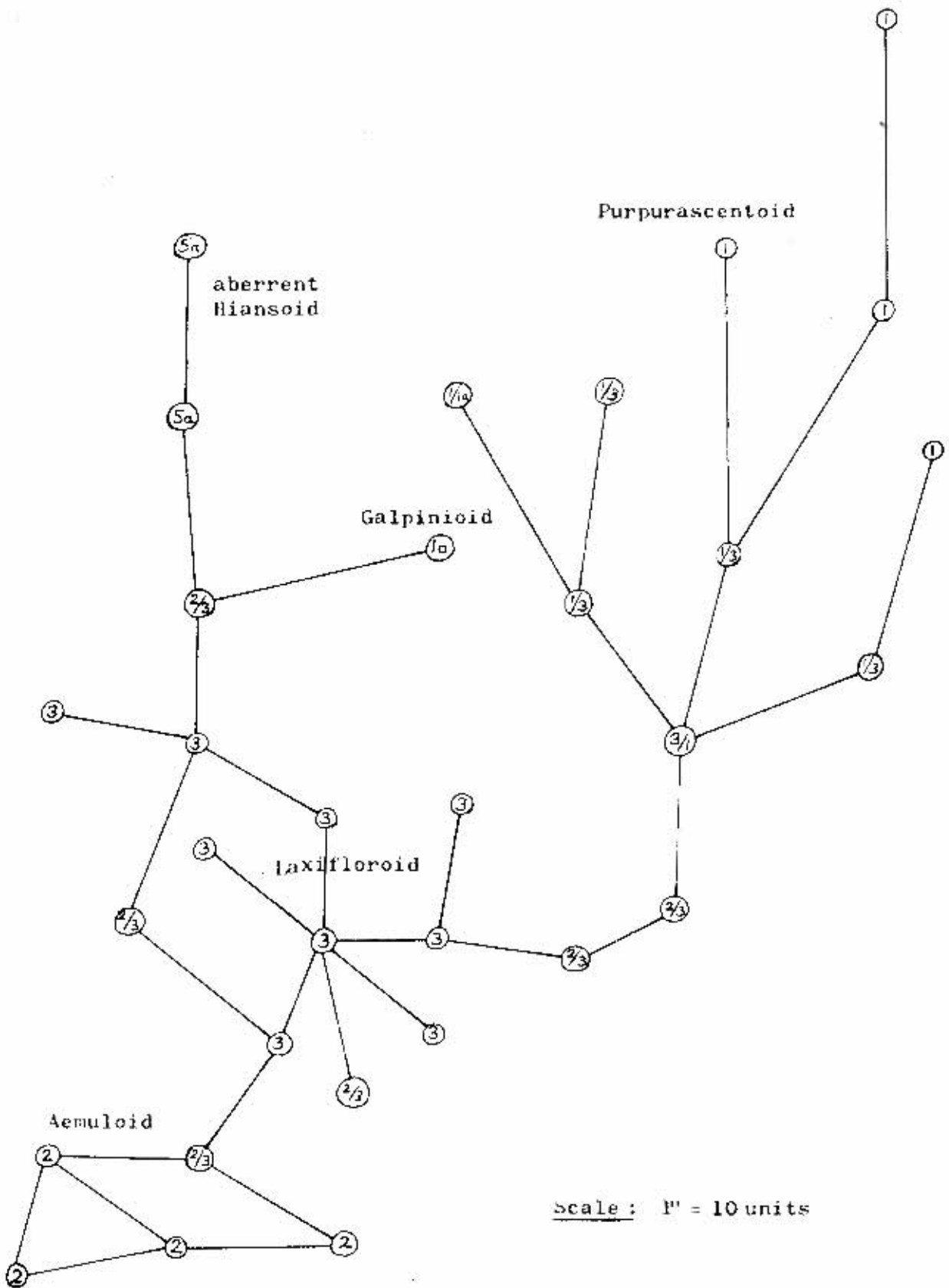


Diagram 8: Showing lines of minimum  $N_{kk}$  values between specimens of the E. hians - E. laxiflora complex.

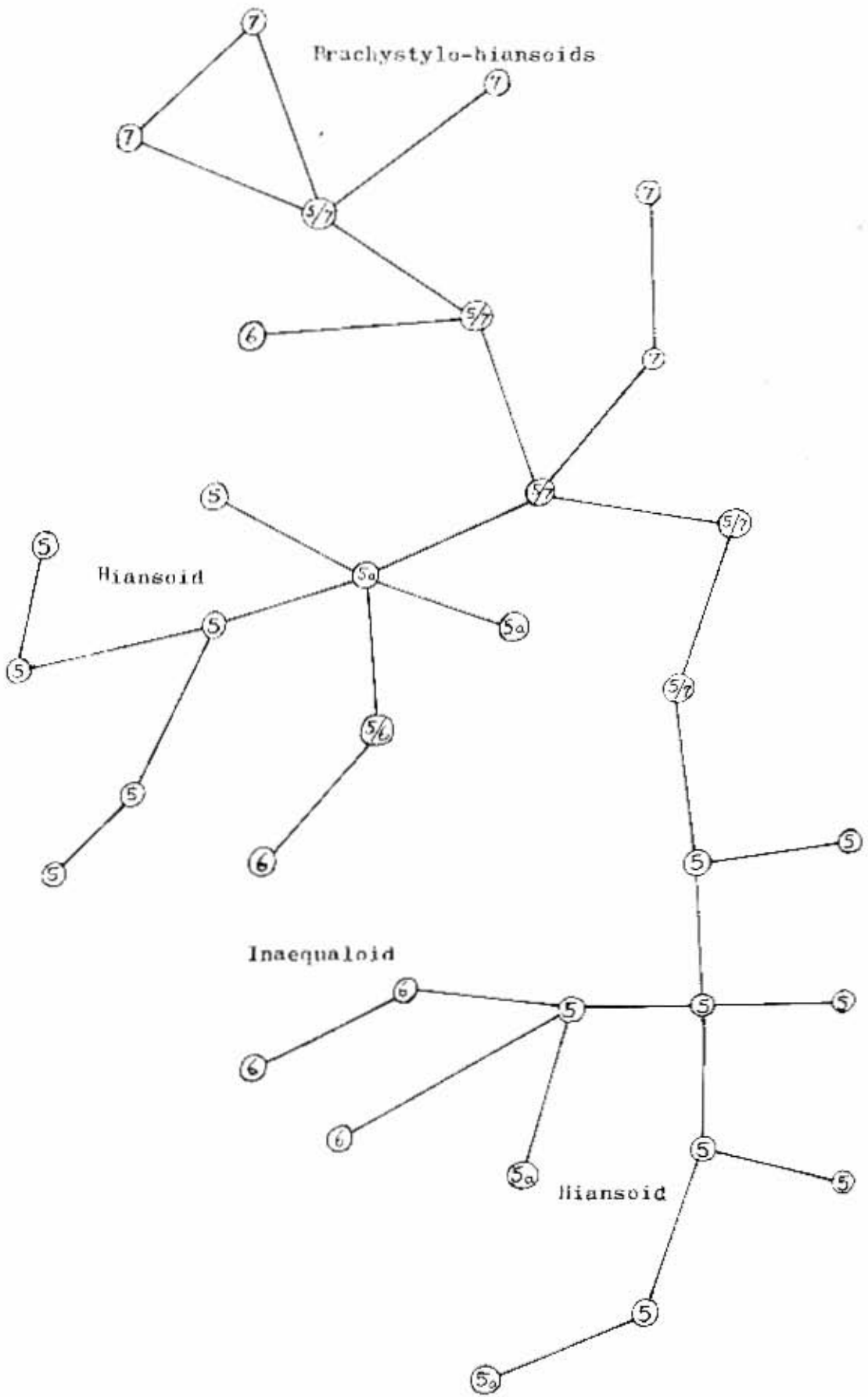


Diagram 8 (continued). See text.

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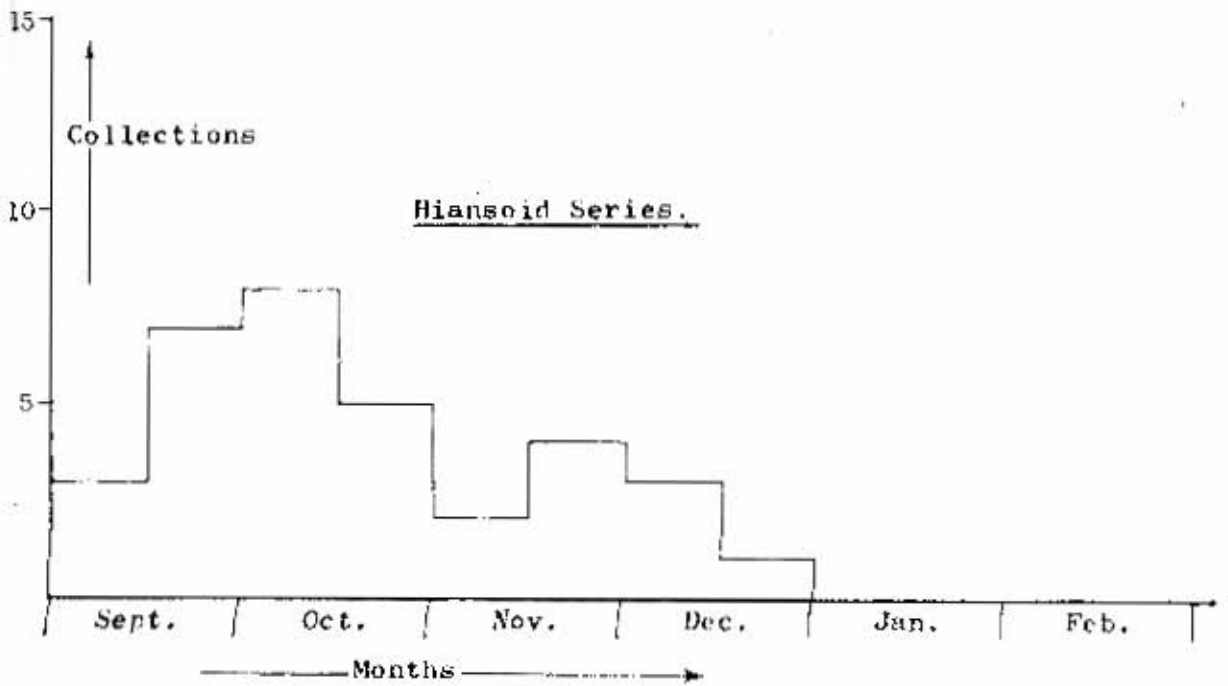
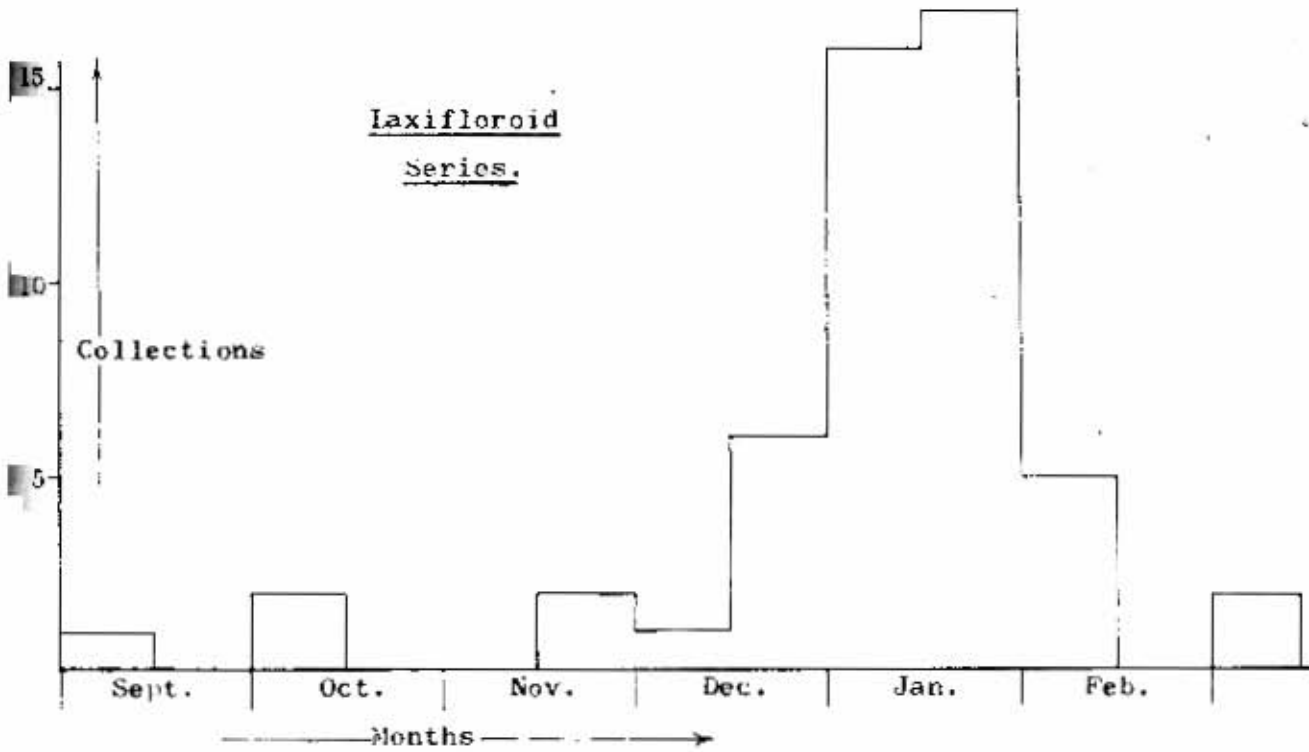
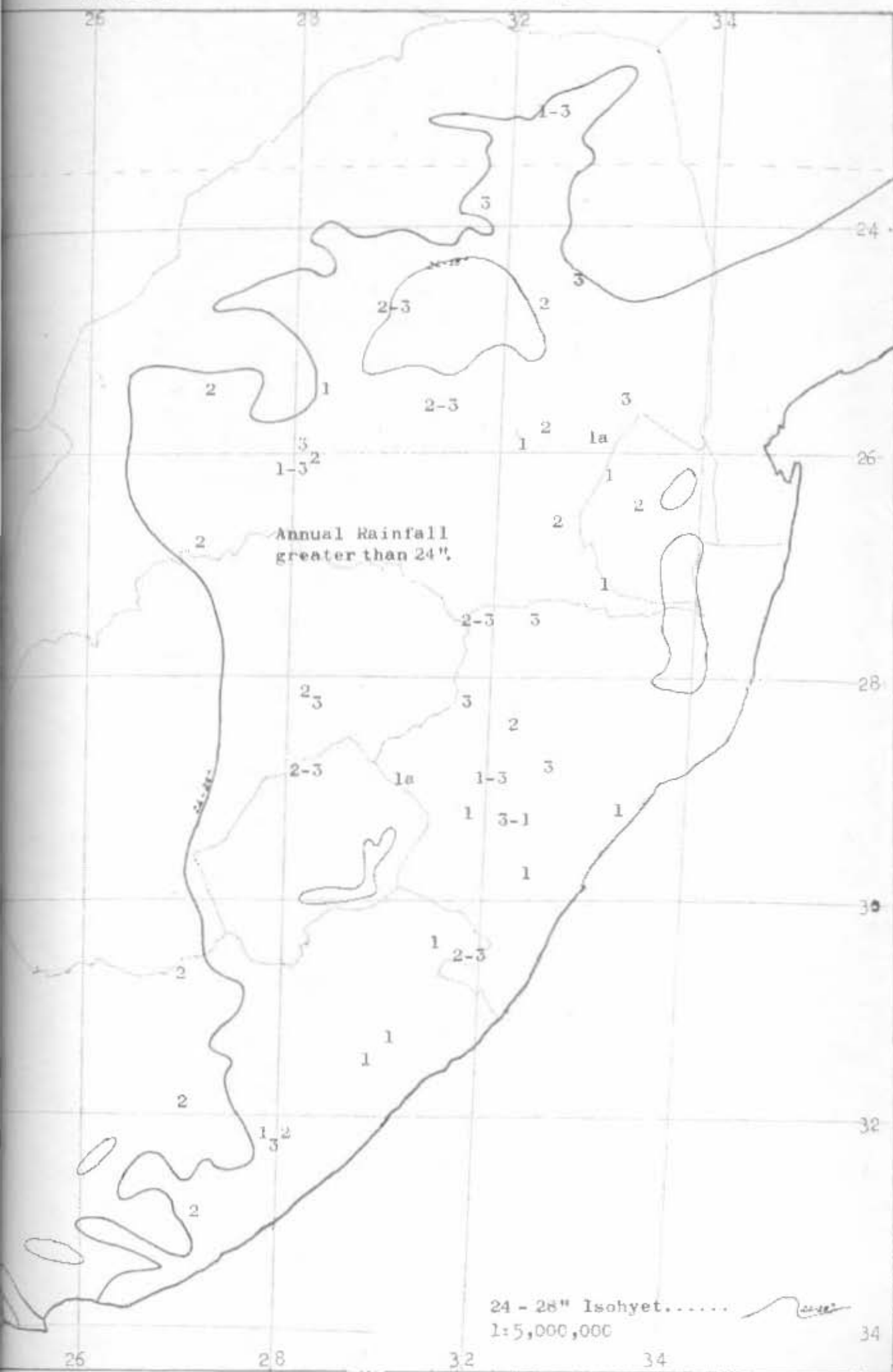
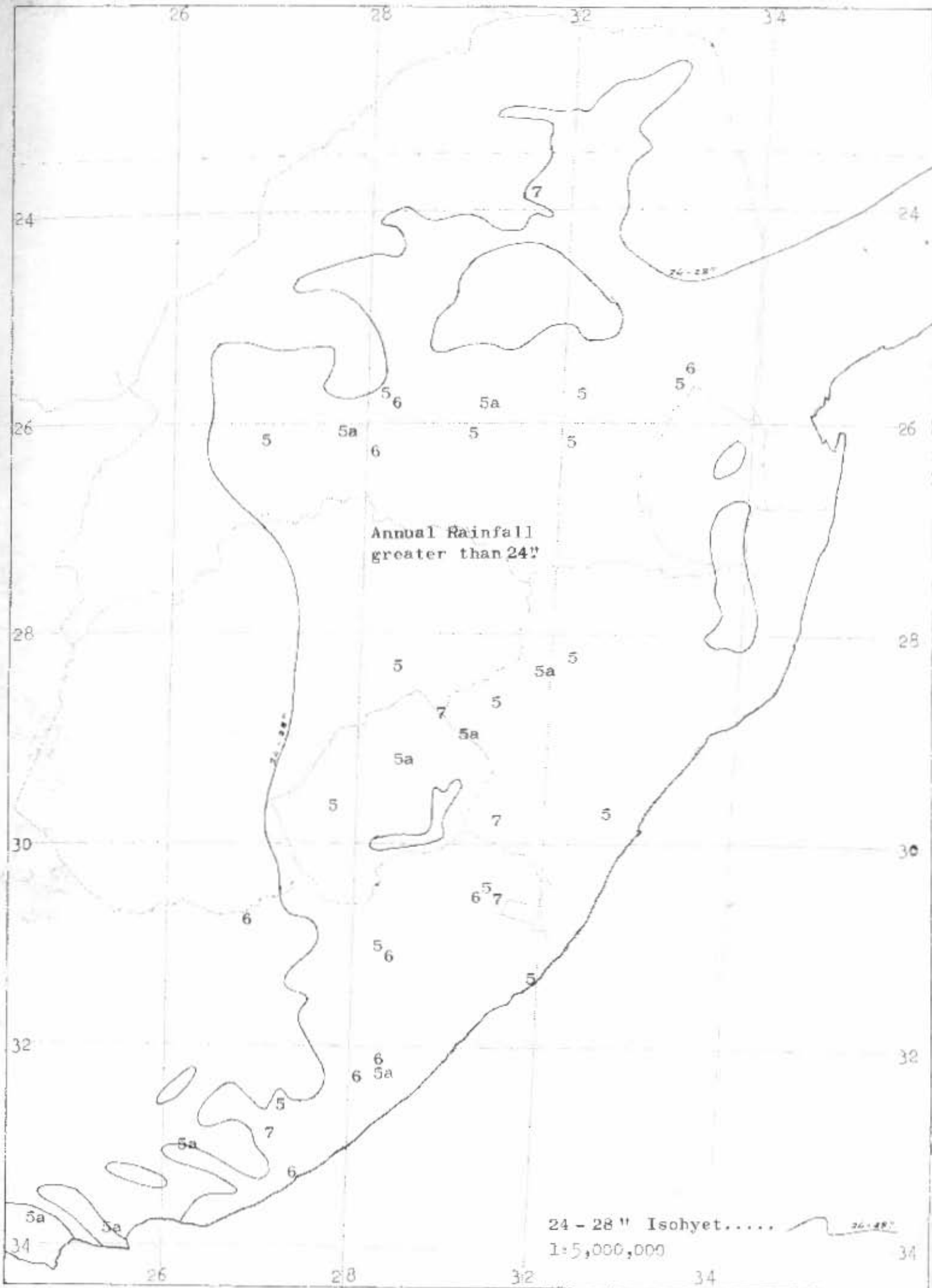


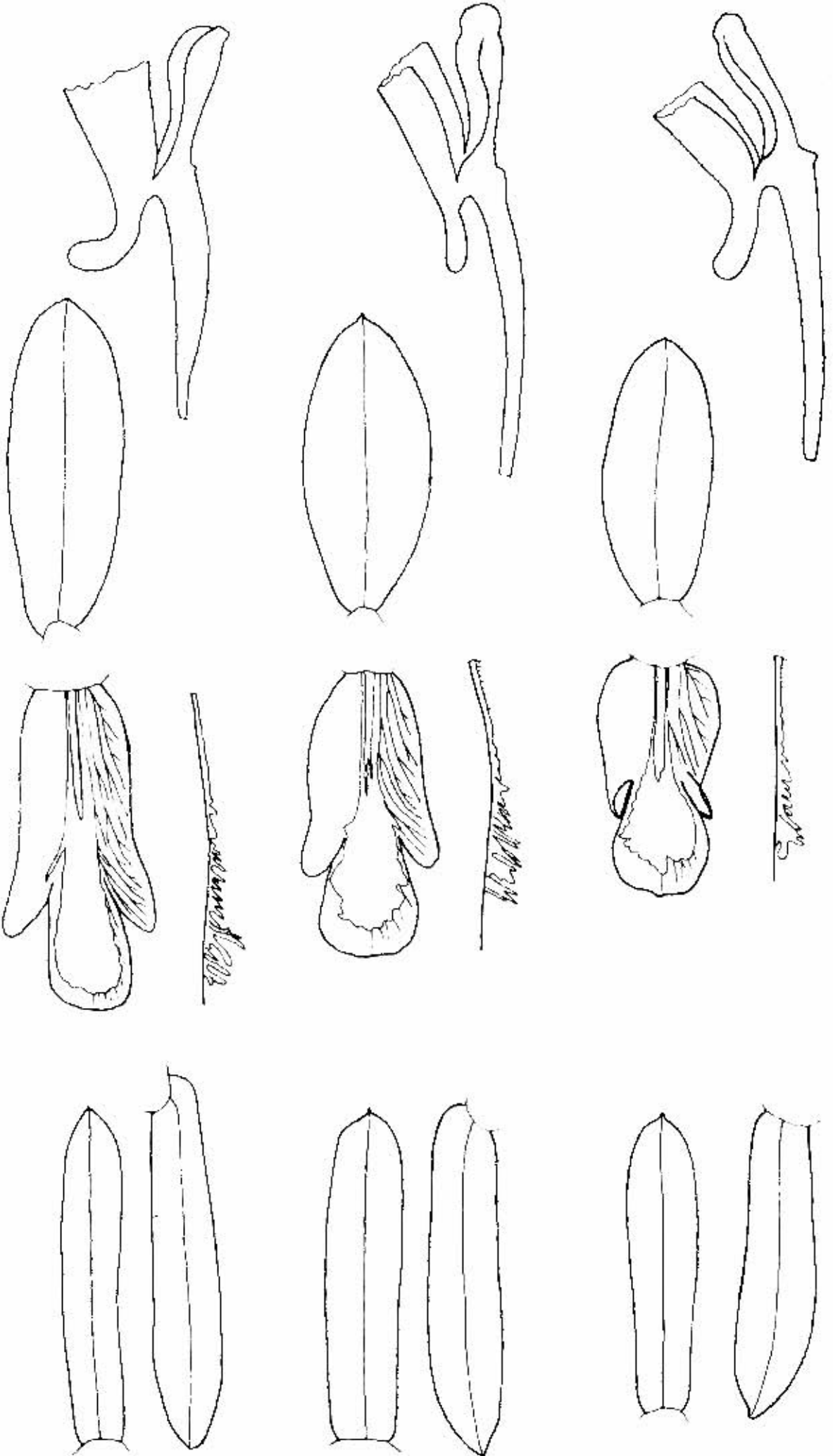
Diagram 9: Showing frequency distributions of dates of collection of flowering specimens of the Hiansoid and Laxifloroid Series.



Map 3: Distribution of variants of the Laxifloroid Series. Records are indicated in terms of the Section Numbers on page 28.



Map 4: Distribution of variants of the Hiansoid Series. Records are indicated in terms of the Section Numbers on page 28. Representatives of Sections 5 and 5a are also recorded from the Knysna District.



1. Bolus 8775.

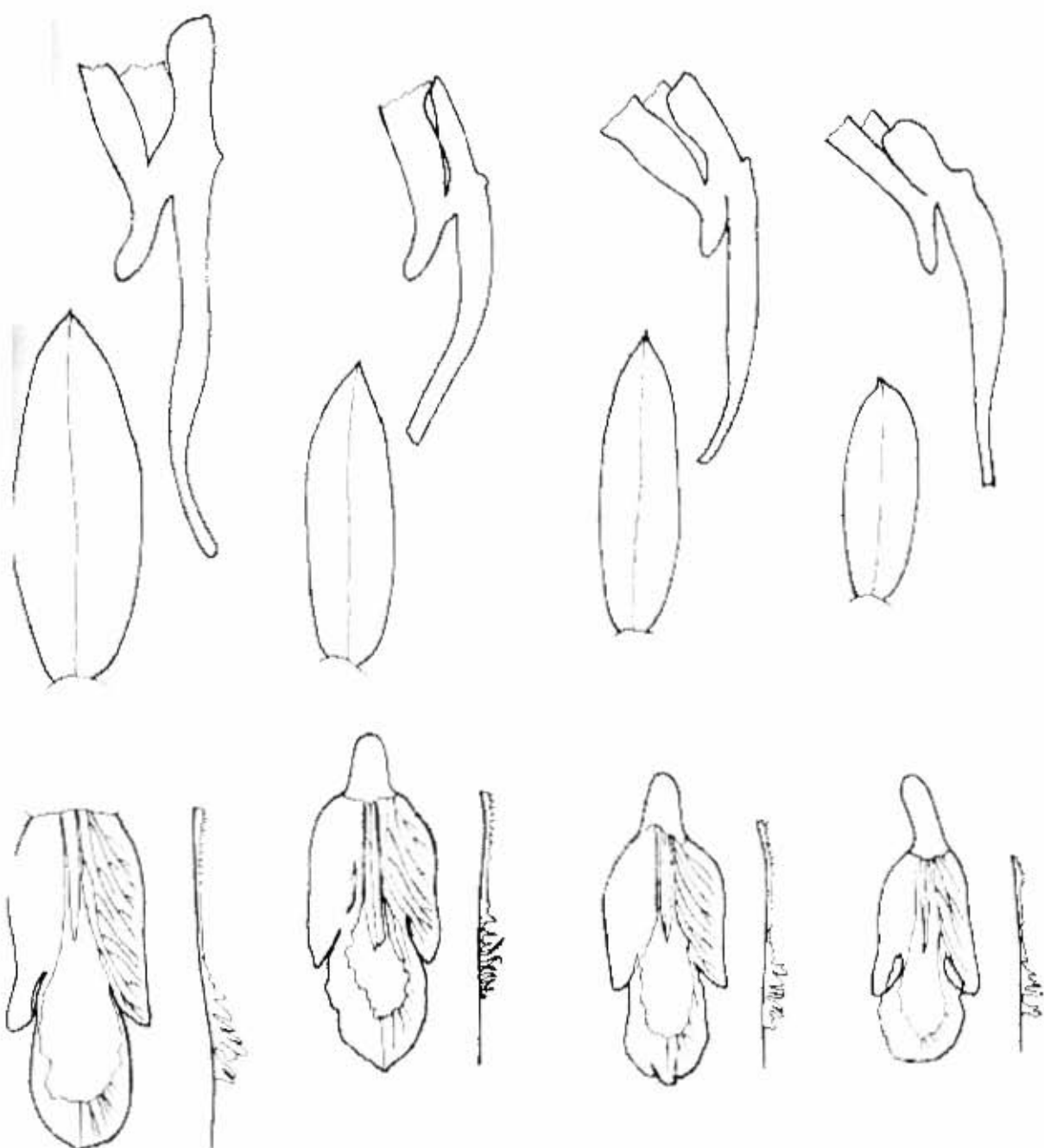
Utata Dist.  
Section 1.

2. Bolus Herb. 6110

Natal.  
Section 1.

3. Tyson 1912.

Unzinkulu Dist.  
section 1-2/3.

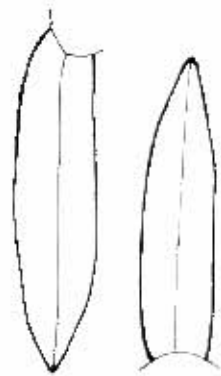
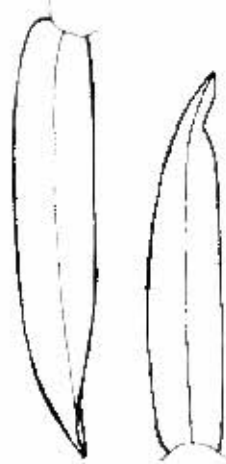
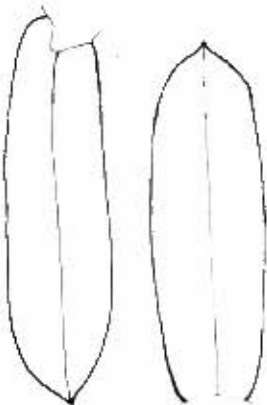
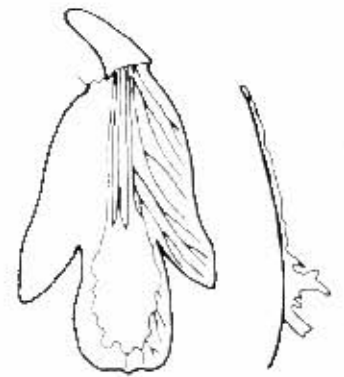
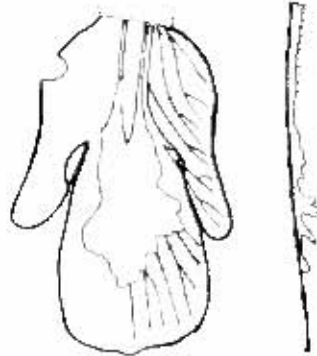
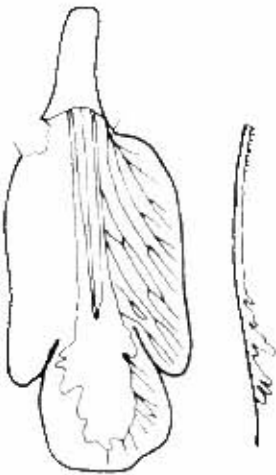
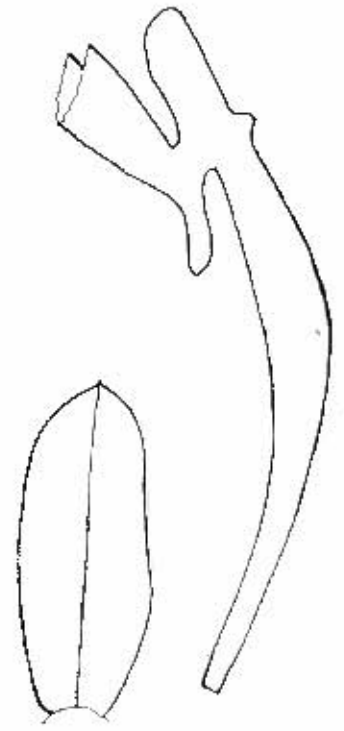
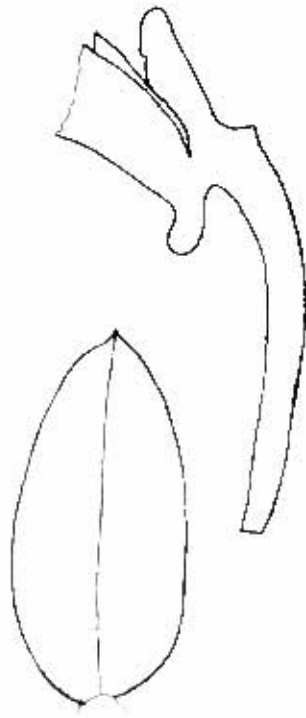
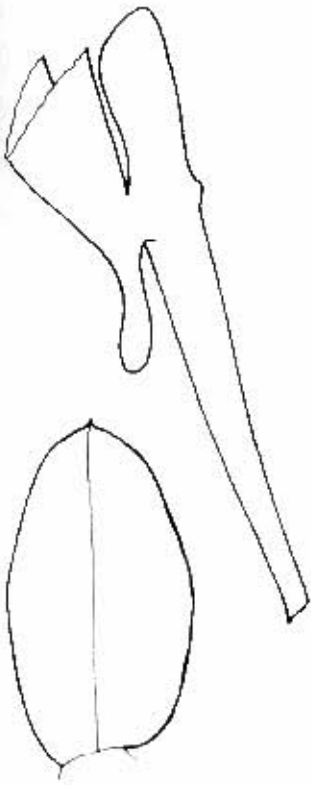


4. Galpin s. n.  
W. Natal.  
Section 1-1a.

5. Hall 612  
E. Transvaal  
section 1-1a.

6. Galpin 1171  
E. Transvaal  
Section 1a.

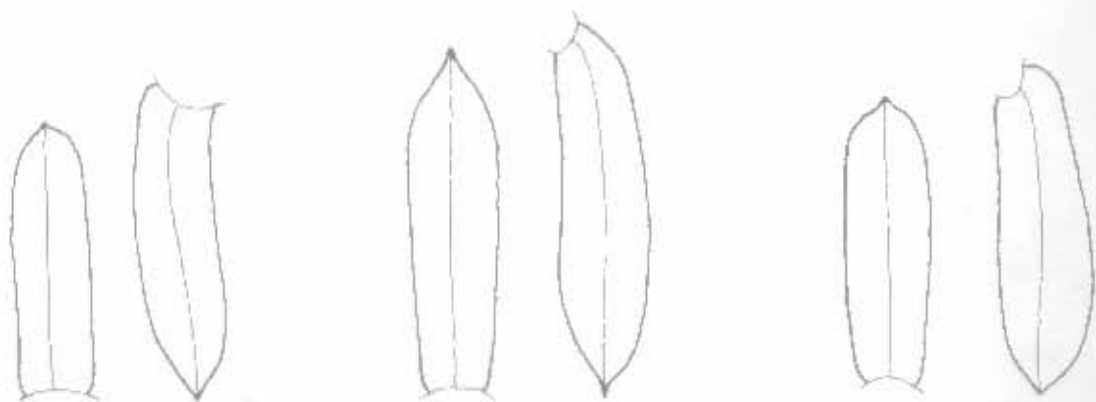
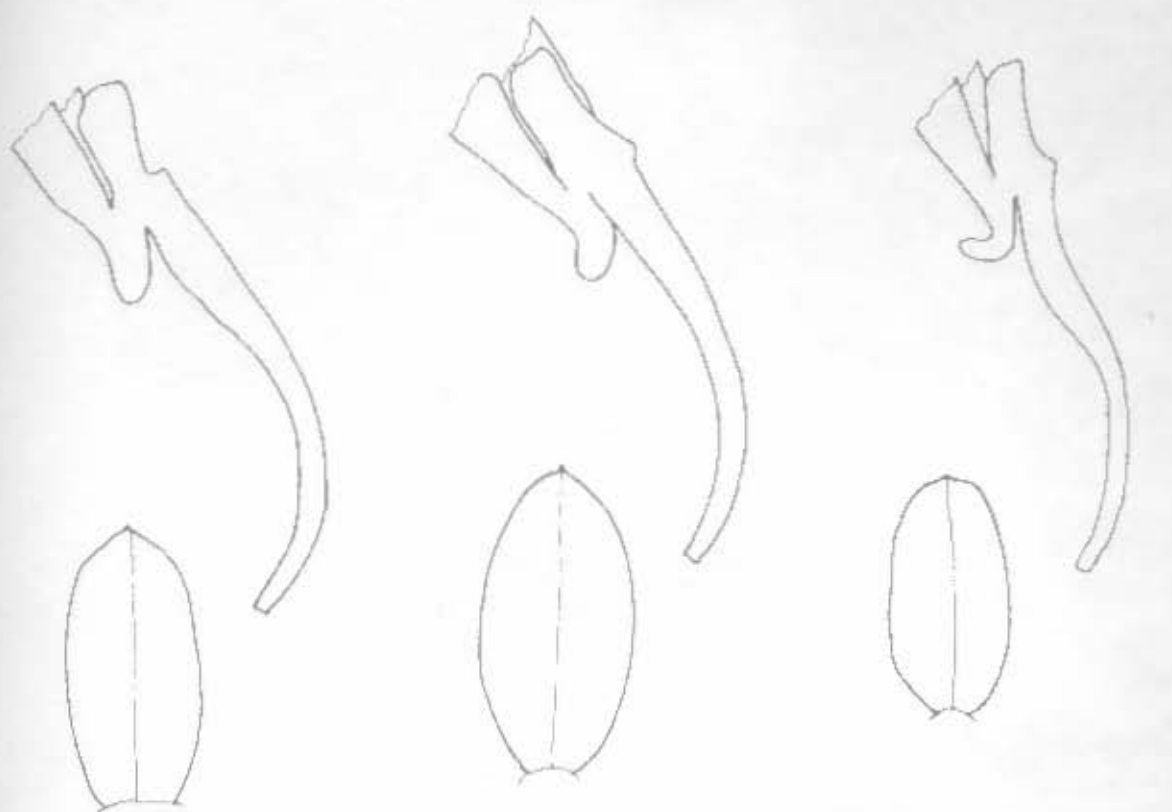
7. Buchanan s.n.  
Natal  
Section 1a.



8. Bolus Herb. 15671  
? Natal  
Section 1-3.

9. Flanagan s. n.  
E. Cape  
Section 1-3.

10. Acocks 17944  
Natal  
Section 3-1.



11. Galpin 2250

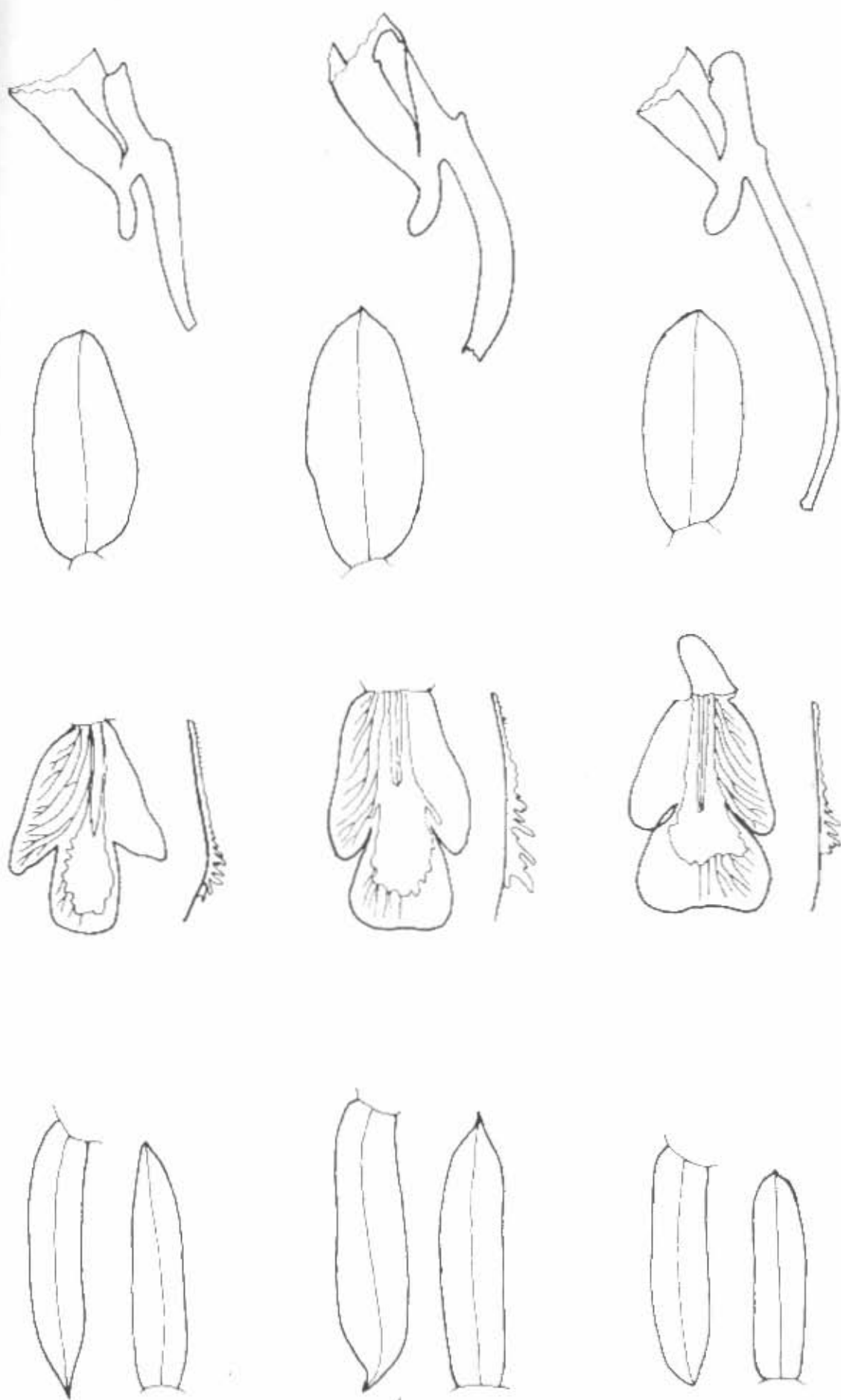
E. Cape  
Section 2.

12. Obermeyer 343

E. Transvaal  
Section 2.

13. Dieterlen 861

Basutoland  
Section 2-3.



14. West 556

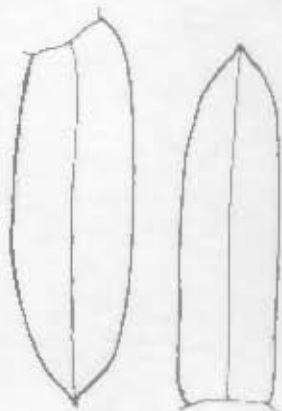
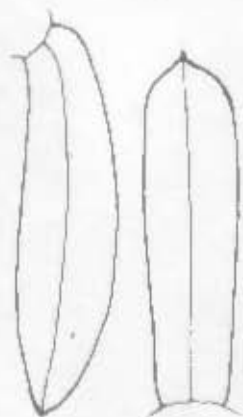
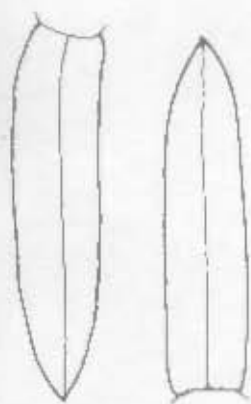
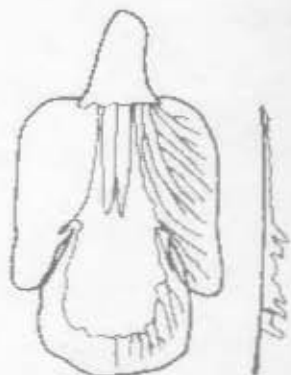
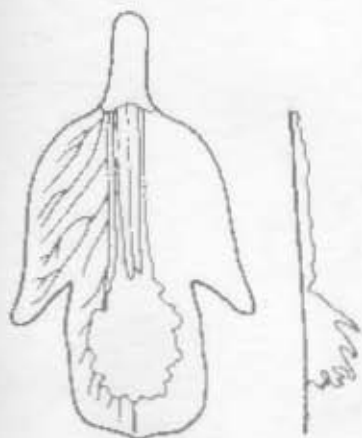
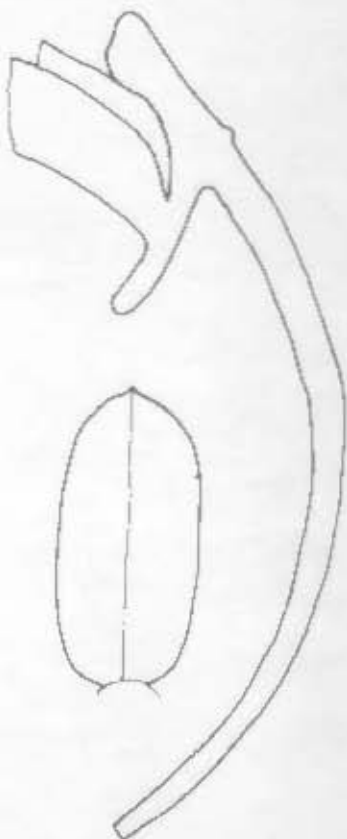
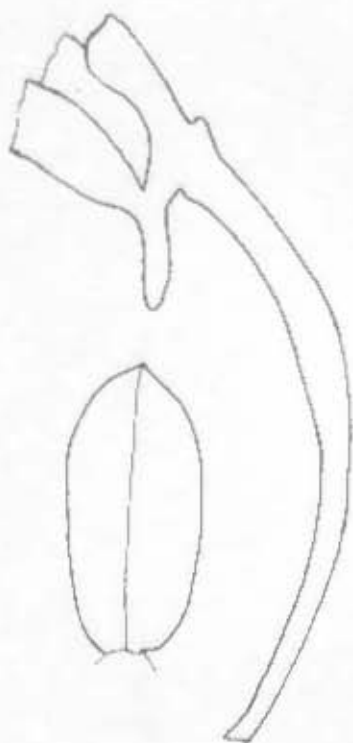
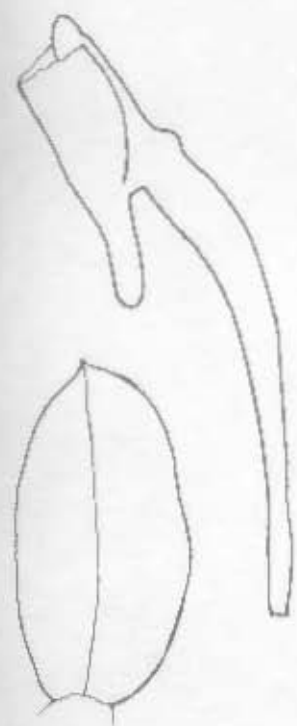
Natal  
Section 2 - 3

15. Schlechter 4057

E. Transvaal  
Section 2 - 3.

16. Burt-Davy 15054

Central Transvaal  
Section 2 - 3



15b. Hall 654

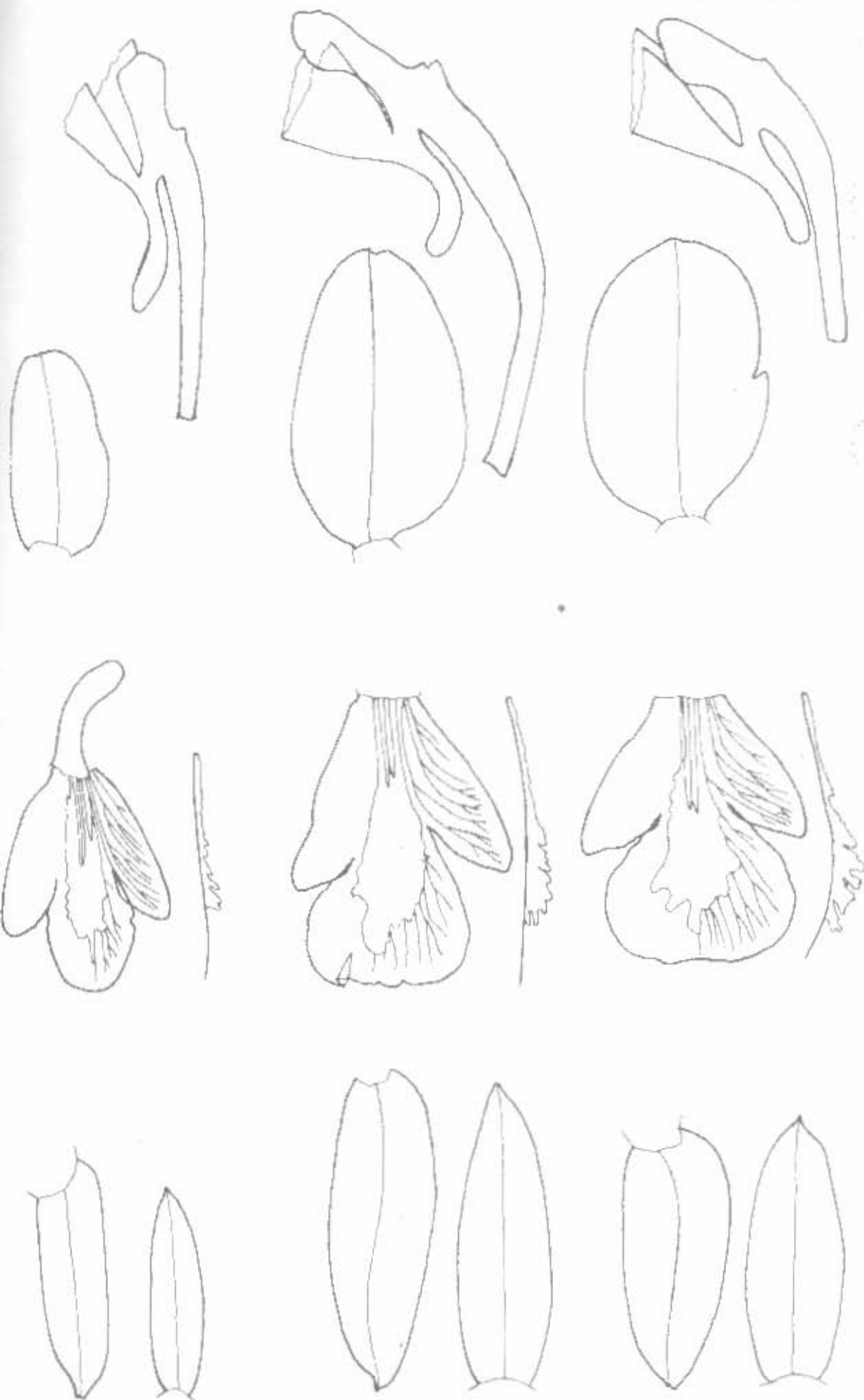
N. E. Cape  
Section 3 - 2.

16b. Herb. Transv. Mus 15224

? E. Transvaal  
Section 3.

17. Flanagan 1699

E. Cape  
Section 3.



18. Bolus Herb. 10675

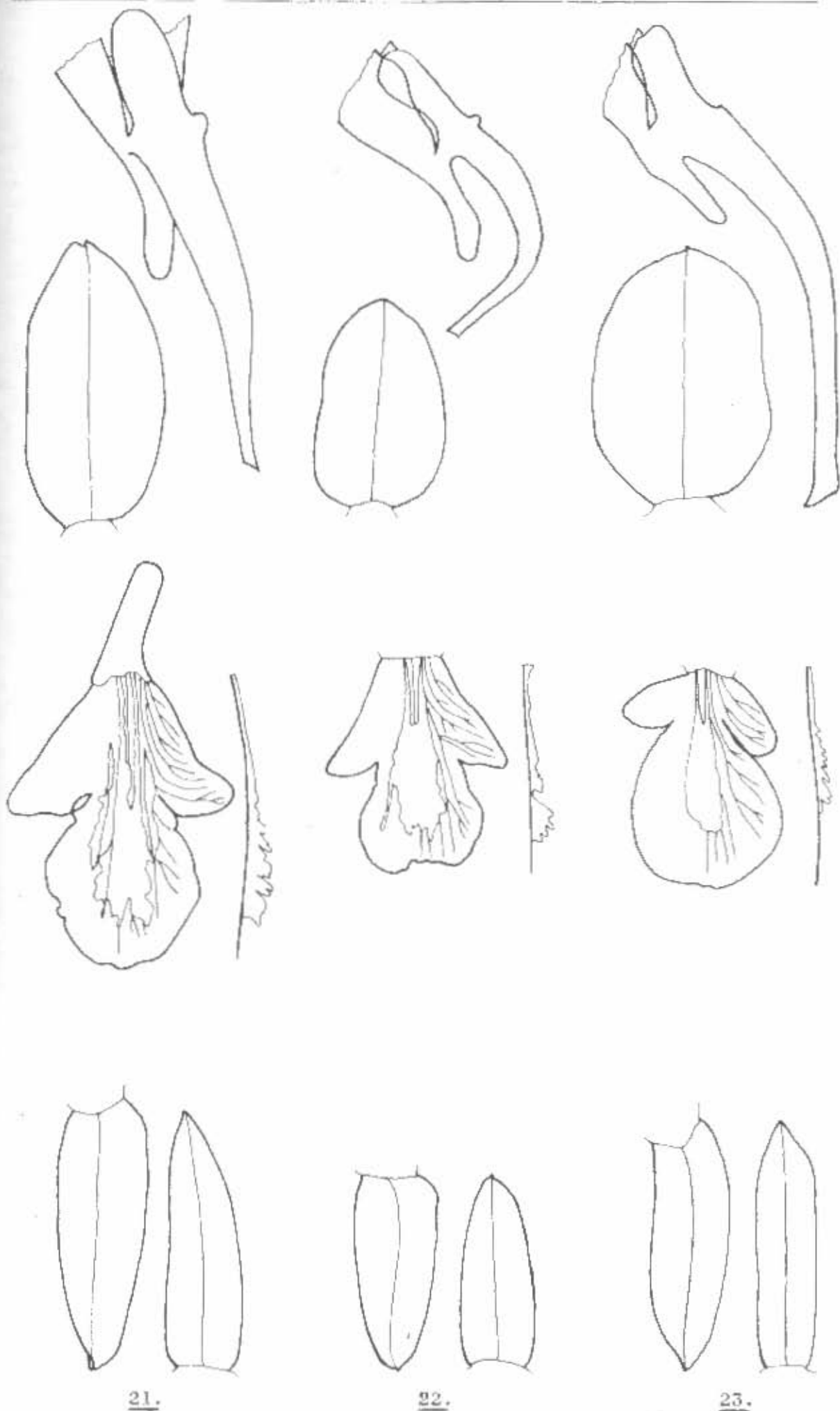
E. Transvaal  
Section 5.

19. Wood s. n.

O. F. S.  
Section 5.

20. Poterson s. n.

E. Cape  
Section 5.



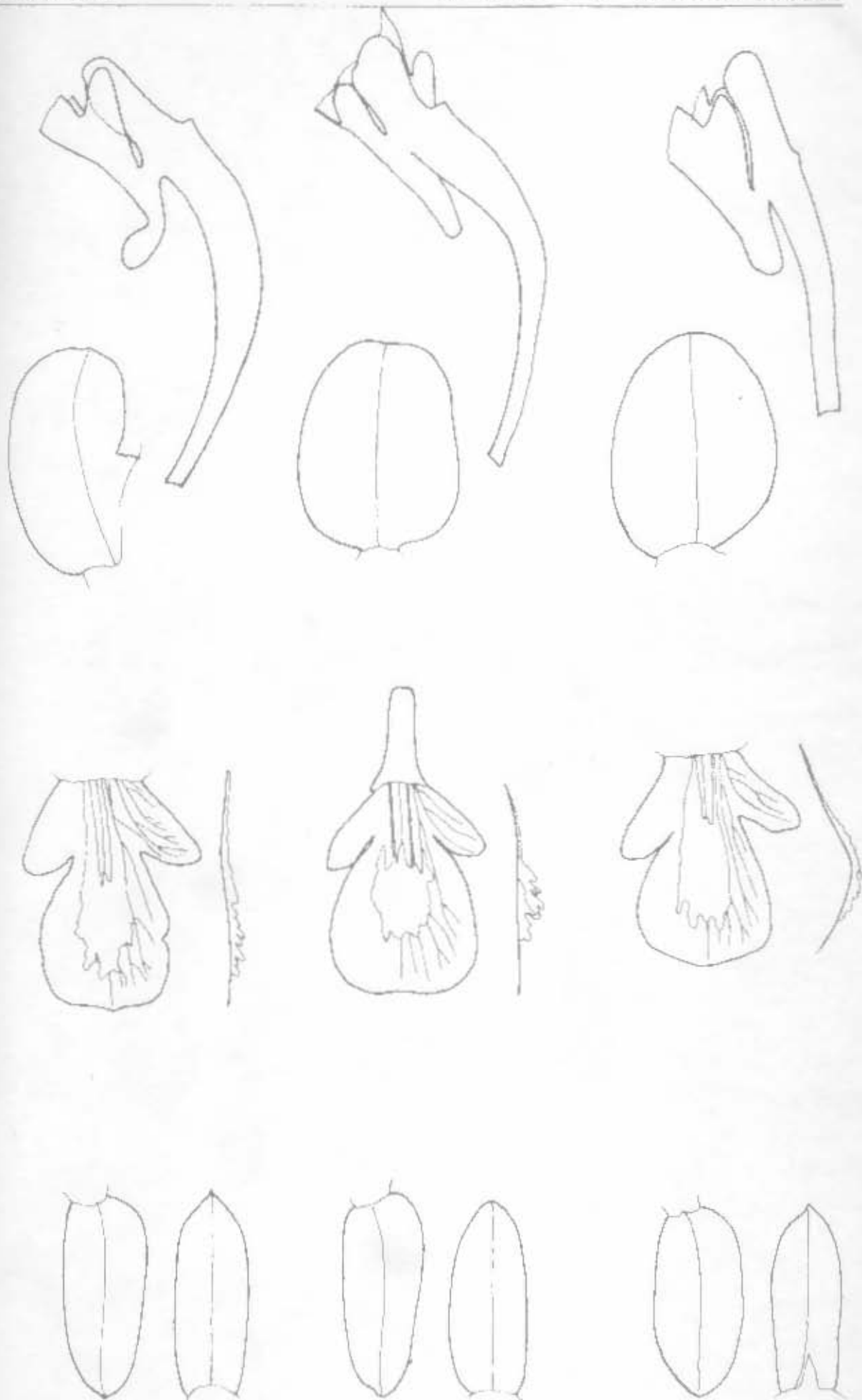
21.

22.

23.

Tyson 1602 : N. E. Cape.

Sections 5 and 7 represented in a single gathering.



24. Schnell s.n.

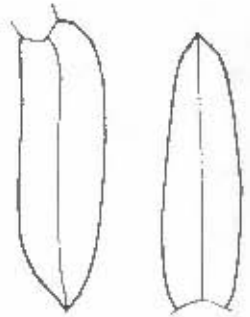
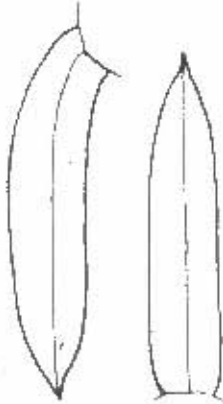
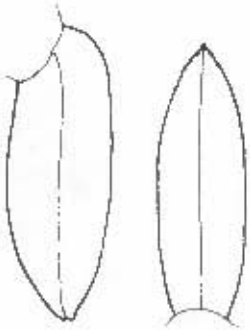
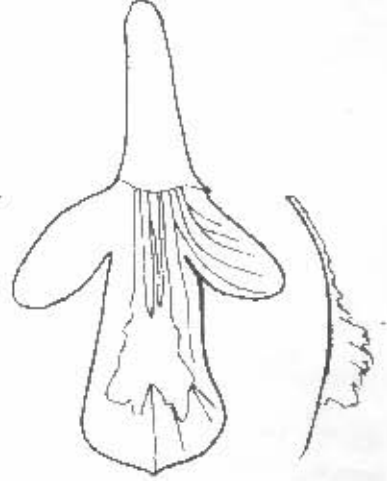
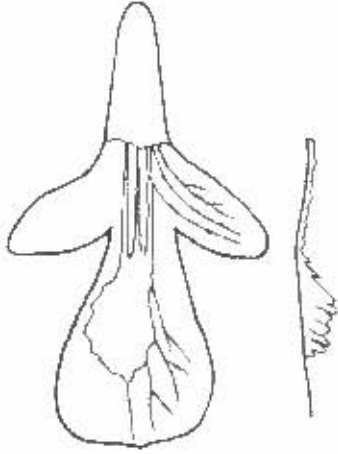
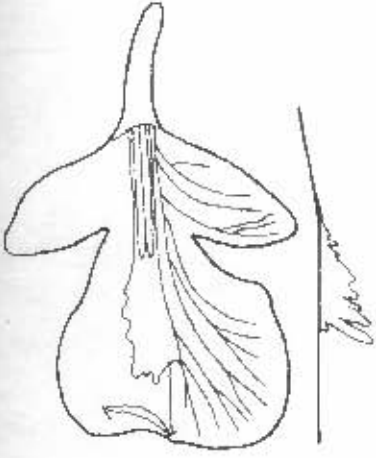
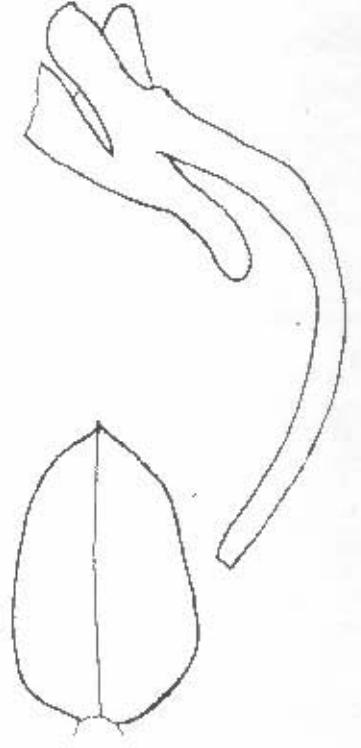
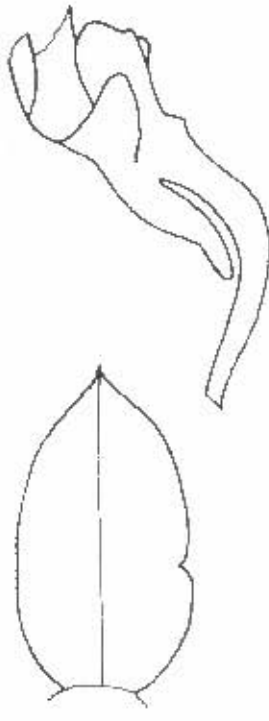
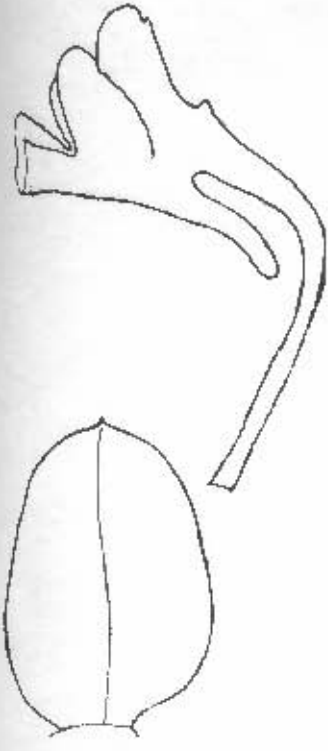
E. Cape  
Section 5-7.

25. Wood 4264

Natal  
Section 7.

26. Flanagan 2232

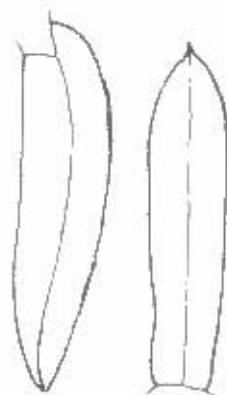
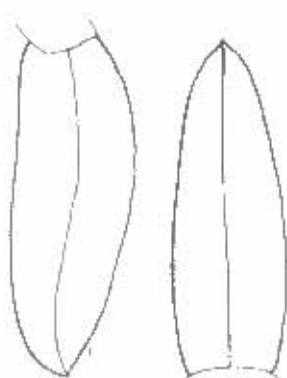
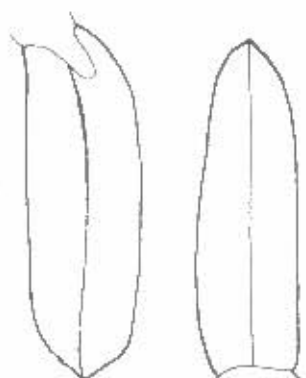
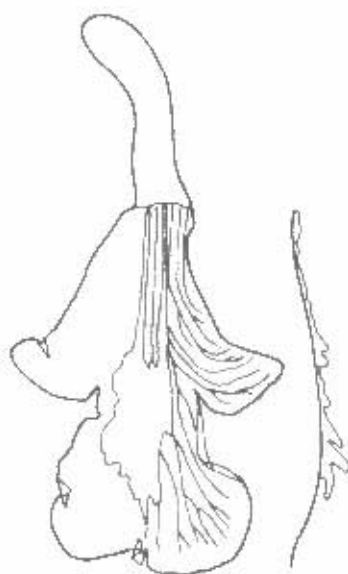
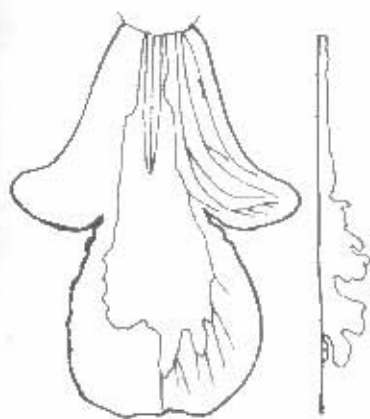
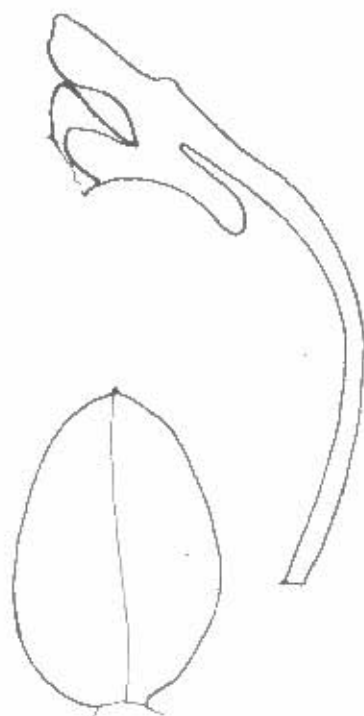
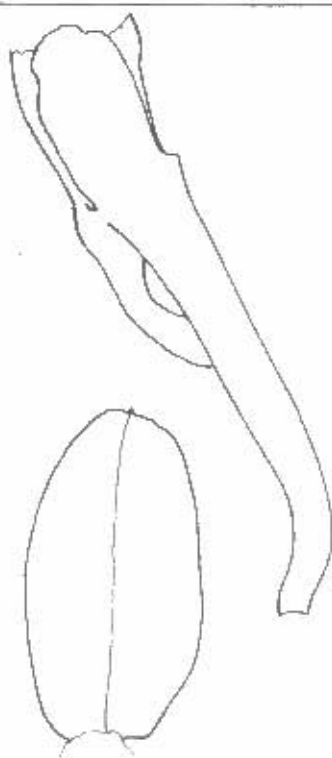
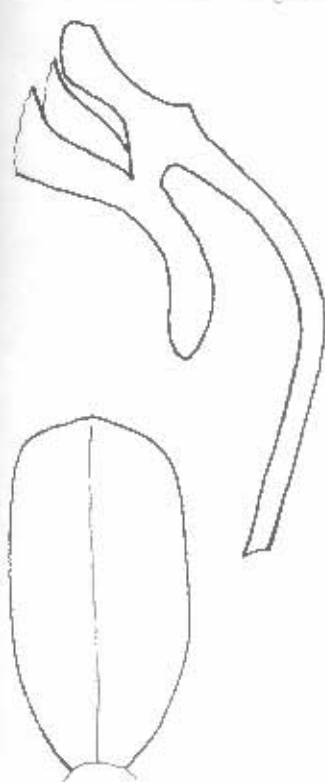
E. Cape  
Section 7.



27. Schweickerdt 716  
W. Natal  
Section 7.

28. Dyer 3283  
W. Natal  
Section 7.

29. Schweickerdt s.n.  
N. E. Transvaal  
Section 7.



30. Galpin 170

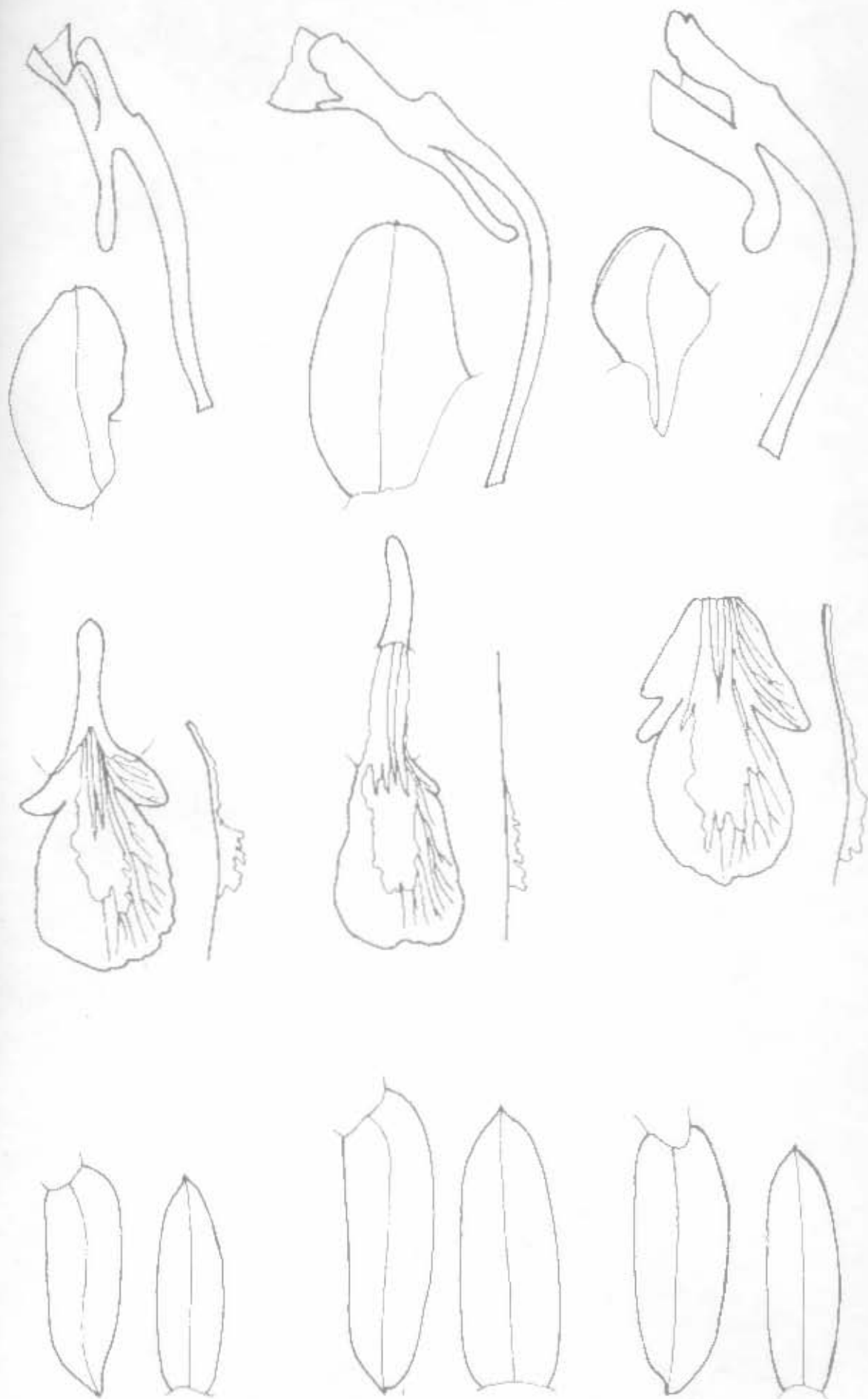
E. Cape  
Section 5.

31. Schlechter 3431

Natal  
Section 5a.

32. Schlechter 3431

Natal  
Section 7.



33. Bolus 5980

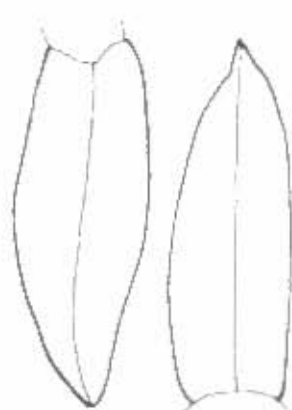
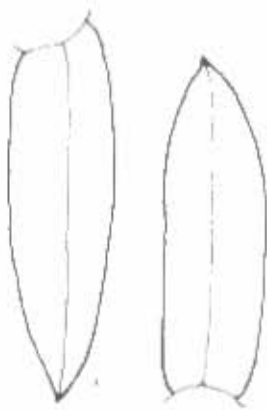
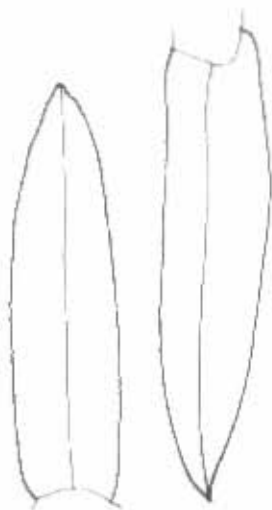
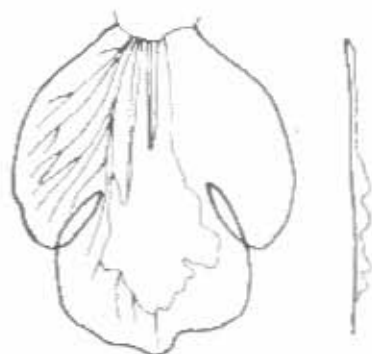
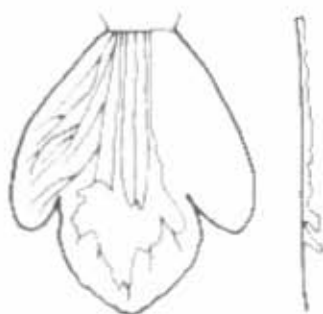
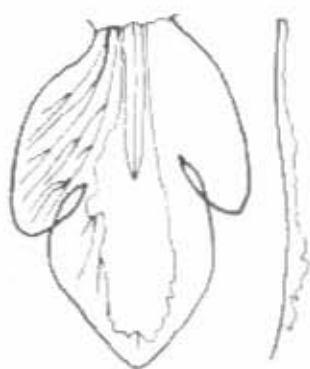
E. Cape  
Section 5a - 7.

34. Fourcade 6162

E. Cape  
Section 5a.

35. Schnell s. n.

E. Cape  
Section 5a.



36. Schlechter 3432

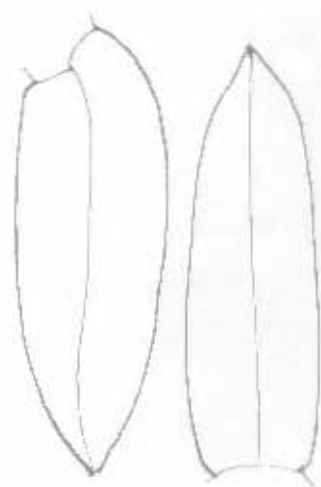
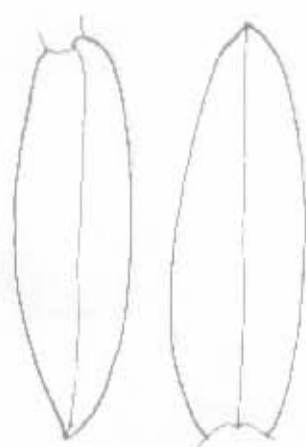
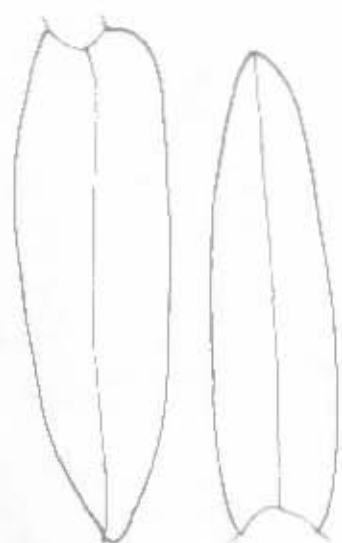
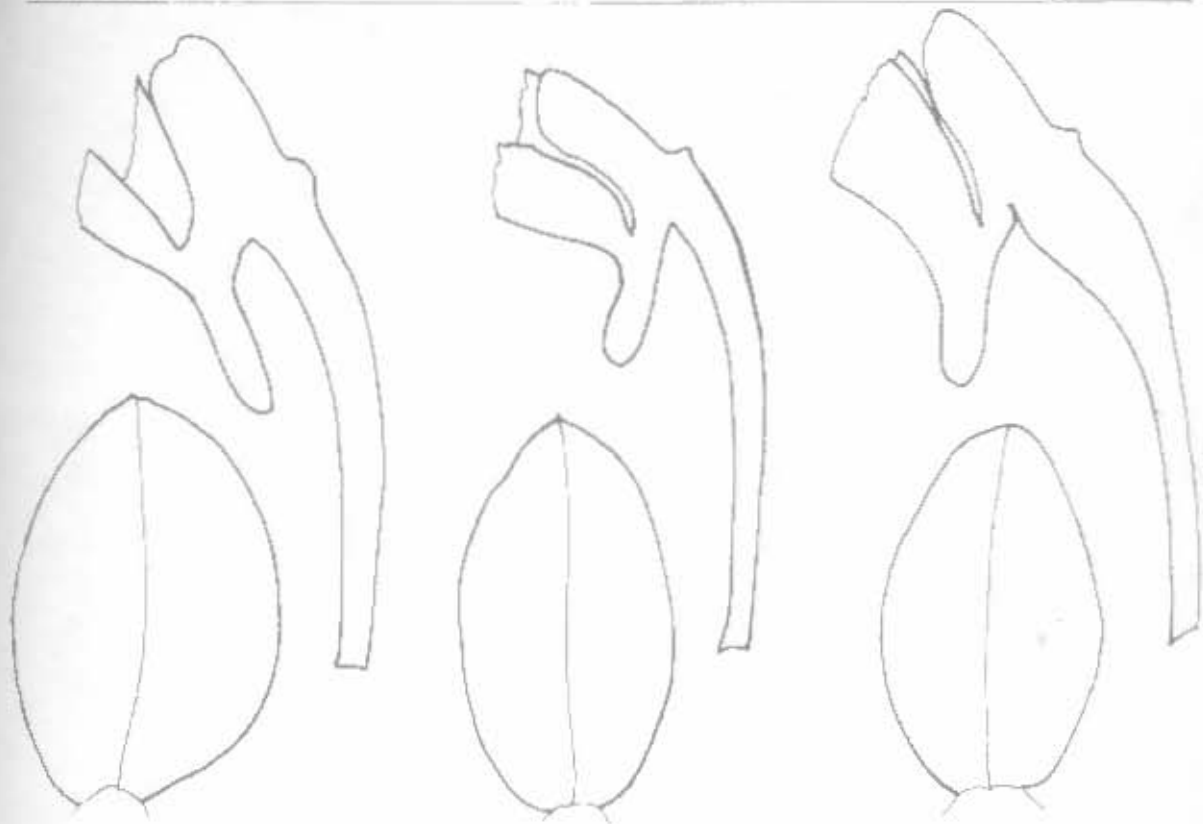
Natal  
Section 6.

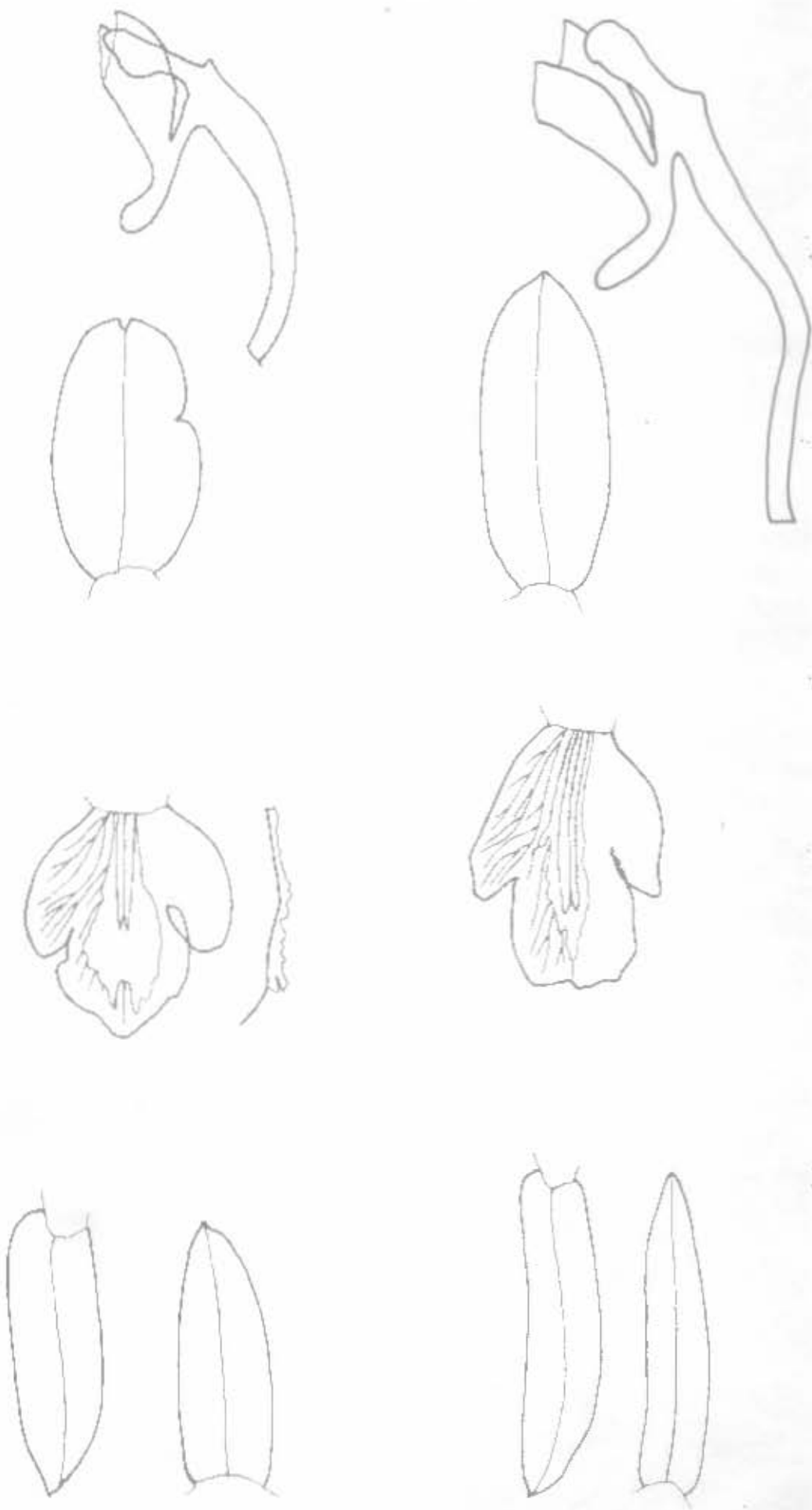
37. Bolus Herb. 26578

Central Transvaal  
Section 6.

38. Bolus Herb. 10676

? Transvaal  
Section 6.

39. Bolus Herb. 26679E. Cape  
Section 6.40. Tyson 1601N. E. Cape  
Section 6.41. Bolus 10671N. E. Cape  
Section 6.

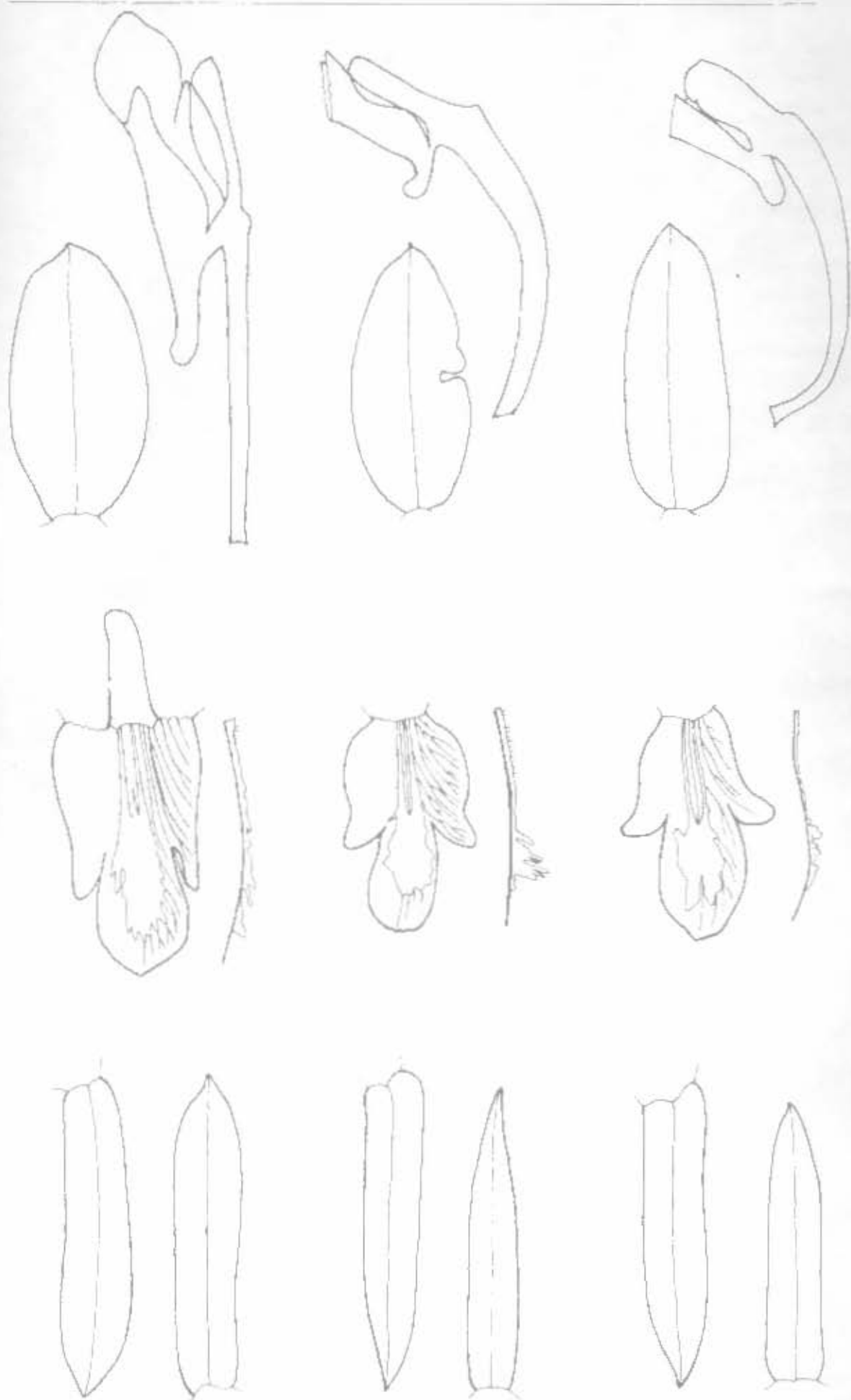


42. Burtt - Davy 1018

Central Transvaal  
Section 0.

45. Galpin 509

E. Transvaal  
Section 6.

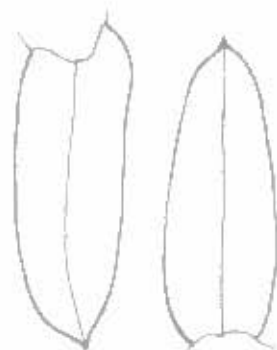
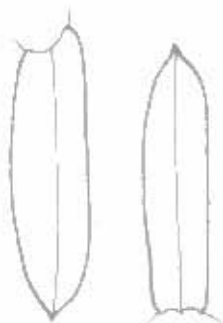
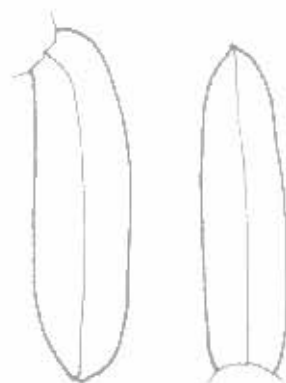
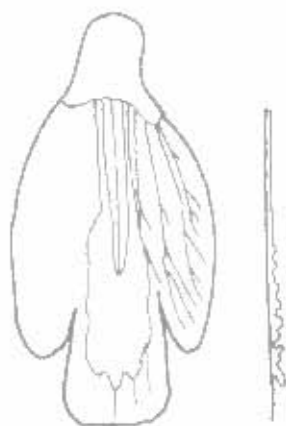
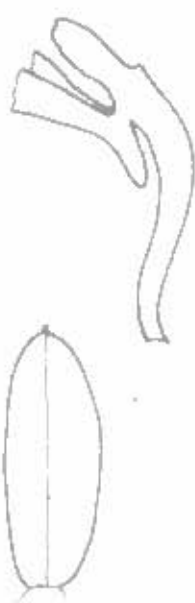


44. Pegler 524  
E. Cape  
Variant of Section 1.

45. Galpin s. n.  
Natal  
Section 3-2.

46. Flanagan 1117  
E. Cape  
Section 2.

(Miscellaneous variants)



47. Schlechter 3397

Natal  
Variant of section 3

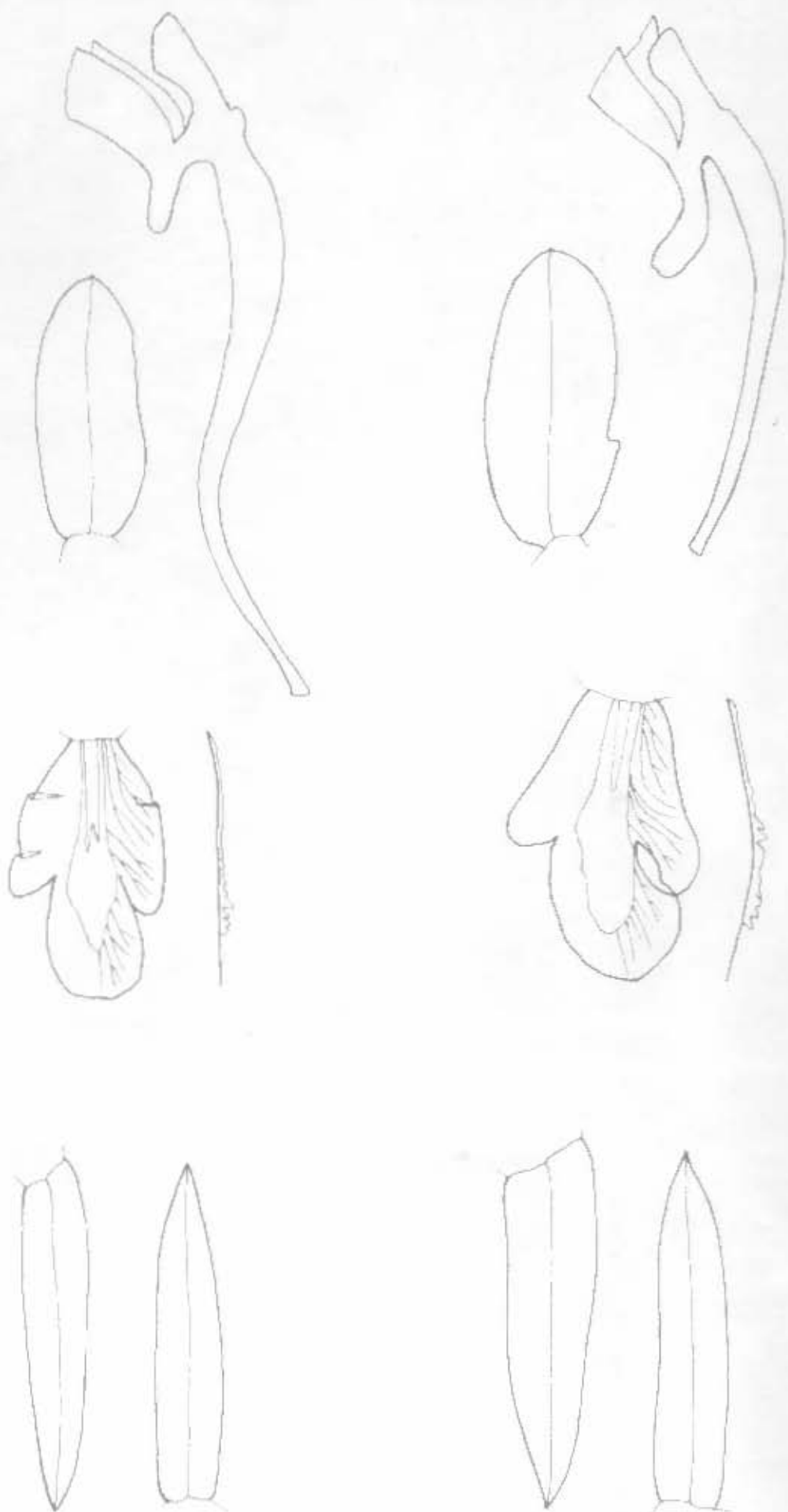
48. Doc 42.

E. Cape  
Section 1,  
green flowers.

49. Nat. Herb Pretoria,  
No 28740.

Basutoland,  
Section 5; distinguished  
from 2 by veg. char's.

(Miscellaneous variants)



50. Burtt-Davy 1024

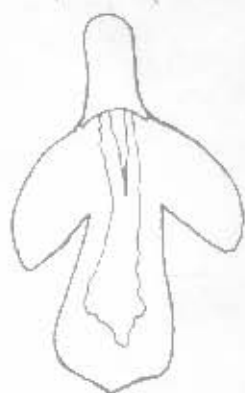
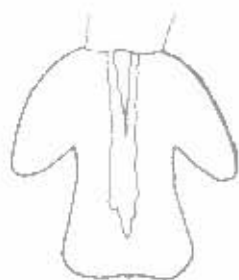
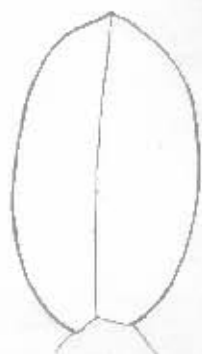
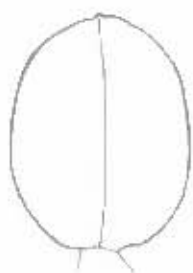
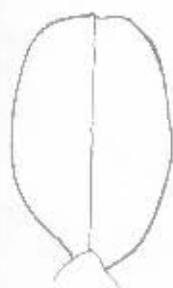
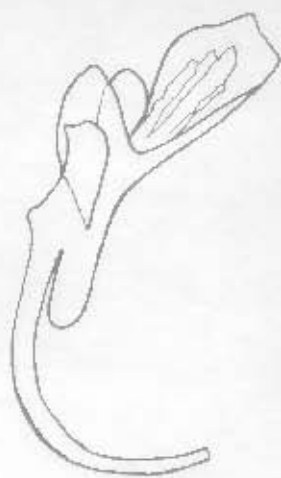
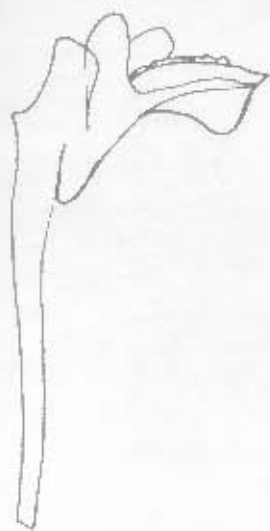
N. Transvaal  
Section 2-3.

51. Bolis 3817

Central Transvaal  
Section 5a.

(5) ELLOPHIA BRACHYSTYLA: The rather close affinities of this group with the *E. hians* - *E. laxiflora* complex are discussed on page 50. While considerable variation in flower size is evident in the drawings of flower parts on pages 64 and 65, the continuity of such variation provides no basis for further subdivision of the group. Similar conclusions were reached in a survey of the shapes of floral and vegetative parts.

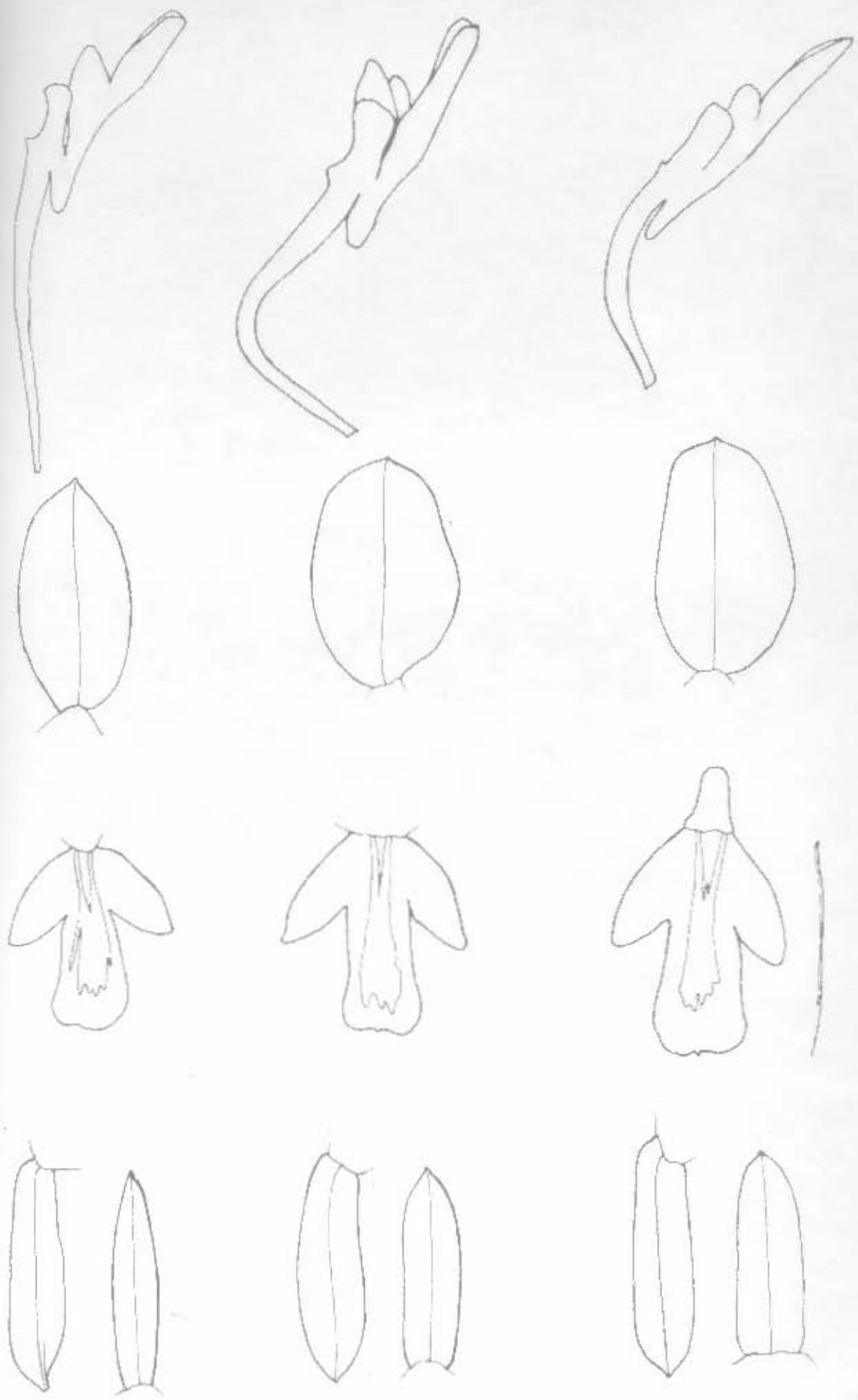
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Schlechter 6489.  
Insiswa Mtn.  
N. E. Cape.

Schnell, s.n.  
Máclear Dist.  
E. Cape.

N. M. Harrison l.  
Lions River Dist.  
Natal.



Bews in Bolus Herb. 15399

Lions River Dist.

Natal.

Scheiße 5098.

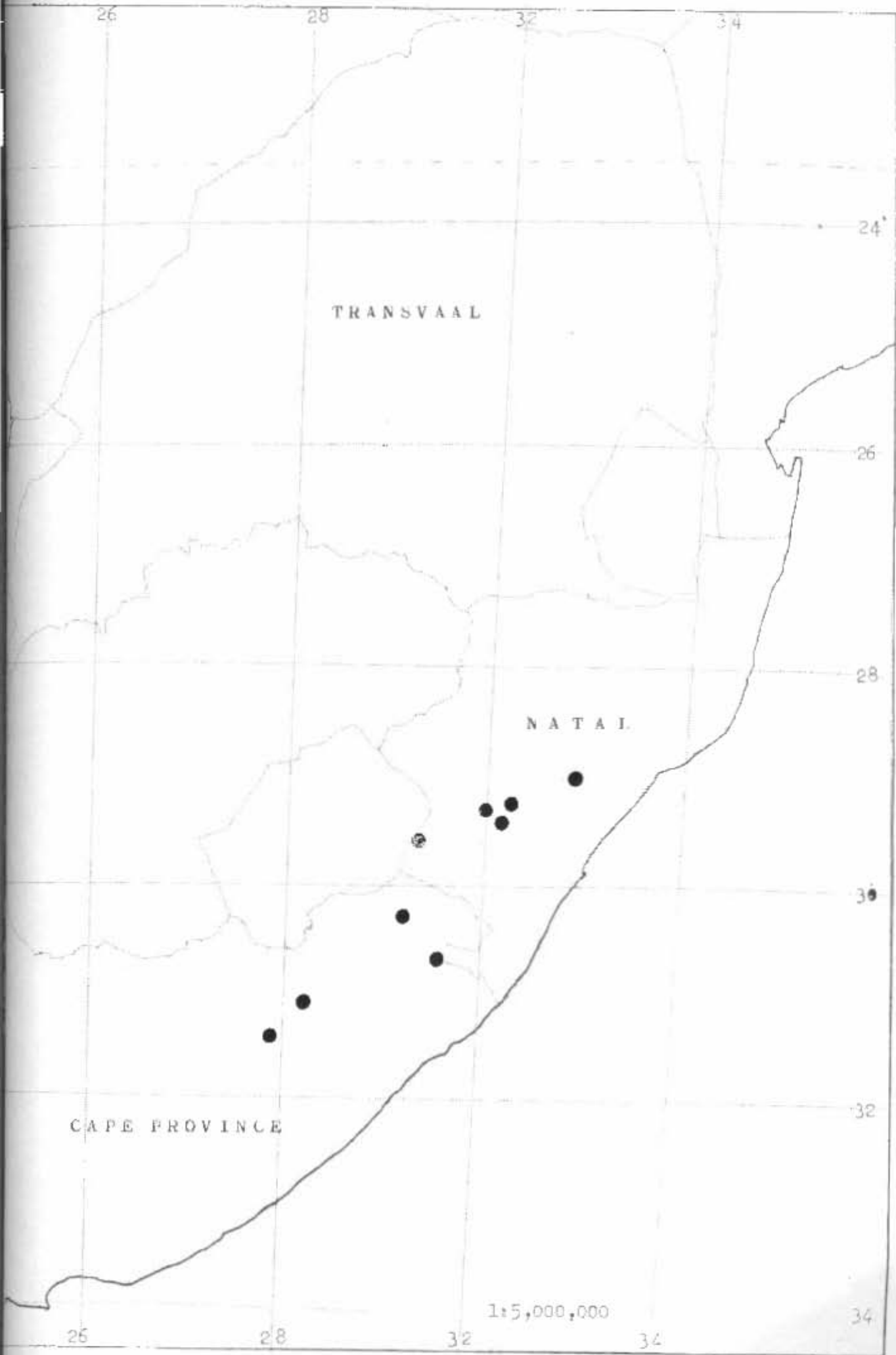
Lioné R. Dist.

Natal.

Rogers 15109.

Underberg Dist.

Natal.

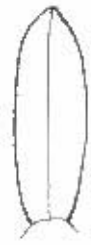


MAP 5: Distribution of *E. brachystyla* Schltr.

(6). EULOPHIA CORALLORHIZIFORMIS: This group is included in the present work primarily because it bears superficial resemblances to certain forms of the *E. hians* - *E. laxiflora* complex (see section 2, page 28). However, the very small flowers, rather obovate petals, and the narrow basal part of the labellum distinguish this group to such a degree that a critical analysis would be unnecessary.

While there appears to be a certain amount of variation in floral morphology, particularly in the shape of the side lobes of the labellum, the continuity of such variation makes it impractical to delimit further taxa within the group. Similar conclusions were reached regarding certain highly variable vegetative characters, notably the scape length, which may range from 18 to 54 cms. in specimens from a single locality.

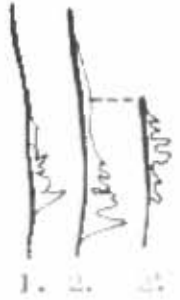
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Gillfillan 345  
Middelburg Dist.  
Central Transvaal

Murray 6  
Pietersburg Dist.  
N. Transvaal

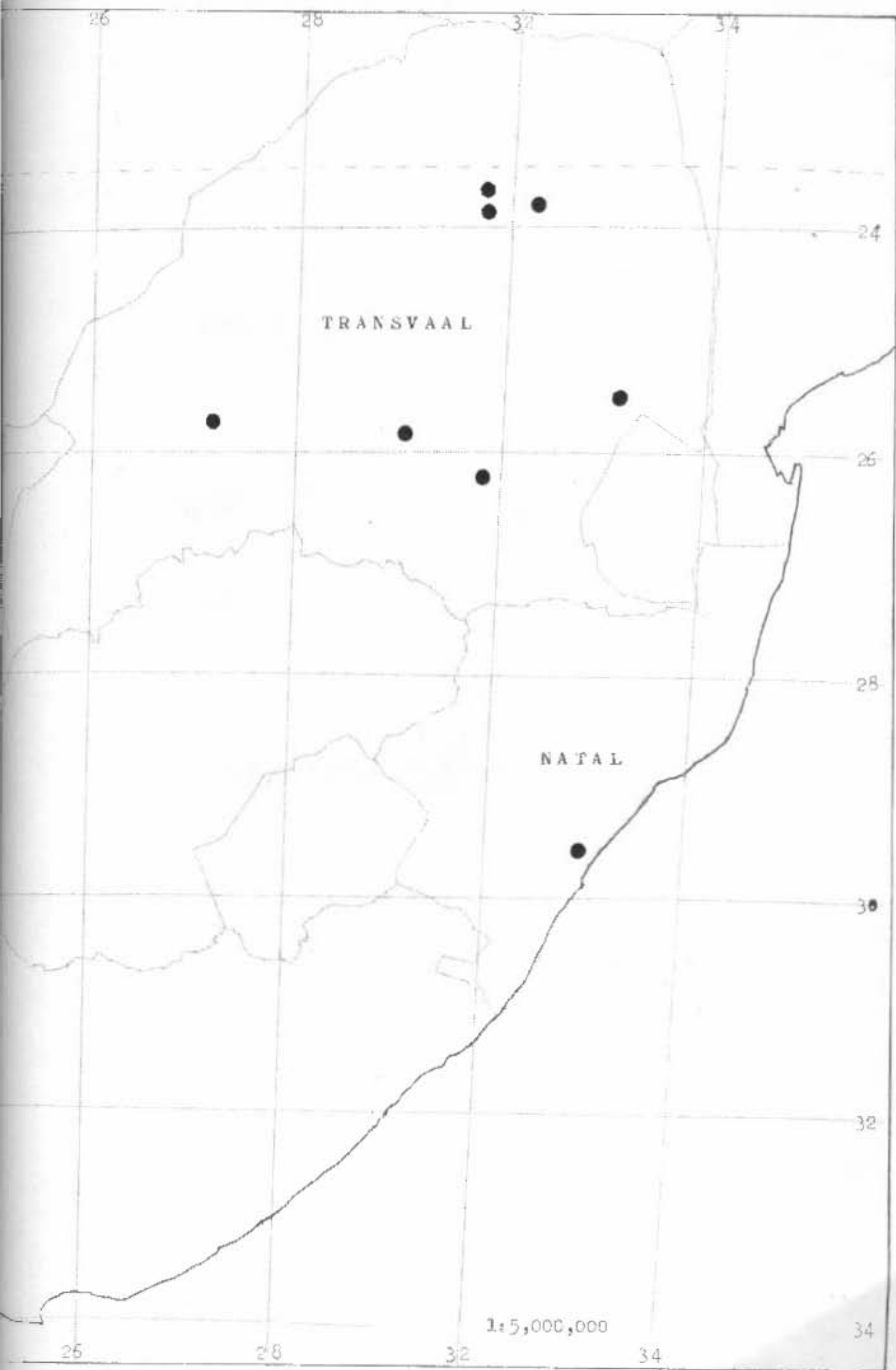
Galpin 1221  
Barberton  
E. Transvaal



Wood 4075  
Durban.  
Natal Coast.

Perler 1001  
Rustenburg.  
N. W. Transvaal

Nogg 14657  
Woodbush  
N. E. Transvaal



Map 6: Distribution of *E. corallorhiziformis* sens. lat.

TAXONOMY.

(1). EULOPHIA PETERSII Reichb.f., Flora, 48, 186 (1865), in note, Otia Bot. Hamb., 2, 74 (1881); Rendle, J. Linn. Soc. (Bot.) 30, 384 (1894); Rolfe, in Dyer, Fl. Trop. Afr., 7, 55 (1897); Durand and Schinz, Consp. Fl. Afr., 5, 26 (1892).

———Galeandra petersii Reichb.f., Linnaea, 20, 697 (1847); Klotzsch, Peters Reise Mossamb. (Bot.), 514 (date unknown).

———Eulophia caffra Reichb.f., Flora, 48, 186 (1865); Rolfe, in Dyer, Fl. Cap., 5, (5), 23, (1912); Bolus, J. Linn. Soc. (Bot.) 25, 184 (1889); Durand and Schinz, Consp. Fl. Afr., 5, 19 (1895); L. Bolus, Fl. Pl. Afr., 8, t. 313 (1928).....SYNON. NOV.

———Eulophia longipedunculata Rendle, J. Linn. Soc. (Bot.) 30, 382, (1892).

———E. schimperiana A. Rich., Tent. Fl. Abyss., 2, 283 (date not available); Schweinfurth, Bull. Herb. Boiss., 2, App. 2, 89 (1894).

———Epidendrum schimperianum Hochst. ex A. Rich., Tent. Fl. Abyss., 2, 283 (date not available).

———Eulophia circinnata Rolfe, Kew Bull., 1910, 280 (1910)..SYNON. NOV.

DESCRIPTION:

Plants often forming large clumps, 0.5 - 2.6 m. high.

Rhizome robust, 1 - 2 cm in diameter, clothed with scarious, deltoid, amplexicaul bracts 1 - 2 cm long, and bearing long fleshy roots 0.5 cm in diameter.

Pseudobulbs erect, the greater part lying above the soil level, stoutly fusiform to subvoid, somewhat sulcate, polished, (6-) - 10 - 15 - (18) cm long, 2 - 4 cm in diameter, bearing 1 - 5 leaves near the apex and 3 - 5 marcescent papery deltoid-acuminate bracts which become more crowded below, shortening from 8 - 10 cm to 3 - 5 cm basally.

Leaves 1 - 5, distichous, rigidly coriaceous, ensiform, one or both margins minutely to clearly serrulate. Both surfaces minutely pale spotted, dark green, the upper deeply canaliculate, the lower keeled with dark longitudinal striae marking the veins.

Inflorescence erect, slightly flexuose, branches absent or with first or second order branching distally, 0.5 - 2.6 m high,

the surface covered with a fine waxy bloom, bearing 3-6 distant, deltoid-acuminate to lanceolate amplexicaul sheaths 2.0-3.5 cm long.

Bracts subtending the upper branches and flowers not amplexicaul, linear-lanceolate, acuminate, 1.0-2.5 cm long.

Flowers conspicuous, 3.5-6.0 cm long, generally distant. Petals and sepals greenish brown, lip white with wine-red crests and nerves.

Pedicels twisted, smooth, 1.0-1.5 cm long. Ovary twisted, minutely sulcate, 1.5-2.0 cm long.

Sepals spreading, linear-oblong to obovate, acute, circinnate in mature flowers, the lateral sepals often falcate and slightly auricled at the base of the abaxial margin, 2.2-3.0 cm long, 4-6 mm wide.

Petals lying against the column and side lobes of the labellum, linear-oblong to subobovate, acute, revolute in mature flowers, 15-30 mm long, 5-7 mm wide.

Labellum pandurate to clearly 3-lobed, 20-35 mm long excluding the the 2-3 mm spur at the base, attached to the foot of the column by a short to vestigial mentum. Middle lobe  $\frac{1}{2}$ - $\frac{1}{2}$  as long as the labellum, linear-oblong to obovate, the apex acute, obtuse or retuse, margins frequently much crisped. Lateral lobes varying from linear with a suddenly rounded apex, to a wide base with the distal margin curving gradually into the middle lobe.

Inner surface of the labellum with ridges above all major nerves, the crests above the three central nerves more prominent, consisting of low fleshy ridges basally, rising to erect crenulate blades 1-3 mm high, terminating 2-4 mm from the apex.

Column subclatate, 9-14 mm long. Stigma transversly elliptical. Anther 4mm long, the operculum 2-horned.

**TAXONOMY:** The proposal of E. caffra Reichb.f. and E. circinnata Rolfe as synonyms of this species is at present somewhat tentative, as no Types were available to the author. However, the differences between the Type descriptions appear to be trivial in comparison with the range of forms examined, and none seem to describe the apparently distinct form from Angola (see pages 9-11).

Further, the two minor variants from Rhodesia, Transvaal and the East African Coast, whose distinction is chiefly based on inflorescence branching, are not considered to be of great enough significance for their recognition as separate species (see pages 8 and 9). It is evident from descriptions however that such distinctions have been regarded as affording species status to the forms in several separate instances, so that the synonyms may be grouped as follows :-

Branched form

*E. petersii*  
*E. schimperiana*  
*E. circinnata*

Unbranched form

*E. caffra*  
*E. longipedunculata*

SPECIMENS EXAMINED:

NATAL: Zululand, near Nongosa, A. Roberts in Herb. Transv. Mus. 28735 (PRE) ; Lady Duncan in Nat. Herb. Pretoria 28746 (PRE) ; Eshowe, I.C.Verdoorn and R.A.Dyer in Nat. Herb. Pretoria 24546 (PRE) ; P.A. van der Bijl in Herb. Bolus 15717 (BOL) ; Zululand, E.B.Houting in Nat. Herb. Pretoria 28745 (PRE) ; Hlabisa, H.Feidler 1072 (PRE) ; Msinga, Tugela ferry, L.E.Codd 6337 (PRE) ; Hlabisa, Somkele, E.R. Harrison 35 (BOL) ; Zululand, Empangeni, Bennet in Herb. Bolus 25243, (BOL).

TRANSVAAL: Nelspruit, H.G.Breyer 17706 (PRE) ; Barberton, Slaaihoek, I.B.Pole - Evans 3920 (PRE) ; Kruger Nat. Park, H.B. van der Schijff 1285 (PRE) ; Krantzberg, Codd and Erens in Nat. Herb. Pretoria 28743 (PRE) ; Zoutpansberg, above Saltpan, A.O.D.Mogg 24475 (PRE) ; Pietersberg, Smitsdrift, Kies and Bruce 55 (PRE) ; Pietersberg, J.E.Repton s.n. (PRE) ; Pietersberg, Boyne, F.Thompson and N.R.Smuts in Bolus Herb. 26744 (BOL) ; Pietersberg, Near Smitsdrift, F van der Merwe 272 (PRE).

Barberton, Umvoti Creek, W.Culver 31 (BOL); Barberton, Plaston, W.E.Holt 286 (PRE); White River, F.A.Rogers 24902 (PRE); Lydenberg, Burgers Fort, F. van der Merwe 6 (PRE).

SOUTHERN RHODESIA: Birchenough Bridge, A.A.Obermeyer 2438 (PRE); Zimbabwe, G. van Son in Herb. Transv. Mus.29402 (PRE); Salisbury District, Greatrex 63, 63a (PRE); Rumani, Greatrex in Nat. Herb. Pretoria 28737 (PRE); Salisbury district near Arcturus, A.V.Hall 214 (BOL).

PORTUGUESE EAST AFRICA: Goa Island, A.F.Gomes e Sousa 3500 (PRE); Namagoa, Mocuba, H.G.Faulkner 6 (PRE).

WITHOUT LOCALITY: Sanderson 1015 (BOL); J.Gerstner 3843 (BOL); Bolus Herb. 26734 (BOL).

ECOLOGY, DISTRIBUTION, CYTOLOGY: The species as described above has been recorded from a wide range of localities, chiefly near the East African Coast, from Natal to as far North as Abyssinia and Eritrea (Rolfe, 1897). It may be found in a wide variety of habitats, ranging from dry savannah to the moist banks of streams and even close to the shores of coral islets (Gomes e Sousa, private communication). It should be mentioned here that there is no apparent correlation between significant variation and local habitat conditions.

Only a rather approximate chromosome number could be obtained for this species, probably lying in the range  $2n=70-80$ . The number was recorded from material collected by Thompson and Smuts at Boyne, Pietersberg District, Transvaal (Bolus Herb. No. 26744). The specimens have close affinities with the group designated as Form II on page 8. It is possible that further cytological evidence from this and other forms might be of considerable value in assessing relationships within the complex.

EULOPHIA ALOIFOLIA Welw. ex Reichb.f., Flora, 50, 104 (1865).

ANGOLA, Catengue, 13° 0' S., 13° 45' E., N. R. Smuts 1521 (BOL).

This extra - South African species is cited here chiefly because of its high degree of affinity with E. petersii. This relationship is discussed elsewhere (see Form III, pages 8 - 11). No description is given as available material is limited to a single specimen (Smuts 1521). This plant was found in loose, gravelly sand at the base of bushes, in a low rainfall area (probably about 8 - 12" per annum).

(2). EULOPHIA NUTANS Sonder, Linnæa, 19, 73 (1847); Bolus, J.

Linn. Soc. (Bot.), 25, 183, (1889); Reichb.f., Walp. Ann. Bot. Syst., 1, 785 (1849); Durand and Schinz, Consp. Fl. Afr., 5, 26 (1892); Kränzl., Ann. Hofmus. Wien, 20, 12 (7 1905); Rolfe, in Dyer, Fl. Cap., 5(3), 24 (1912); Bolus, Ic. Orch. Austr. - Afr., 2, t. 9 (1911).

— E. tenella Reichb.f., Linnea, 20, 681 (1847); Schlechter, Ann. Transv. Mus., 10, 236 (1924); Rolfe, in Dyer, Fl. Cap., 5(3), 24, (1912).

— E. natalensis Reichb.f., Flora, 48, 186 (1865); Bolus, J. Linn. Soc. (Bot.), 25, 184 (1889); Durand and Schinz, Consp. Fl. Afr., 5, 24 (1892); Rolfe, in Dyer, Fl. Cap., 5(3), 24 (1912)....  
.....SYNON. NOV.

— E. collina Schltr., Eng. Bot. Jahrb., 20, Beibl. 50, 3, (1895); Rolfe, in Dyer., Fl. Cap., 5(3), 24 (1912).....SYNON. NOV.

— E. flaccida Schlechter, Eng. Bot. Jahrb., 20, Beibl. 50, 3 (1895); Bolus, Ic. Orch. Austr. - Afr., 2, t. 20, (1911); Rolfe, in Dyer, Fl. Cap., 5(3), 25 (1912); Schltr., Fedde Rep. Beih., 68, t. 76 (1932).....SYNON. NOV.

#### DESCRIPTION:

Plants seldom in clumps, 20 - 30 (-50) cm high.

Rhizome irregularly moniliform, 0.4 - 2.0 cm in diameter, the thickened portions rather flattened below and obliquely conical.

above, clothed with fibrous, closely adpressed membranous amplicaul deltoid sheaths.

Roots borne mostly on the thin portions of the rhizome, 0.15 - 0.20 cm in diameter.

Leaves borne at the summit of the thickened portion of the rhizome, the fascicle 4 - 6 sheathed at the base, the sheaths becoming more spreading and passing into the leaves above. Leaves 2 - 4, suberect, ensiform, conduplicate, the longest 20 - 30 - (45) cm long, 2 - 7 mm wide.

Scape flexuose, (17) - 20 - 30 - (54) cm long, 1.0 - 2.5 mm in diameter, bearing 3 - 5 distant narrowly deltoid acuminate sheaths, 2 - 10 cm long. Bracts subtending the flowers ascending, lanceolate - acuminate, 5 - 13 mm long.

Flowers inconspicuous, 1 - 2 cm long, about 10 - 25 in a somewhat crowded raceme. Sepals dark green and maroon, petals yellow and orange, often purple tinged, labellum white basally, becoming orange to purple distally, the central crest bright yellow.

Pedicels 2 - 3 mm long, twisted, indistinguishable from the basal portion of the ovary, deeply sulcate. Ovary deeply sulcate, inflated distally, 5 - 12 mm long.

Sepals spreading, mostly oblong but sometimes elliptical to obovate, shortly acuminate, slightly fleshy, 5 - 10 mm long, the lateral sepals scarcely falcate and rather more concave than the odd sepal.

Petals spreading, broadly ovate, sometimes suborbicular to broadly oblong, minutely apiculate, 4 - 8 mm long.

Labellum distinctly 3 - lobed, 8 - 12 mm long including the spur. Middle lobe broadly obovate, the apex truncate to retuse, the lateral margins stiffly deflexed. Side lobes  $\frac{1}{2}$  -  $\frac{1}{3}$  as long as the labellum, suboblong, the apex frequently a little divergent. Spur cylindrical, lying close beneath the ovary, straight to slightly curved, stout, 2 - 3 mm long.

Adaxial surface of the labellum with broad ridges above all major nerves, being most prominent above the three central nerves.

Crest above the middle nerve very low at the base, rising to a thick fleshy blade 1mm high distally. Two adjacent ridges similar, but higher at the base of the labellum, adnate to the central crest for part of their length but free distally, the distal apices of all three crests projecting beyond the termination of their line of attachment to the labellum.

Column stout, broadly oblong, truncate, 2-4 mm long; Stigma conspicuous, transversely elliptical. Anther minute, the operculum 1 mm wide.

TAXONOMY: The morphology of flowers from Isotype material of E. natalensis Reichb.f. appears to lie well within the limits of variation of other specimens referred to E. flaccida Schltr. and E. nutans Sond., between which the author can find no consistent differences. Although the Types of E. nutans and E. flaccida have not been examined, it seems very likely that all three names are synonymous, and should therefore be referred to the earliest epithet, E. nutans Sond. No material was seen that had been authentically named E. tenella Reichb.f. or E. collina Schltr.; however, both have been relegated to synonymy by Schlechter and Rolfe respectively.

ECOLOGY, DISTRIBUTION AND CYTOLOGY: In South Africa, this species is chiefly found in areas near the coasts of Natal and the Eastern Cape Province, with the exception of a single record from N. E. Basutoland (see map 2, page 18). The species has also been found by the author and other collectors in Southern Rhodesia, although there is no evidence in available records of its occurrence in intervening areas in the Transvaal. In spite of this

apparently disjunct distribution, there seems to be no essential dissimilarity in the morphology of the outliers (see drawings on page 19).

The species is typically found in grassland communities, sometimes forming sparse colonies of ten to forty or more plants, although from the authors experience, such colonies may be very widely dispersed in a given area.

Chromosome counts were attempted using root tip material from plants of a large colony at Coldspring, near Grahamstown, E.Cape (Hall 606). Only rather approximate data could be obtained, the diploid numbers being of the order of 100-120. This high number, indicating polyploidy, together with the probably disjunct type of distribution, rather points towards the interesting speculation that E. nutans may be a species in a stage of senescence, on the basis of Willis' Age and Area theory (Willis 1922). However the evidence is rather too tenuous to warrant anything more than a mere suggestion of this idea.

#### SPECIMENS EXAMINED:

NATAL: Up Park near Verulam, Wood 1417 (BOL); Clairmont, Wood 12224 (PRE); Natal, Gueinzius s.n. (BOL); Kranskop, Wennig, s.n. (BOL); Camperdown, E.E.Galpin 10291 (PRE); Ingogo, A.A.Obermeyer, Herb. Transv. Mus. 35937 (PRE).

CAPE PROVINCE: Kentani, A.Pegler 290 (PRE, BOL); Albany, Grahamstown, H.Bolus 7336 (BOL), J.Glass in Herb. Schönland 24 (BOL); Port Elizabeth, Cutting s.n. (BOL); near Komgha, H.G.Flanagan 1645 (BOL, PRE); Stutterheim, near Fort Cunningham, H.Bolus 10291 (BOL); near Kingwilliamstown, Schnell s.n. (BOL); Grahamstown, H.G.Breyer 28 (PRE); Alexandria, de Bega Heights, E.E.A. Archibald 5397 (PRE); Nqanduli Heights, A.Pegler 622 (BOL); Port Snt. Johns, J.Hutchinson 1742 (PRE, BOL); Lusikisiki, Umsikaba Gorge, Acocks 13269 (PRE); Albany, Grahamstown, A.V.Hall 606 (BOL).

BASUTOLAND: Leribe, Dieterlen 405b (PRE):,

SOUTHERN RHODESIA: Eastern Districts, Chimanimani Mts., A.V.Hall 340 (BOL).

- (3). EULOPHIA HIANS Sprengel, Syst. Veg., 3, 720 (1826); Lindl., Gen. and Sp. Orch., 183 (1840); Bolus, J. Linn. Soc. (Bot.), 25, 182 (1889); Bolus, Ic. Orch. Austr.-Afr., 2, t.18 (1911); Durand and Schinz, Consp. Fl. Afr., 5, 22 (1892); Schlechter, Eng. Bot. Jahrb., 20, Beibl. 50, 25 (1895).
- Satyrin hians Linn.f., Suppl. Pl., 401 (1781).
- Limodorum hians Thunberg, Prodr. Fl. Cap. 3 (1794).
- Eulophia clavicornis Lindl., Comp. Bot. Mag., 2, 202 (1836).
- E. emarginata Lindl., Comp. Bot. Mag., 2, 202 (1836); Drège, Zwei Pfl. Documente, 46 (1844); Krauss, Flora, 305 (1845); Krauss, Beitr. Fl. Cap. und Natal., 157 (1846).
- E. platypetala Krauss in Flora, 305, (1845), non Lindl.
- E. violacea Reichb.f., Linnaea, 20, 683 (1847); H. Bolus, J. Linn. Soc. (Bot.), 25, 183 (1889); Durand and Schinz, Consp. Fl. Afr. 5, 26 (1892); Rolfe, in Dyer, Fl. Cap., 5 (3), 33 (1912); H.M.L. Bolus, Ann. Bolus Herb., 4, t.14 (1928).....SYNON. NOV.
- Graphorchis clavicornis Kuntze, Rev. Gen., 662 (1891).
- G. emarginata Kuntze, Rev. Gen., 662 (1891).
- Eulophia inaequalis Schlechter, Engl. Bot. Jahrb., 20, Beibl. 50, 3, 26 (1895); Rolfe, in Dyer, Fl. Cap., 5 (3), 49 (1912); H. Bolus, Ic. Orch. Austr.-Afr., 3, t.8 (1913).....SYNON. NOV.
- E. transvaalensis Rolfe, Kew Bull., 1910, 282 (1910); Rolfe, in Dyer, Fl. Cap., 5, (3), 31 (1912).....SYNON. NOV.
- E. aliwalensis Rolfe in Kew Bull., 1910, 368 (1910); Rolfe, in Dyer, Fl. Cap., 5 (3), 31 (1912).....SYNON. NOV.

DESCRIPTION:

Plants seldom forming clumps, (10) - 15 - 35 - (48) cm high.

Rhizome irregularly moniliform, the thickened portions 7 - 15 mm in diameter, obliquely conical on the upper side, covered with the fibrous remains of decayed sheaths.

Roots 1.3 - 2.0 mm in diameter when dry.

Leaves scarcely visible to 2/3 developed at time of flowering, the upper 2 - 4 leaves when mature reaching 14 - 40 cm long, 0.4 - 0.8 cm wide, slightly spreading, V-shaped in transverse section, the three major veins subemergent on the abaxial surface. Upper 2-4 leaves passing into 2-3 spreading leaves

1/3 - 1/8 as long, finally passing into sheaths below.

Scape frequently a little stout, 1.9 - 3.2 mm in diameter, occasionally subflexuose, 15 - 35 cm high, bearing 3 - 5 short basal sheaths and 3 - 5 distant ovate-lanceolate cauline sheaths, being as long as the internode clothed, only at the base of the scape; much shorter distally, the penultimate sheath being  $\frac{1}{4}$  -  $\frac{1}{2}$  - (rarely  $\frac{7}{8}$ ) as long as the internode it loosely clothes. Floral bracts ovate-acuminate, 5 - 15 mm long.

Flowers (15) - 20 - 35 - (40) mm long, borne in lax racemes of 3 - 15 flowers. Sepals dark brownish purple or greenish brown, petals and labellum suffused with pale purple or yellow.

Pedicels angular at the base, becoming shallowly sulcate distally, 5 - 10 mm long. Ovary superficially indistinguishable from the pedicel, becoming broader distally, with shallow sulcae between broad longitudinal ribs, 5 - 12 mm long.

Sepals spreading, (9) - 10 - 14 - (22) mm long, (2.5) - 3.5 - 4.5 - (5.0) mm wide, ovate-oblong to linear-oblong, obtuse to shortly acuminate to acute. Lateral sepals subfalcate, one of the lateral sepals sometimes partly fused to the odd sepal.

Petals connivent with the column and labellum, (9) - 10 - 14 - (18) mm long, distorted petals shorter, basically ovate to broadly oblong, obtuse. Adaxial and sometimes the abaxial margins frequently variously distorted, the petals in such cases being fused to part or whole of the length of the column.

Labellum 3-lobed, or sometimes reduced to a single lobe by fusion of the base with the column, (12) - 14 - 20 - (25) mm long including the (2) - 4 - 5 - (7) mm long spur. Middle lobe obovate, obtuse to retuse, or ovate and subacute, (4) - 5 - 7 - (9) mm long, (3) - 5 - 7 - (9) mm wide at its broadest point, the margins somewhat crenulate and sometimes asymmetrically irregular. Lateral lobes highly variable, ranging from 4 - 10 mm long, attached

to  $\frac{1}{4}$  -  $\frac{1}{2}$  of the length of the limb of the labellum, the lateral margin concave to convex, sometimes irregular, the apex rounded to subacute. Spur usually conspicuous, (0.7) - 1.0 - 1.3 - (1.4) times as long as the adaxial length of the column, often clavate, set apart from the ovary by a vestigial to conspicuous mentum, usually curved away from the ovary.

Adaxial surface of the labellum with crests of dissected blades often reaching 3 mm high, above the three central nerves and usually their main branches. on the middle lobe, such nerve branch crests being absent in forms with reduced labellum side lobes. Crests on the middle nerve weaker than on adjacent nerves, obsolescent basally where adjacent crests are produced as nearly smooth narrow ridges.

Column somewhat stout. 4 - 6 mm long. Stigma transversely narrowly elliptical. Anther 1.5 - 2.0 mm broad.

TAXONOMY: Variation studies indicate that a minor variant may be distinguishable within the taxon described above. (See page 35). However, it is considered that further information from field studies would be required before formal recognition could be given to the group.

Few of the important Type specimens were available to the author for revision of synonymy, although the majority of the Type descriptions were reasonably precise. In a number of cases however the opinions of previous workers could only be very approximately verified. The material and data from which the present author derived the synonymy is given below:—

<u>Species</u>	<u>Basis for comparison of synonyms</u>
<i>Ellophia hians</i> Spreng. ....	Burchell 6147, compared by N.E. Brown with the type of the earliest homonym, <i>Satyrium hians</i> Linn. f.

(Contd.)

<u>Species</u>	<u>Basis for comparison of synonyms (Contd.)</u>
<u>E. clavicornis</u> Lindl. ....	Synonymous in the opinion of Rolfe (1912). Type description seen.
<u>E. emarginata</u> Lindl. ....	Same data as preceding species.
<u>E. platypetala</u> Krauss, non Lindl. ....	Type description not available; synon- ymous in the opinion of Rolfe (1912).
<u>E. violacea</u> Reichb.f. ....	Type probably destroyed in the Berlin Herbarium; however, the concept is clear from the Type description.
<u>E. inaequalis</u> Schltr. ....	Concept clear from the Type description and specimens named by Schlechter (Sch- lechter 3431, Galpin 509).
<u>E. transvaalensis</u> Rolfe....	Isotype material seen, agreeing well with the Type description.
<u>E. engleri</u> Rolfe.....	Isotype material seen, agreeing well with the Type description.

Other species have been published whose descriptions match various forms of this enlarged concept of *E. hians* rather closely. However, as no authentically named specimens were available, one may only suggest synonymous status. These doubtful species are recorded below, their probable affinity with various morphological developments of *E. hians* sens. lat. being described in terms of the section reference numbers used in the Variation studies (pages 28-29).

<u>Eulophia deflexa</u> Rolfe, Kew Bull., <u>1895</u> , 192 (1895).....	Sect. 5.
<u>E. engleri</u> Rolfe, Kew Bull., <u>1910</u> , 282 (1910).....	Sect. 5.
<u>E. longipes</u> Rolfe, Kew Bull., <u>1910</u> , 280 (1910).....	Sect. 5.
<u>E. watkinsonii</u> Rolfe, Kew Bull., <u>1913</u> , 339 (1913).....	Sect. 6.
<u>E. obcordata</u> Rolfe, Kew Bull., <u>1917</u> , 82 (1917).....	Sect. 5-7.
<u>E. triloba</u> Rolfe, Kew Bull., <u>1917</u> , 81 (1917).....	Sect. 5-7.
<u>E. amajubae</u> Schltr., Ann. Transv. Mus., <u>10</u> , 236 (1924)....	Sect. 7.

A SELECTION OF THE SPECIMENS EXAMINED:

CAPE MIDLANDS: George, on the road from the Newsakamma R. to the Great Brak R., W.J.Burchell 6147 (BOL); Humansdorp, Oudebosch, C.Fourcade 1726 (BOL); Knysna, Kirby, Fourcade 4171 (BOL); Humansdorp, Hankey Rd., Fourcade 6162 (BOL).

E. AND N.E. CAPE: Port Elizabeth, Redhouse, F.Paterson s.n. (BOL); Albany, Grahamstown, H.Bolus 5980, E.E.Galpin 170, A.V.Hall 552-560, 598, 607 (BOL); Kingwilliamstown, Perie, H.G.Flanagan 2232 (BOL); East London, Nahoon River, Galpin 7875 (PRE); Near Komgha, Flanagan 1117 (BOL); Kentani, A.Pegler in Bolus Herb. 26679, Pegler 781 (BOL); Aliwal North, Elands Hoek, H. Bolus 10671 (BOL); Maclear, Ugie, J.Schnell s.n. (BOL); Kokstad, F. Tyson 1601, 1602 (BOL); Lusikisiki, Egossa, T.R.Sim 2453 (BOL).

NATAL: Liddesdale, J.M.Wood 4264 (BOL); Klip River, Ladysmith, R.Schlechter 3431, 3432 (BOL); South of Underberg, R.A.Dyer 3283 (PRE); Bergville, Cathedral Peak, E.A.C.L.E.Schelppe 840 (BOL); Estcourt, Cathkin Park, Galpin 11705 (PRE); Camperdown, Drummond, Galpin 10289 (PRE); Bergville, Mont Aux Sources, H.G.Schweickerdt 716 (PRE); Bergville, Oliviershoek Pass, A.V.Hall 588 (BOL).

BASUTOLAND: Mafeteng, Likhoele, A.Dieterlen in Nat. Herb. Pretoria 28731, 28740 (PRE); Morija, Makhoarane Mt., Dieterlen 1112 (PRE).

ORANGE FREE STATE: Bethlehem, T.Potgeiter 81 (PRE).

TRANSVAAL: Barberton, Sheba Mt., Bolus 10675, (BOL); Barberton, Saddleback range, Galpin 550 (PRE, BOL), Galpin 1026 (PRE), Galpin 509 (BOL); Vaal Bank between Devils Kantoer and Pretoria (? S. of Middelburg), Bolus 10676 (BOL); Carolina, Galpin 13435 (PRE); Belfast, Machadodorp, R.G.Strey 2801 (PRE); Pietersberg, Woodbush, Schweickerdt s.n. (PRE); Springs, Dersley,

R.A.H. Flugge - de - Smidt s.n. (PRE); Pretoria, Magaliesberg, J.W. Mogg 1 (BOL); Witbank, F.A. Rogers in Herb. Transv. Mus, 24897 (PRE); Ventersdorp, Goedgedacht, Sutton 705 (PRE); Pretoria, Groenkloof, J. Burt - Davy 1048 (BOL); Pretoria, Mogg in Bolus Herb. 26678 (BOL).

DISTRIBUTION, ECOLOGY AND CYTOLOGY: Representatives of the enlarged concept of E. hians appear to be distributed throughout those parts of South Africa receiving summer rainfall and an annual average greater than 24" (see map 4, page 43). The author has also seen specimens that superficially match this species in the Government Herbarium, Salisbury (SRGH), that were collected in the East and Central Districts of Southern Rhodesia.

Judging from the authors observations and data on Herbarium labels, it appears that this species is chiefly found in open grassland, frequently on well drained slopes in sandy or stony soils. Flowering usually occurs in the months September, October and November.

The implications of the rather high chromosome number, found to be close to the range  $2n = 109 - 112$ , are discussed elsewhere (see pages 26 and 27).

- (4). EULOPHIA CARUNCULIFERA Reichb.f., Flora, 64, 329 (1889); Bolus, J. Linn. Soc. (Bot.), 25, 184 (1889); Durand and Schinz, Consp. Fl. Afr., 5, 20 (1892); Rolfe, in Dyer, Fl. Cap., 5 (3), 26 (1912); H.M.L.Bolus, Fl. Pl. Afr., 25, t.966 (1945).
- E. laxiflora Schlechter, Eng. Bot. Jahrb. 20, Beibl. 50, 4, 26 (1895); Bolus, Ic. Orch. Austrn - Afr., 2, t.15 (1911); Rolfe, in Dyer, Fl. Cap., 5 (3), 26 (1912).....SYNON. NOV.
- E. galpinii Schlechter, Eng. Bot. Jahrb., 20, Beibl. 50, 10 (1895); Rolfe, in Dyer, Fl. Cap., 5 (3), 26 (1912)....SYNON. NOV.
- E. aemula Schlechter, Eng. Bot. Jahrb. 20, Beibl. 50, 26 (1895); H.Bolus, Ic. Orch. Austrn - Afr., 2, t.16 (1911); Rolfe, in Dyer, Fl. Cap., 5 (3), 27 (1912); Summerhayes, Bot. Notiser 1937, 193 (1937).....SYNON. NOV.
- E. flanagani Bolus, Trans. S. Afr. Phil. Soc., 16, 143 (1905); Bolus, Ic. Orch. Austrn - Afr., 2, t.14 (1911); Rolfe, in Dyer, Fl. Cap., 5 (3), 28 (1912).....SYNON. NOV.
- E. purpurascens Rolfe, Kew Bull., 1910, 281 (1910); Rolfe, in Dyer, Fl. Cap., 5 (3), 29 (1912); H.M.L.Bolus, Fl. Pl. Afr., 8, 307 (1928).....SYNON. NOV.
- E. barbata Bolus, Ic. Orch. Austrn - Afr., 3, t.12 (1913), non Spreng., Syst. Veg., 3, 720 (1826).....SYNON. NOV.
- E. gladioloides Rolfe, Kew Bull., 1910, 281 (1910); Rolfe in Dyer, Fl. Cap., 5 (3), 30 (1912).....SYNON. NOV.
- E. decurva Schlechter, Annals of the Transvaal Museum, 10, 235 (1924).....SYNON. NOV.
- E. ernestii Schlechter, Annals of the Transvaal Museum, 10, 236 (1924).....SYNON. NOV.

DESCRIPTION :

Plants slender, sometimes forming small clumps, (14) - 30 - 50 - (80) cm high.

Rhizome irregularly moniliform, the thickened portions 1.0 - 1.5 cm in diameter, obliquely conical on the upper side, covered with the fibrous remains of decayed sheaths.

Roots 1.0 - 2.0 mm in diameter when dry.

Leaves well developed at the time of flowering, the upper 2 - 4 leaves reaching (10) - 22 - 40 - (70) cm long, (3) - 4 - 6 - (10)

mm broad, slightly spreading, V-shaped in transverse section, 3-5 major veins subemergent on the abaxial surface. Upper 2-4 leaves passing into 2-3 spreading leaves  $1/6 - 1/2$  as long, finally passing into sheaths below.

Scape frequently very slender, 1.0-2.3 mm in diameter near the base, occasionally subflexuose, very rarely with one or two branches below the raceme of flowers, bearing 3-5 short basal sheaths, and 3-5 distant lanceolate to narrowly lanceolate cauline sheaths, obscuring the internodes below, decreasing a little in relative length above, the penultimate sheath (0.5) - 0.8 - 1.1 - (1.4) times as long as the internode it clothes. Bracts subtending flowers ovate to narrowly ovate, acuminate, 5-18 mm long.

Pedicels angular at the base, shallowly sulcate distally, 5-15 mm long, superficially indistinguishable from the ovary.

Ovary expanded distally, 5-15 mm long

Sepals spreading, linear-oblong to subobovate-oblong, (8) - 11 - 14 - (16) mm long, (1.8) - 2.0 - 3.0 - (4.0) mm broad, the lateral sepals subfalcate.

Petals connivent with the column and labellum, subovate or subobovate-oblong, obtuse, frequently apiculate, or narrowly oblong and acute, (8) - 9 - 14 - (16) mm long, (2.8) - 4.0 - 6.0 - (7.0) mm broad, the margins very rarely a little distorted.

Flowers (15) - 20 - 25 - (35) mm long, borne in somewhat lax racemes of about 5-25 flowers. Sepals green or purplish brown, petals pale purplish pink, pale yellowish green, or pale straw yellow. Labellum white suffused with green, or purple with yellow crests, or pale straw yellow lined with purple.

Labellum 3-lobed, (9) - 12 - 15 - (20) mm long, including the (2) - 3 - 4 - (6) mm long spur. Middle lobe obovate to obovate-oblong, obtuse, sometimes retuse, rarely subacute, (3) - 4 - 6 - (7) mm

long, (3.0) - 3.5 - 4.0 - (4.5) mm wide at the broadest point, the margins rarely a little crenulate. Lateral lobes attached to more than half the length of the limb of the labellum, frequently falcate-divergent near the obtuse to subacute apex, contracted at the base. Spur variable, ranging from a stout 2mm long spur lying close beneath the ovary, to a curved 3-4 mm spur set apart from the ovary by an inconspicuous mentum, to a straight or curved 3-6 mm spur attached to a rather conspicuous mentum.

Adaxial surface of the labellum with crests most developed above the three central nerves and their main branches on the middle lobe, with minute ridges on nerves near the distal margin of the lateral lobes. Central nerve with the basal 1/3 uncrested, the distal 2/3 with a low crenulate ridge increasing distally to fleshy lacerated blades or papillae; two adjacent nerves and their main branches on the middle lobe crested similarly, but with low, fleshy, minutely pubescent ridges produced to the base of the labellum.

Column stout to slender, varying from (2.5) - 3 - 7 (7.5) mm long. Stigma transversely elliptical. Anther 1-1.5 mm broad.

TAXONOMY: Variation studies show that a considerable number of species should be relegated to synonymy in this group. Fortunately, Type material for comparison was available for the majority of species, as follows:—

<u>Name</u>	<u>Material used for comparison</u>
<u>Eulophia carunculifera</u> Reichb.f...	Flowers from the Type (Buchanan, Natal), and the Type description.
<u>E. laxiflora</u> Schltr.....	Iso-syntype specimens (J.M.Wood 3430), and the Type description.
<u>E. galpinii</u> Schltr.....	Iso-type specimens (E.E.Galpin 1151), and the Type description.
<u>E. aemula</u> Schltr.....	Isotype material of 2 of the 5 Syntypes (Schlechter 4057, Culver 14), also the Type description.

<u>Name</u>	<u>Material used for comparison (Contd).</u>
<u>E. flanaganii</u> Bolus.....	The Holotype (Flanagan 1029), 2 paratypes (Galpin 1713, F.Bolus 249), and the type description.
<u>E. purpurascens</u> Rolfe .....	Isotype specimens (J.M.Wood 1367), and the type description.
<u>E. gladioloides</u> Rolfe.....	Isotype specimens (J.M.Wood 7922), and the Type description.
<u>E. barbata</u> Bolus.....	Drawing of Holotype, material named by Bolus, and the Type description.
<u>E. decurva</u> Schltr.....	Isotype specimens (H.G.Flanagan 1117), and the Type description.
<u>E. ernestii</u> Schltr.....	Isotype specimens (E.E.Galpin 2250), and the Type description.

In addition, it was found that the rather scanty Type description of E. nelsonii Rolfe (Kew Bull., 1910, 369, 1910) closely matches a number of forms within this enlarged species concept, the only doubtful character being the 'broadly elliptic' labellum. However, no authentically named material was available; the proposal of synonymous status for this species can therefore only be tentative.

SELECTION OF SPECIMENS EXAMINED:

E. AND N.E. CAPE PROVINCE: Kingwilliamstown, Frankfort Hill, R.C.Doe 42 (BOL); near Kongha, H.G.Flanagan 1699 (BOL); Near Kei Mouth, Flanagan 1029 (BOL); Queenstown, E.E.Galpin 1713, 2250 (BOL); Queenstown, Lesseyton Nek, Galpin 1713b (BOL); Aliwal North, Elands Hoek, F.Bolus in Bolus Herb. 10543, 10544 (BOL); S. of Umzinkulu, A.V.Hall 654 (BOL); Umzinkulu, Clydeside, F.Tyson 1912 (BOL); Mqanduli, A.Pegler 624 (BOL); Umtata, Engcekusi, H.Bolus 8775 (BOL).

NATAL: Buchanan s.n. (BOL); Klipriver, near Wesselsnek, R.Schlechter, 3397 (BOL); Blaauw Krantz, J.M.Wood 3430 (BOL);

Near Newcastle, Wood 6748 (BOL); Helpmekaar, L.E.Codd 163 (BOL); Tugela, Tongaat R., Wood in Bolus Herb. 1367 (BOL); Estcourt, Cathkin Park, Galpin s.n. (BOL); Lions River, Lidgetton, Wood 7922 (BOL); H.Bolus 6110 (BOL); Estcourt, Tabamhlope, O.West 556 (PRE); Lions River, Balgowan, J.P.H.Acocks 13944 (PRE).

ORANGE FREE STATE: Bethlehem, Senekal, E.Wium 21 (PRE).

BASUTOLAND: Leribe, A.Dieterlen 1109, 861 (PRE).

SWAZILAND: Mbabane, Dalriach, H.Bolus 12302 (BOL); Mankaiana, Mkonde River, R.H.Compton 26454 (BOL).

TRANSVAAL: Barberton, Lomatie valley, Galpin 1151 (BOL); Lydenberg, W.Marais 413 (PRE); Pilgrims Rest, Spitskop, H.T.Schepers in Herb. Transv. Mus. 15224 (BOL); Lydenberg, A.A.Obermeyer 343 (PRE); Belfast, Schoongezicht, F. van der Merwe 1243 (PRE); Carolina, near Nelshoogte Pass, A.V.Hall 642 (BOL); Middelberg, near Botsabelo, Schlechter 4057 (BOL, PRE); Vereeniging, Burtt-olm, J.Burtt-Davy 15054 (BOL); Pretoria, R.Leendertz 4010 (PRE); Potgeitersrust, Leendertz 6558 (PRE); Waterberg, Springbok Flats, Burtt-Davy 1024 (BOL); Rustenberg, Crocodile R., Pegler s.n. (BOL); Potchefstroom, Klipdrif, J.J.Theron 1184 (PRE).

ECOLOGY, DISTRIBUTION AND CYTOLOGY: Like its ally, E.hians, this species has been recorded from most parts of South Africa receiving summer rainfall and an annual average greater than 24" (see map 3, page 42). However, the distribution range does not appear to extend further East than Kingwilliamstown. It is probable that forms of this species are found in Southern Rhodesia. Close resemblances have been noted between material at the National Herbarium, Pretoria, and specimens collected near Salisbury (authors observations and F.C.Greatrex, M.S.). It should be added here that there appears to be no correlation between variation and geographical distribution.

Data on Herbarium labels indicates that the species is

generally very rare at a given locality. From the authors experience this may be an outcome of the fact that the plants are relatively inconspicuous and rather difficult to find.

The species is most often recorded from open grassland, the terrain varying from steep, sometimes rocky hillsides, to flats which may be dry, or moist to the extent of being marshy. Again, no marked correlation is evident between variation in floral morphology and habitat conditions. Flowering is most common in the late summer months December, January and March.

The implications of the chromosome number obtained for representatives of this species ( $2n = 50 - 56$  and  $54 - 56$ ), are discussed elsewhere (see pages 26 and 27).

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(5). EULOPHIA BRACHYSTYLA Schlechter, Eng. Bot. Jahrb., 26, 336 (1899); Rolfe, in Dyer, Fl. Cap., 5 (3), 29 (1912).

DESCRIPTION:

Plants slender, 20-30 cm high.

Rhizome irregularly moniliform, the thickened portions 0.5-1.4 cm in diameter, obliquely swollen on the upper side, clothed with the fibrous remains of decayed sheaths.

Roots 1.5-2.0 mm in diameter when dry.

Leaves usually full grown at flowering time, the upper 2-3 leaves (10)-15-25-(35) cm long, erect, narrowly ensiform, 0.4-0.7 cm broad; the lower 1-2 leaves never exceeding 7-10 cm long, arcuate-spreading, passing into 3-5 adpressed sheaths below.

Scape rather slender, 1.0-2.0 mm in diameter near the base, somewhat flexuose, 20-30 cm high, bearing 3-5 short basal sheaths and 3-4 narrowly lanceolate cauline sheaths, as long as the internode at the base of the scape, relatively much shorter distally, the penultimate sheath  $\frac{1}{2}$  -  $\frac{1}{2}$  as long as the internode it clothes. Floral bracts lanceolate, acuminate, 0.5-1.5 cm long.

Flowers 2.0-2.5 cm long, borne in lax racemes of 5-20 flowers. Sepals greenish purple, petals mauve, the labellum mauve with white to purple crests.

Pedicels shallowly sulcate, 3-6 mm long. Ovary rather deeply sulcate, 5-7 mm long.

Sepals spreading, oblong, obtuse to shortly acuminate, 7-10 mm long, 2-3 mm broad, the lateral sepals often slightly falcate and occasionally subobovate.

Petals connivent with the column and the labellum, broadly ovate, obtuse, rarely oblong, often a little assymetrical, 7-11 mm long, 5-7 mm broad.

Labellum distinctly 3-lobed, 8-14 mm long including the

2-3 mm long spur. Middle lobe broadly obovate, obtuse to subretuse, rather more than half as long as the limb of the labellum; lateral lobes prominently diverging, the apices obtuse to subacute and lying 2-4 mm away from the margin of the middle lobe. Spur stout, about twice as long as its diameter, lying closely beneath the ovary.

Adaxial surface of the labellum with crests only above the three central nerves and their main branches on the middle lobe. Middle nerve crested in the distal two-thirds with an interrupted low fleshy ridge often T-shaped in transverse section, terminating 1-2 mm short of the labellum apex. Crests on adjacent nerves similar, but produced as thick fleshy ridges to the base of the labellum.

Column rather stout, 2.5 - 3.0 mm long. Stigma broadly obreniform. Anther minute, about 1 mm wide.

TAXONOMY: The Type description of E. zeyheriana Sond. (Linnaea, 19, 73, 1847), although a little imprecise, was found to agree in all essential details with Isotype material of E. brachystyla (R.Schlechter 6489). However, as no type specimens, or other authentically named material of E. zeyheriana was available, its synonymous status must remain in doubt for the present.

SPECIMENS EXAMINED:

CAPE PROVINCE: Between Encobo and Cala, H.G.Flanagan 2706, pro parte (PRE); Mount Currie, Stephany 88 (BOL); Maclear, Ugie, Schnell s.n. (BOL).

NATAL: Insiswa Mt., R.Schlechter 6489 (BOL); Underberg, Ipolela, F.A.Rogers 15109 (BOL); Umgeni River, Dargle, J.Bews in Bolus Herb., 15399 (BOL); Karkloof, Lions River, E.A. C.L.E.Schelpe 5098 (BOL); Lions River, Nottingham Road, N.M.Harrison 1 (PRE); Kranskop, Wennig s.n. (BOL)

**ECOLOGY AND DISTRIBUTION:** Collectors notes indicate that E. brachystyla is a grassland species not requiring special local environmental conditions. In spite of this, there is no record of the species being common in any one locality, and available distribution records are remarkably limited in number. The distribution range appears to be restricted to higher altitudes in the Eastern Cape and Natal (see map 5, page 66).

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(6). EULOPHIA CORALLORRHIZIFORMIS Schlechter, Eng. Bot. Jahrb., 20, Beibl. 50, 9, 26 (1895); Rolfe, Dyer, Fl. Cap., 5 (3), 25 (1913); Summerhayes, Bot. Notiser, 1937, 193 (1937).

—E. bulbinoides Schlechter, Annals of the Transvaal Museum, 10, 234 (1924).....SYNON. NOV.

**DESCRIPTION:**

Plants slender, (18) - 30 - 40 - (54) cm high.

Rhizome irregularly moniliform, the thickened portions 1.0-1.3 cm in diameter, obliquely subconical, the surface clothed with smooth papery bases of sheaths.

Roots rather brittle when dry, 1 mm in diameter.

Leaves fasciculate, erect, very narrowly ensiform, 1.5-3.0 mm broad, the longest leaf 15-30 cm long at the time of flowering, the subsequent 2-3 leaves each half as long as the leaf above, finally passing at the base into 2-3 linear sheaths.

Scape very slender, 0.6-1.5 mm in diameter, (15)-30-40-(54) cm long, subflexuose, bearing 3-5 narrowly lanceolate sheaths, distally only 1/4 - 1/6 as long as the internodes they clothe, basally exceeding the internodes. Floral bracts narrowly lanceolate to deltoid, 3-9 mm long.

Flowers yellow, 0.8-1.3 cm long, in somewhat crowded racemes of 10-30 flowers.

Pedicels nearly smooth, 2-3 mm long. Ovary curved, rather trigonous, the sulcae shallow, 3-4 mm long.

Sepals oblong, slightly recurved, 7-8 mm long, 2.5 - 3.0 mm broad, the lateral sepals very slightly falcate and rather more acute than the subobtusate odd sepal.

Petals obovate, shortly acuminate, as broad and nearly as long as the sepals.

Labellum 3-lobed, 9.0-12.5 mm long including the 2-4 mm long spur. Middle lobe broadly oblong to obovate, the apex truncate to retuse, the margins crenulate, undulate. Lateral lobes scarcely developed at the base, distally expanded into prominent diverging lobes 1.0 - 1.5 mm broad. Spur cylindrical to subconical, lying closely beneath the ovary.

Adaxial surface of the labellum with crests only well developed above the nerves in the distal half. Central nerve crested with a low crenulate ridge increasing distally to a lacinated blade 1 mm high, ceasing 1-2 mm short of the labellum apex. Adjacent nerves similar, but with the low ridge minutely higher towards the base of the labellum.

Column stout, 3.5-4.0 mm long. Stigma transversely elliptical. Anther minute, 1 mm wide.

TAXONOMY: Detailed examination showed that no significant distinction could be found between specimens from the Type collection of E. bulbinoides Schltr. (Wood 4075), and Syntype material of E. corallorhiziformis (Galpin 1221). E. bulbinoides should therefore be relegated to the synonymy of the earlier epithet.

SPECIMENS EXAMINED:

TRANSVAAL: Woodbush, A.O.D. Nogg 14657 (PRE); Donkerhoek, R. Schlechter 3725 (BOL); Pietersburg, Baenertsburg, G. Murray 6 (PRE);

Pietersburg, New Agatha, J. McCallum s.n. (PRE); S.W. of Rustenberg, A. Pegler 1001 (PRE, BOL); Middelberg, Witbank, D.F. Gilfillan 345 in Herb. Galpin, 7241 (PRE, BOL); Barberton, Lomatie valley, Galpin 1221 (PRE, BOL); Barberton, Galpin 1151 (PRE).

NATAL: Clairmont, near Durban, Wood 4075 (BOL).

DISTRIBUTION AND ECOLOGY: Distribution records for this species in South Africa are relatively few in number, most of the localities being at rather high altitude in the Transvaal, with the exception of Woods rather isolated collection from near Durban. It is indicated in the literature that the species extends Northwards to the Eastern Districts of Southern Rhodesia (Summerhayes, 1937) and to the Vipya Mountains in Nyasaland (Williams, 1959).

Throughout the distribution range, it is evident that the species is found invariably in marshy habitats. It generally flowers in December, sometimes in considerable profusion.

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## MISCELLANEOUS AFFINITIES

In this section it is proposed to point out some of the rather more doubtfully distinct relationships among the species not studied in detail, and to suggest techniques by which such relationships might be evaluated. In several cases, lack of material reduces the basis for comparison to the description alone. However, this is no great drawback as in the authors experience lack of material of a given species often indicates that it constitutes an unnecessarily close ally of a more widely recognised taxon, and is thus not of very great significance.

Species are discussed below in approximately the same order as in Dyers Flora Capensis (1912).

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(7) E. chlorantha Schltr. A somewhat distant relative of the variable species E. carunculifera (sens.lat.), but differing from it in having a rostrate anther, and petals markedly narrower than the sepals. Field studies suggest that population variation is very limited.

(8) E. bakeri complex This series, incorporating several species, appears to have a similar variation pattern in the field as in the Laxifloroid series of the E. hians - E. laxiflora complex, and it is evident that analogous methods will be required for the assessment of this group. Judging from descriptions and available material, it is probable that E. bakeri Rolfe, E. complanata Verdoorn, E. ovalis Lindl., E. cooperi Reichb.f., E. ovatifolia Rolfe, and E. pretoriensis L.Bolus, will have to be considered synonymous. E. dregeana Lindl. may be distinguishable on the basis of smaller floral and vegetative parts. E. macowanii Rolfe might possibly be distinguished as a separate subspecies, owing

to its probably distinctive obovate petals, and its almost exclusive occurrence in the S.E. Cape Province, where other forms of the complex are seldom found. E. Schnelliae L. Bolus may be a variant of this last form.

(9) E. platypetala Lindl. Distinguished rather poorly from the preceding complex by high creasing and a small front lobe of the labellum, this species occupies an unusual distribution range, extending from Hermanus to Plettenberg Bay on the South Cape coast. It may be difficult to decide between subspecific and species status for this form. E. lissochiloides Lindl. is probably a synonym of this species.

(10) E. parvilabris Lindl. This species can be rather easily distinguished by its very broad leaves, flowers that are never resupinate, and the relatively short labellum bearing 2-5 blades at the base on the inner surface. These characteristics are shown by material and descriptions of several other species, which may be doubtfully distinct: these species are as follows: E. rehmanni Rolfe, E. amplipetala Schltr., E. stewartiae Rolfe, and E. latipetala Rolfe.

(11) E. calanthoides Schltr. A range of material links this species to a form represented by the Type of E. acuminata Rolfe, which is thus probably synonymous. The description of E. allisonii Rolfe likewise matches Type material of E. calanthoides. The species is characterised by having a spur nearly as long as the column, and in addition a shallow sac in the limb of the labellum below the column apex.

(12) E. subintegra Rolfe. Probably synonymous with E. calanthoides Schltr. or E. parvilabris Lindl., judging from the rather inadequate Type description.

(13) E. nigricans Schltr. The drawing of Schlechtens Type of this species, together with authentically named specimens, match likewise named material of E. woodii Schltr. Descriptions lack suff-

relatively much narrower petals, together with other differences.

(18) E. ensata Lindl. This species represents another ally of E. zeyheri, from which it consistently appears to differ in having smaller flowers and longer scape sheaths. Such differences should be examined statistically for confirmation.

(19) E. leontoglossa Reichb.f. A well marked species characterised by a short, dense raceme of rather long spurred flowers. E. capensis Bolus may be superficially similar, although the flowers are quite spurless in that species. Several colour forms are known, but casual observation in the field has revealed no correlated morphological variation.

(20) E. junodiana Kränzl. A dubious species extremely difficult to place on the basis of available descriptions.

(21) E. shupangae Kränzl. A widespread Tropical African species that is rather rare in South Africa. Summerhayes (1953) has placed the South African species E. papillosa Schltr., E. lata Rolfe, and E. durbanensis Rolfe in the synonymy of this species. It may be found that E. aurea Kränzl. constitutes an additional synonym. South African forms are characterised by the lax inflorescences of yellow spurless flowers, and the relatively large suborbicular middle lobe of the labellum.

(22) E. capensis Bolus A spurless species closely related to E. foliosa Bolus and E. huttonii Rolfe in floral morphology, but differing from both in having a rather shorter raceme of smaller flowers. Both these differences should be verified statistically however. Considerable variations are found in the dimensions of vegetative parts, and it will be necessary to establish whether this is controlled genetically or ecologically. Specimens regarded as E. capensis on the basis of descriptions closely resemble the Type of E. culveri Schltr., which will probably have to be regarded as synonymous.

(23) E. huttonii Rolfe Greater flower size appears to be the chief distinguishing feature between this species and E. capensis Bolus, a superficial examination revealing no major innovations in the floral morphology. The flowers appear to be fewer in number, and borne in a rather longer raceme in E. huttonii. A rigorous analysis of variation together with a cytological examination of these forms will have to be carried out before the status of the two species can be assessed.

(24) E. foliosa Bolus The majority of specimens of this species may be distinguished from E. capensis Bolus and E. huttonii Rolfe by their relatively long and dense racemes. However, when this character breaks down, the only other obvious distinguishing feature lies in the creting of very low warts on the middle lobe of the labellum, the creting being of dissected blades in the other two species. These two distinctions will require close scrutiny before relationships can be evaluated. Judging from descriptions, it is likely that E. boltonii Harv. ex Rolfe is synonymous with this species.

(25) E. tabularis Bolus A form distinguishable from other spurless species by the creting of a single fleshy ridge 2-3 lobed at its distal end on the middle lobe, together with larger flowers and lateral lobes extending to nearly as far as the middle lobe apex

(26) E. parviflorus Bolus Descriptions and representative specimens of this species are scarcely distinguishable from those of E. aequalis Bolus, and it seems very likely that an examination of the Types will reveal that the two concepts are conspecific.

E. bilamellata Schltr. may be a large spurred variant of this species. The group is characterised by the nearly equal dimensions of the petals and sepals, the truncate apices to the side lobes of the labellum, and the creting of low, fleshy keels.

Reichb.f., with which it is distantly allied. The species may be chiefly characterised by the unusually large crests of fluted blades on the distal 2/3 of the labellum, and the conspicuously two-horned anther. The labellum limb is similar to that of E. speciosa in having no distinct notch at the junction of middle and side lobes.

(32) E. buchani (Reichb.f.) Bolus. This species differs in minor features from the preceding species, the most distinctive character being apparent in the sepals, which are spatulate obtuse in E. buchani and lanceolate acuminate in E. porphyroglossa. In addition the flowers tend to be rather smaller, and the crests lower and more dissected.

(33) E. transvaalensis (Rolfe) Bolus. No material of this species was available. However, V.S. Summerhayes (1958) has examined the Type and concludes that it is an ally of E. porphyroglossa (Reichb.f.) Bolus.

(34) E. cucullata (Sw. ex Pers.) Steud. This species is one of the most distinctive of the South African Eulophiae, being characterised by an unusually large rounded sac at the base of the labellum, at the distal edge of which lie 2-3 rhomboid suberect blades. A tropical ally, E. arenaria (Lindl) Bolus only differs by having rather larger flowers. It is not improbable that a topoclinal series of intermediate forms may be revealed in later work.

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## CYTOLOGY.

Several problems accompany the determination of chromosome numbers in *Eulophia*. Chief among these is the difficulty in obtaining suitable material. Flower buds are usually in too advanced a state of development at the stage when plants are identifiable, for counts of haploid sets of chromosomes to be made from androecial material.

Actively growing root apices are likewise infrequent at the time of flowering, there being only 5-10 roots produced each year, the previous years roots being dormant. As these roots seldom branch, the number of actively growing apices is rather limited. In the present work, cultivation of rhizomes to obtain suitable material in subsequent seasons was not successful. For various reasons, the author was only able to collect limited rhizome material on the first tour of South Africa, and those collected on the second trip have shown little evidence of producing meristematic tissues. Finding plants in the field proved to be an additional difficulty, as *Eulophia* is no exception to the rule that orchids tend to be rather widely dispersed throughout a given area (Hall 1959, in press).

Finding suitable chromosome figures for counting is often hampered by the high frequency of cells in the meristematic region containing granules of roughly the same number and size range as the chromosomes themselves. These cell inclusions can be distinguished from chromosomes by staining however.

Three methods of staining chromosomes were investigated, using root tips of a locally available species of a genus closely allied to *Eulophia*, namely *Acrolophia lamellata*. The results were confirmed on a limited number of root tips of *Eulophia hians* Spreng. It was found that the Aceto-Carmine squash technique as described

in Darlington and La Cour (1942), gave extremely poor staining of chromosomes, with a high degree of background colouration of the cytoplasm. This agrees with the results of Wimber (1956), who proposes a modification of the Lacmoid squash technique developed by Mehlquist (1947). The modified Lacmoid technique was tested by the author, again with unsatisfactory results. Finally, a Feulgen squash technique (after Riley, M.S.) was tried, and was found to give reasonably satisfactory results. The method was as follows :--

(1) Root tips were cut off 1 cm. from the end and placed in a saturated solution of para-dichlorobenzene in water (colchicine advocated by Riley was not available). After 6-8 hours in this solution the root tips were washed.

(2) Fixation was then carried out by immersion a 3:1 mixture of Alcohol and acetic acid.

(3) The length of field trips necessitated storing root tips treated as above. On the suggestion of Dr. E. A. Schelpe of the Botany Department, University of Cape Town, the material was kept in the fixative and examined as soon as possible after the expedition.

(4) Hydrolysis was then carried out at 60° C. in a solution of 20% hydrochloric acid. The root tips were hydrolysed for 10-15 minutes, and then washed several times in distilled water.

(5) Staining was effected by Feulgens solution prepared according to the method in Darlington and La Cour (1942). Optimum results were obtained by immersion in this solution for 2-4 hours in strong daylight.

(6) The root tips were then placed in a drop of 45% acetic acid on a slide, and a cover slip placed on top of the preparation. Pressures of the order of 100 lbs/sq. inch were applied to the cover slip, the slide being cushioned by a wrapping of several layers of filter paper. Microscopic examination was carried out immediately afterwards.

It was unfortunate that Colchicine was not available to the author. As its effect of disorganising the process of

spindle formation and spreading the chromosomes throughout the cell is highly desirable, a substitute was sought. Such a substitute, para-di-chlorobenzene, was suggested by D.S. Mitchell (private communication). While chromosomes from root tips treated with this substance were somewhat easier to count, the effects were by no means marked.

While this staining procedure is quite adequate for discrimination between cell inclusions and chromosomes, the colour produced was not deep enough to show the outline of each chromosome with any degree of clarity. Accordingly, examinations were made by means of phase contrast equipment by Leitz. This technique of examination proved to be extremely successful; in the author's opinion, some 10-20 times better contrast was obtained between chromosomes and cytoplasm than by more conventional methods of staining and observation. A highly commendable feature of the Leitz apparatus is the degree of control of contrast afforded by the Heine Condenser. This was of particular use with the oil immersion objective, where the field could be given a gray background for visual observation and a high contrast very bright background for photography.

It can be seen from Table 13 that chromosome numbers in the species of *Eulophia* examined tend to be rather large. The difficulties of making reasonably accurate counts of large numbers of chromosomes are considerable, particularly where the outlines of aggregates have to be recorded accurately. Unfortunately, neither of the two Camera Lucida systems available were satisfactory for reproducing details of faint structures. This was partly due to the fact that the cells containing chromosomes frequently occupied only a very small part of the field of observation, even using the 90 x objective. The reduction of contrast at prism reflecting surfaces may further reduce the efficiency of such apparatus.

While direct visual observation and drawing without Camera Lucida apparatus may yield quite useful results, rather significant errors may be incurred, particularly when the chromosomes do not lie in one plane of focus. Accordingly, the author was led to use a photographic method in which a series of photographs were taken at planes of focus 1 - 0.5  $\mu$  apart. The photographs were printed as transparencies. The outlines of Chromosomes on the projected image of each transparency could then be drawn with considerable accuracy, those on each transparency being drawn if they had not been clearly recorded on the photograph of the previous plane of focus in the series. In cases of doubtful distinction in aggregates of chromosomes, the results of direct visual observation were used in conjunction with this technique. Technical details are given below.

A 35mm camera with a 50mm f. 3.5 lens at full aperture, focussed at infinity, was aligned with the optic axis of one of the binocular eyepieces (10x magnification) of the microscope. This allowed focussing to be carried out through the other eyepiece, the two eyepieces having been previously set at their maximum distance apart. The current from the transformer to the 6 volt bulb was then adjusted to 5 amps and the Heine condenser set to give maximum contrast with a bright background. The plane of focus was adjusted to a level at which chromosomes were just visible, and photographs were taken of this and successive planes of focus through the specimen, 1.0-0.5  $\mu$  apart, the vertical distances being determined from graduations on the fine focussing knob. Fine grain high contrast panchromatic film (Adox KB17), with a speed rating of 32 A.S.A, was used in the camera. Optimum results were obtained with this film with an exposure of 7 and 5 seconds, using the 90x (N.A.1.15) and 40x (N.A. 0.70) objectives respectively. It was always reasonably certain that an image would be obtained of the cell containing chromosomes, as the photographs covered a sufficiently large area of the field to allow for errors in camera alignment. Pertinent areas of the resulting negatives were then enlarged

eight times on to high contrast fine grain transparency film. The transparencies were then placed in an enlarger and magnified by projection to a convenient size (usually enlarged by about 5 times). The chromosomes could then be drawn from the projected images of each series of photographs, as described above. Photographs of a precisely ruled grating with intervals of 1/100 mm were enlarged in the same way, to give an estimate of the scale of the resulting drawings.

Drawings of chromosome sets showing a low probable counting error are illustrated in Figs. C1 - C16. Dotted lines between chromosomes indicate where the outlines were doubtful on the photographic record, and could only be resolved by direct observations on the microscope slide.

The high degree of success of this method in objectively recording the relative size, shape and position of the chromosomes suggests that it may be of considerable value to cytologists in South Africa, where high chromosome numbers tend to be rather frequent (M.R.Levyns, D.L.Olivier, private communication).

#### Chromosome Number and Morphology.

It was found that the best chromosome figures for counting occurred at the metaphase and late prophase stages of cell division. At these stages the chromosomes were generally (0.8) - 1 - 2 - (2.5)  $\mu$  long in the majority of species examined. In outline, the chromosomes appeared to be relatively short and broad, apparently devoid of constrictions typically found in longer chromosomes. In several instances strands were seen joining chromosomes into chains or groups. This was especially evident in material of E.foliosa Bolus (See fig.C13). The phenomenon has been recorded previously by many workers in diverse orchid genera, and it is frequently dismissed as an artifact brought about by poor fixation. Casual observations

by the author indicate that the number of groupings formed may fluctuate considerably from cell to cell. Furthermore, the experiments of Johnson (1951) have indicated that the frequency and extent of groupings may be markedly altered by supplying Rib<sup>on</sup>ucleic acid to a solution bathing the roots, or by adding barbituric acid, whose molecular structure is such that it interferes with the normal metabolism of Ribonucleic acid. It thus seems that linkage formation is variable and not characteristic of a given genome.

The linking of chromosomes in this way has an important bearing on the counting procedure. The most rigorous examination of the linkage seldom reveals a definite line showing where one chromosome ends and the next begins. Accordingly, the number of chromosomes present can only be ascertained from the undulations of the outline of the grouping. Much time was spent in the cytological work searching for suitable chromosome figures having the lowest frequency of these inter-chromosome linkages.

Chromosome numbers of varying degrees of accuracy were obtained for fourteen species (Table 13). It is apparent that three series of numbers are present, approximately rather closely to  $2n = 56, 72, \text{ and } 112$ , with corresponding gametic numbers of 28, 36 and 56.

The lowest common multiple of these figures is 4, which has actually been postulated as being probably the most common basic number in the Orchidaceae (Wanscher, 1934 and Duncan, 1959). If 4 should be the basic number in *Eulophia*, one would have to propose a high degree of polyploidy in the derivation of the gametic numbers obtained. Alternatively, one may suggest basic numbers of 7 and 9, implying the presence of somewhat

distinct evolutionary series.

Both records of a gametic number of ca. 38 were found in members of the previously accepted genus Lissochilus R.Br. Owing to the high frequency of intermediate forms, this genus has been relegated to the synonymy of Eulophia (Bolus 1889). While the two species with  $n = 36$  (E. speciosa Bolus, E. buchanani Bolus) lie well within the concept of Lissochilus, a third species of similar morphology, E. tuberculata Bolus, was found to have a gametic number of about 56. It thus seems improbable that chromosome number would aid in distinguishing the genus Lissochilus. Regarding the basic number, it is considered unwise to forward anything more than tentative suggestions on the basis of available information.

The implications of results for each species are discussed separately in the sections on Taxonomy.

**TABLE 13: Chromosome Numbers.**

<u>Collectors No.</u>	<u>Species.</u>	<u>Approx. Locality.</u>	<u>Probable Chromosome Number</u>	<u>Comments.</u>
A.V.Hall 601	<i>E. petersii</i> sp. <i>petersii</i>	N.Tvl.	70-80	Approximate
" 606	<i>E. nutans</i>	E.Cape	100-120	"
" 634	<i>E. carunculifera</i> (2-39)*	N.E.Cape	50-56	Accurate (C3)†
" 642	<i>E. carunculifera</i> (1a)	E.Tvl.	54-56	" (C2)
" 553	<i>E. hians</i> <sup>x</sup> spec.a.	E.Cape	100-112	" (C1)
	" b.		90-130	Approximate
	" c		90-130	"
" 588	<i>E. hians</i>	W.Natal	100-120	"
" 573	<i>E. chlorantha</i>	E.Tvl.	56-58	Accurate (C6)
			51-58	" (C5)
" 653	<i>E. dregeana</i> specimen a.	N.E.Cape	54-57	" (C9)
	" b.		55-59	" (C8)
" 643	<i>E. parvilabris</i>	E.Tvl.	55-56	" (C10)
			55-56	" (C11)
" 551	<i>E. aequalis</i>	E.Cape	55-56	" (C4)
" 614	<i>E. leontoglossa</i>	Cent.Tvl.	50-60	Approximate
" 610	<i>E. capensis</i>	E.Cape	56	Accurate (C12)
		S.W.Cape	50-60	Approximate
" 622	<i>E. foliosa</i>	E.Tvl.	53-56	Accurate (C13)
" 636	<i>E. buchanani</i>	E.Tvl.	72	" (C16)
" 638	<i>E. buchanani</i>	E.Tvl.	72	" (C16)
F.M.Isaac s.n.	<i>E. speciosa</i>	E.Cape	71-78	" (C14)
A.V.Hall 656	<i>E. tuberculata</i>	E.Cape	107-115	Mod. accurate

\* Numbers allocated to forms of this species in Table

† Numbers preceded by C refer to the chromosome drawings on pp.

x Purple flowered.

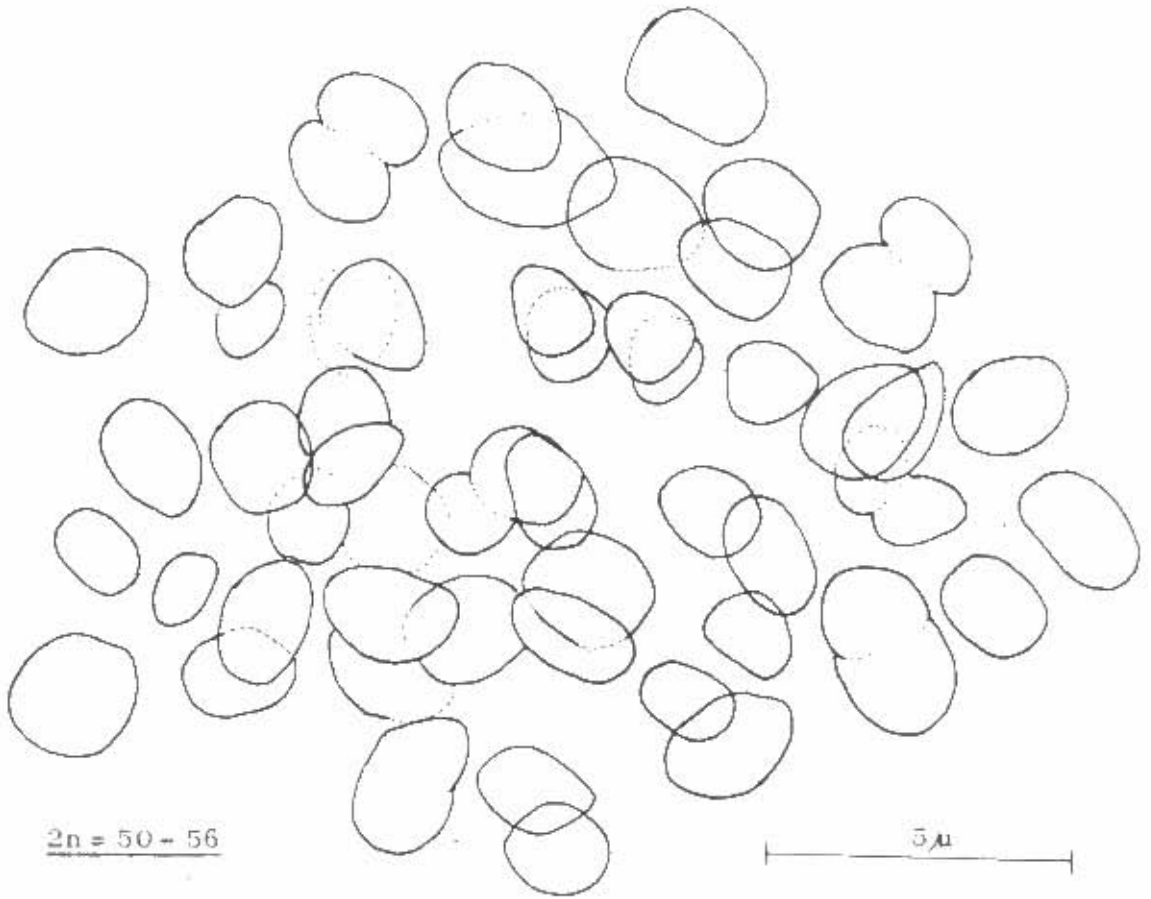


Fig. C3: *E. carunculifera sens. lat.* Chromosomes from a root tip of a specimen from Umzimkulu, N. E. Cape (Hall 642)

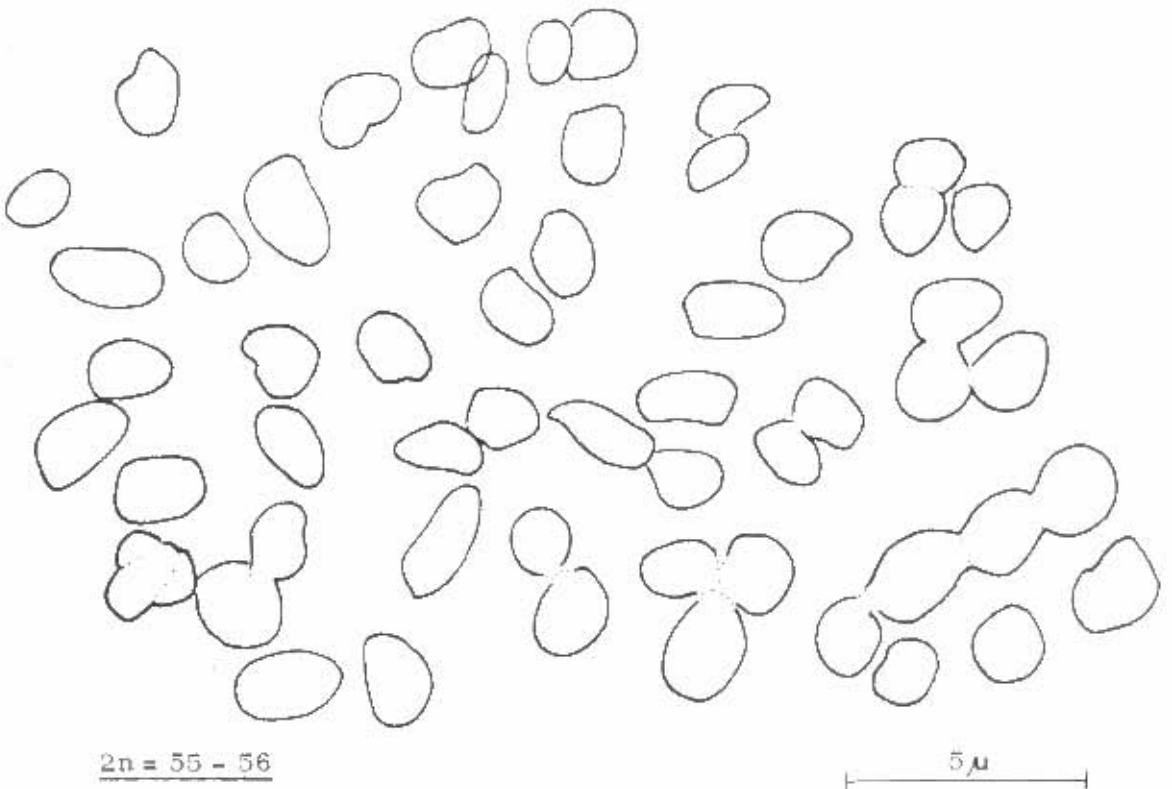


Fig. C4: *E. aequalis Lindl.* Chromosomes from a root tip of a specimen from Grahamstown, E. Cape. (Hall 551).

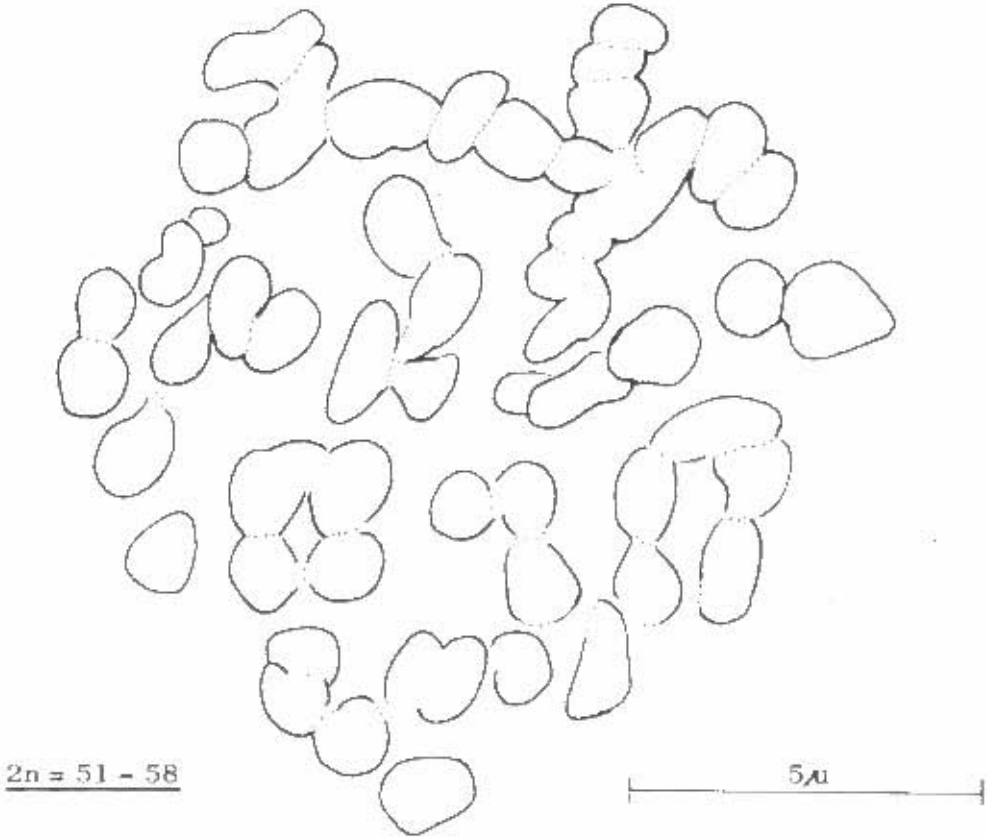


Fig. C5 : *E. chlorantha* Schltr. Chromosomes from a root tip of a specimen found near Barberton, E. Transvaal (Hall 573)

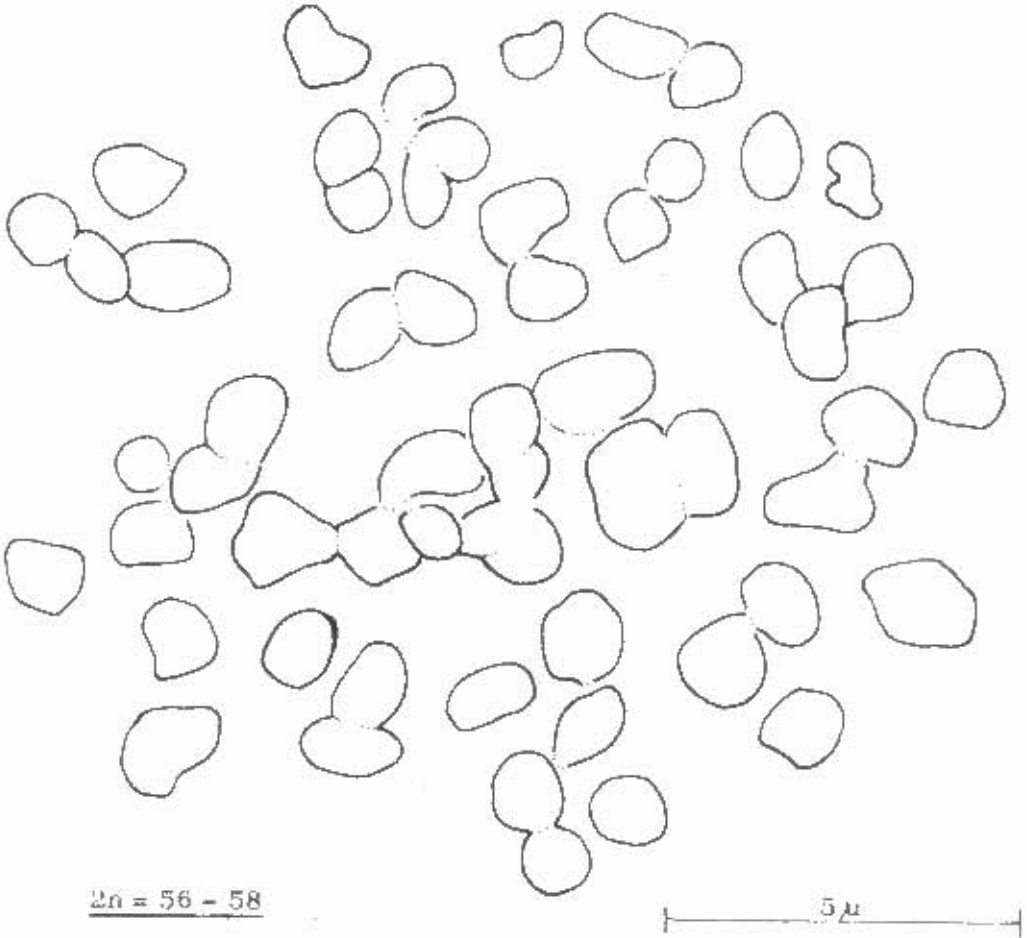


Fig. C6 : *E. chlorantha* Schltr. See data above.

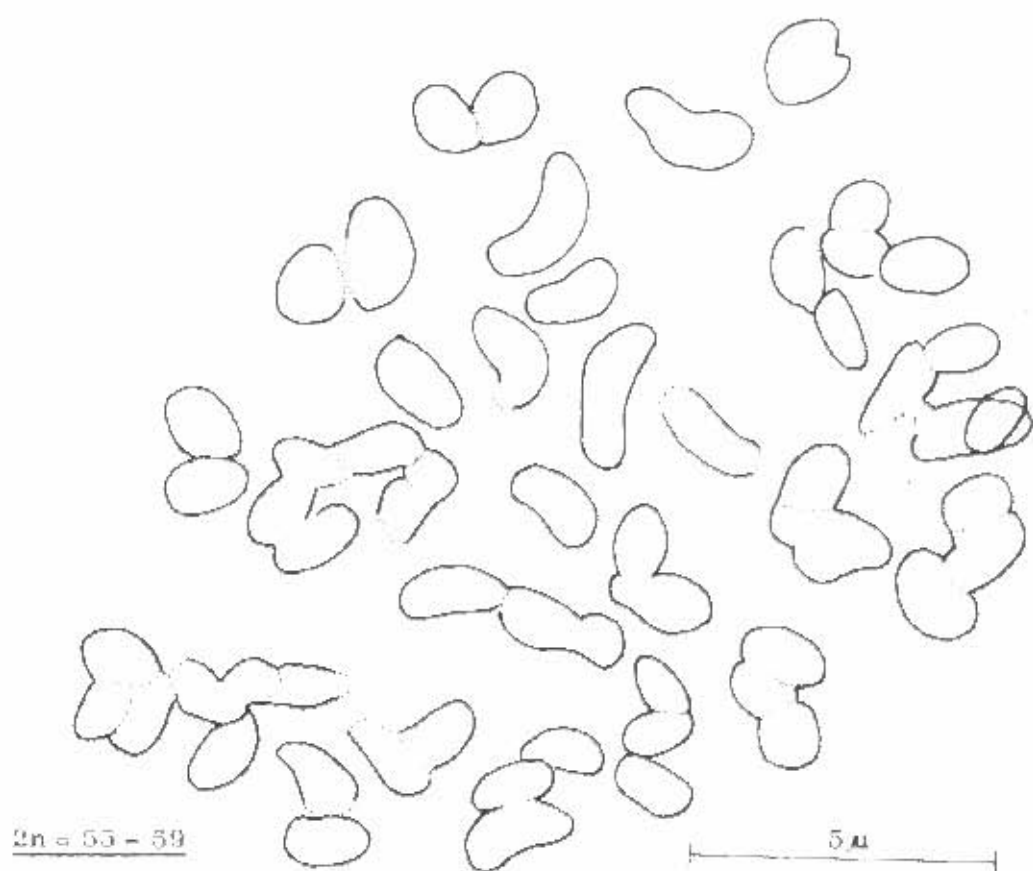


Fig. C8: *E. dregeana* Lindl. Chromosomes from a root tip of a specimen collected near Umzinkulu, N. E. Cape (Hall 653).

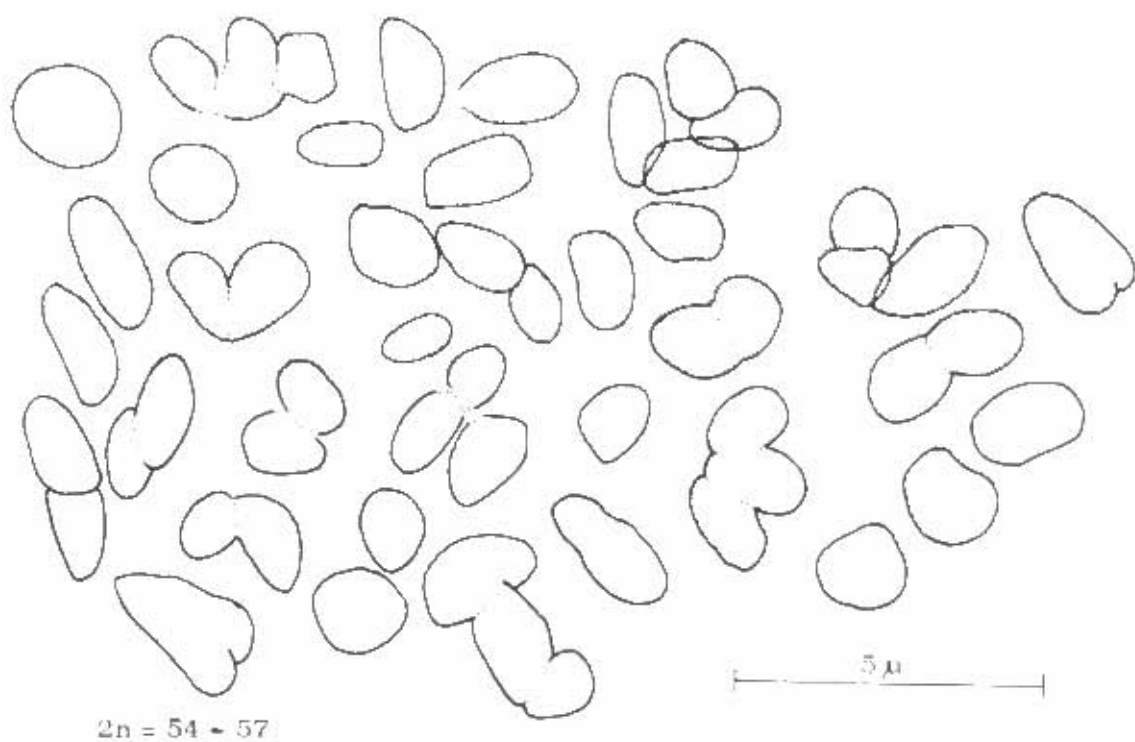


Fig. C9: *E. dregeana* Lindl. Chromosomes from a rhizome bud of a different specimen from that used in Fig. C7, but found at the same locality (Hall 653).

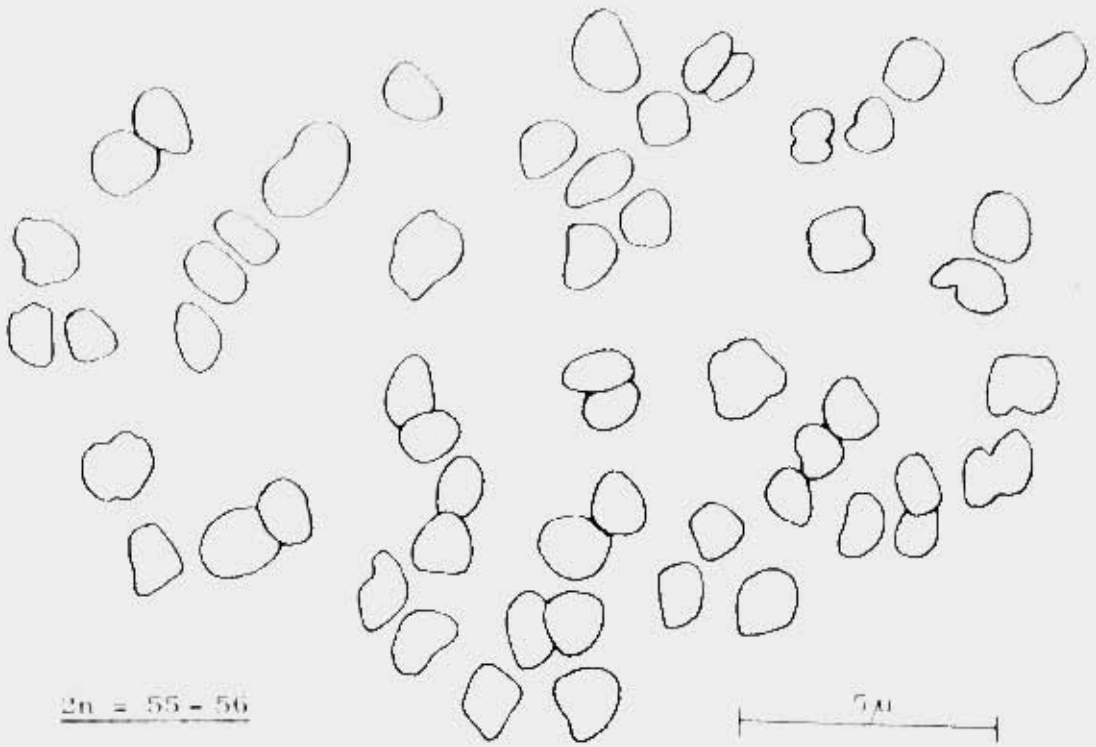


Fig. C10: *E. parvilabris* Lindl. Chromosomes from a root tip of a specimen collected near Nelshoogte Pass, Eastern Transvaal (No11615).

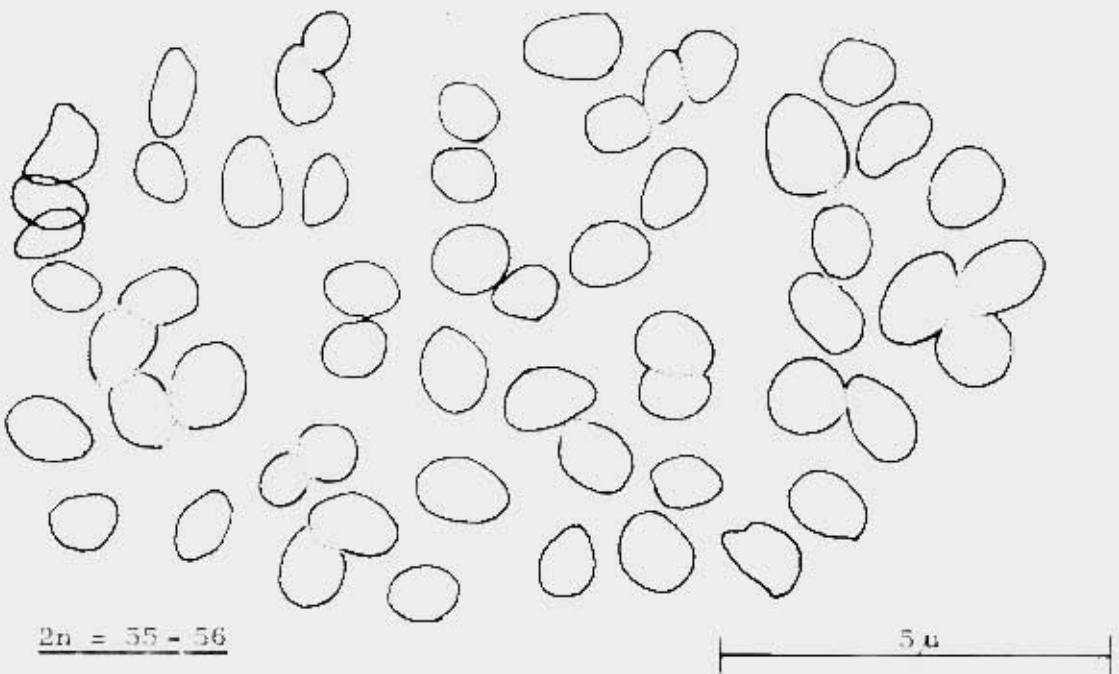


Fig. C11: *E. parvilabris* Lindl. Chromosomes from a root tip of the same specimen used in Fig. C10.

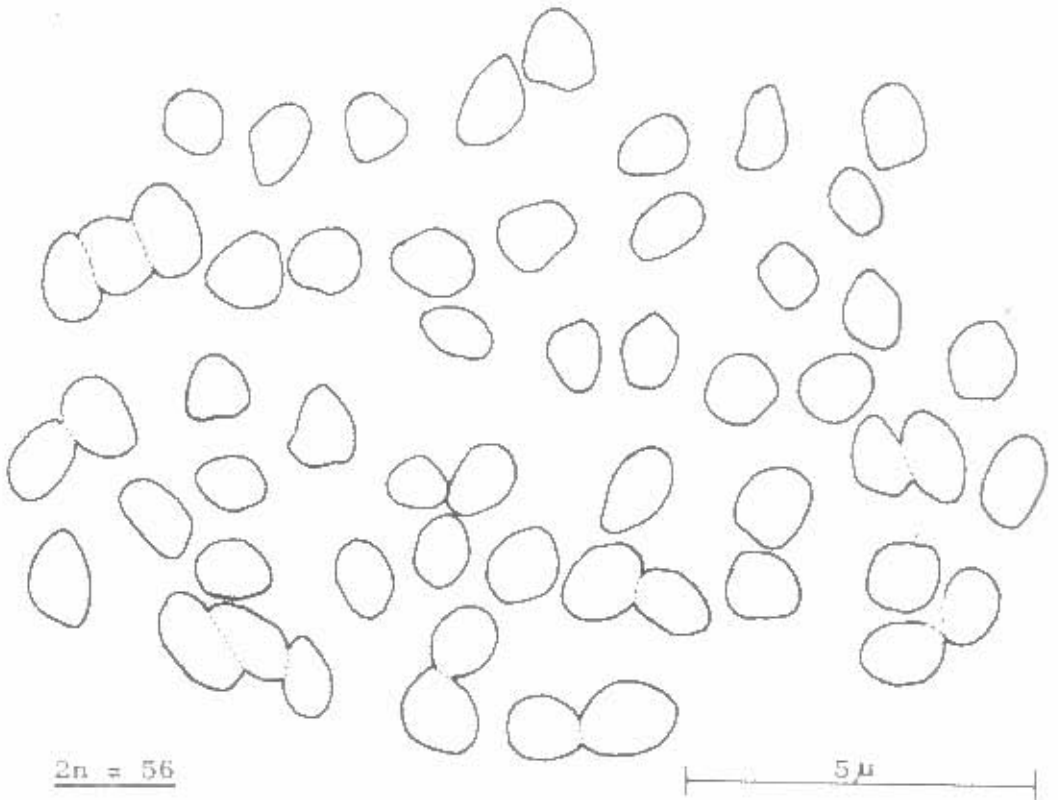


Fig. C 12: E. capensis Bolus Chromosomes from a root tip of a specimen collected on the Hogsback, Kingwilliamstown District, E. Cape (Hall 610).

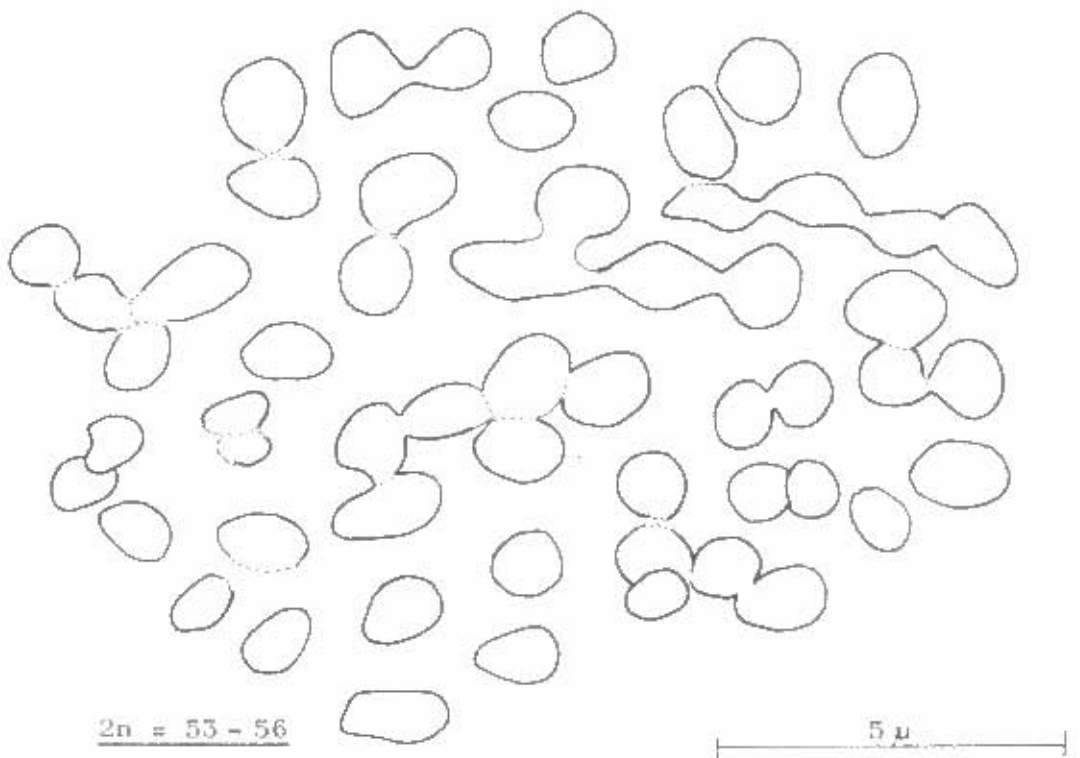


Fig. C 15: E. foliosa Bolus Chromosomes from a rhizome bud of a specimen collected near Wonderfontein, Belfast District, E. Transvaal (Hall 622).

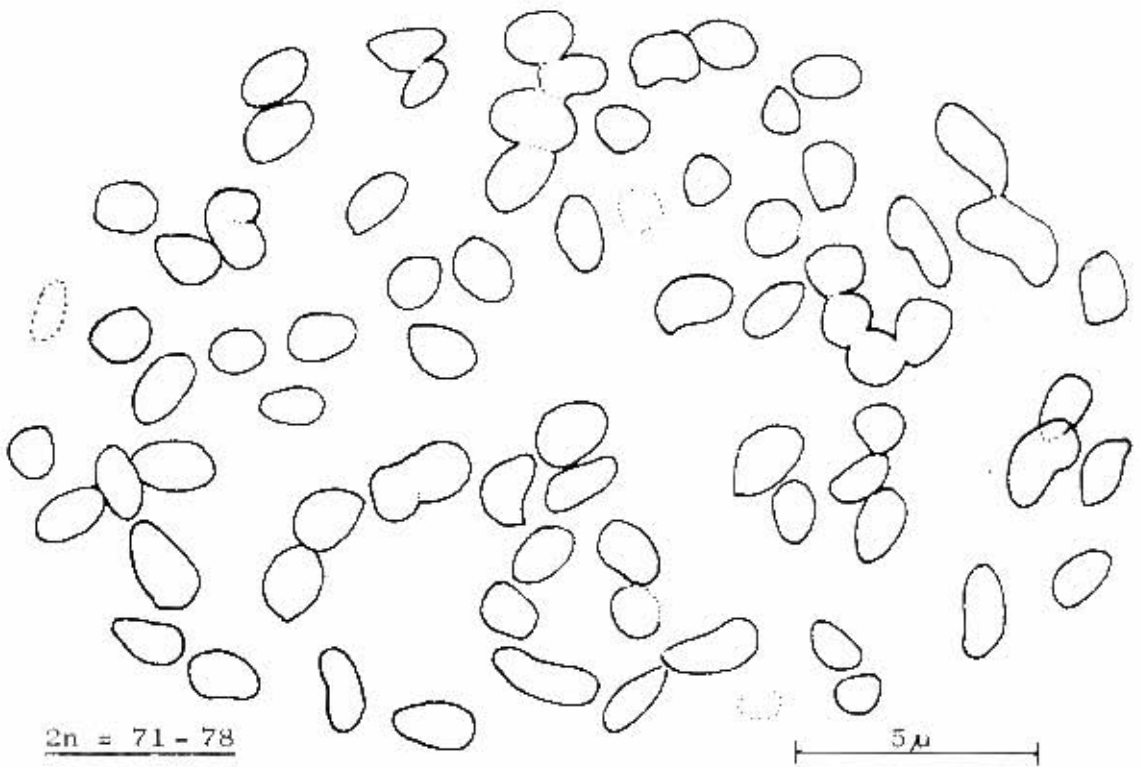


Fig. C 14 : E. speciosa Bolus Chromosomes from a specimen collected at Port St<sup>l</sup> Johns by Mrs. F. M. Isaac (F.M. Isaac sn.)

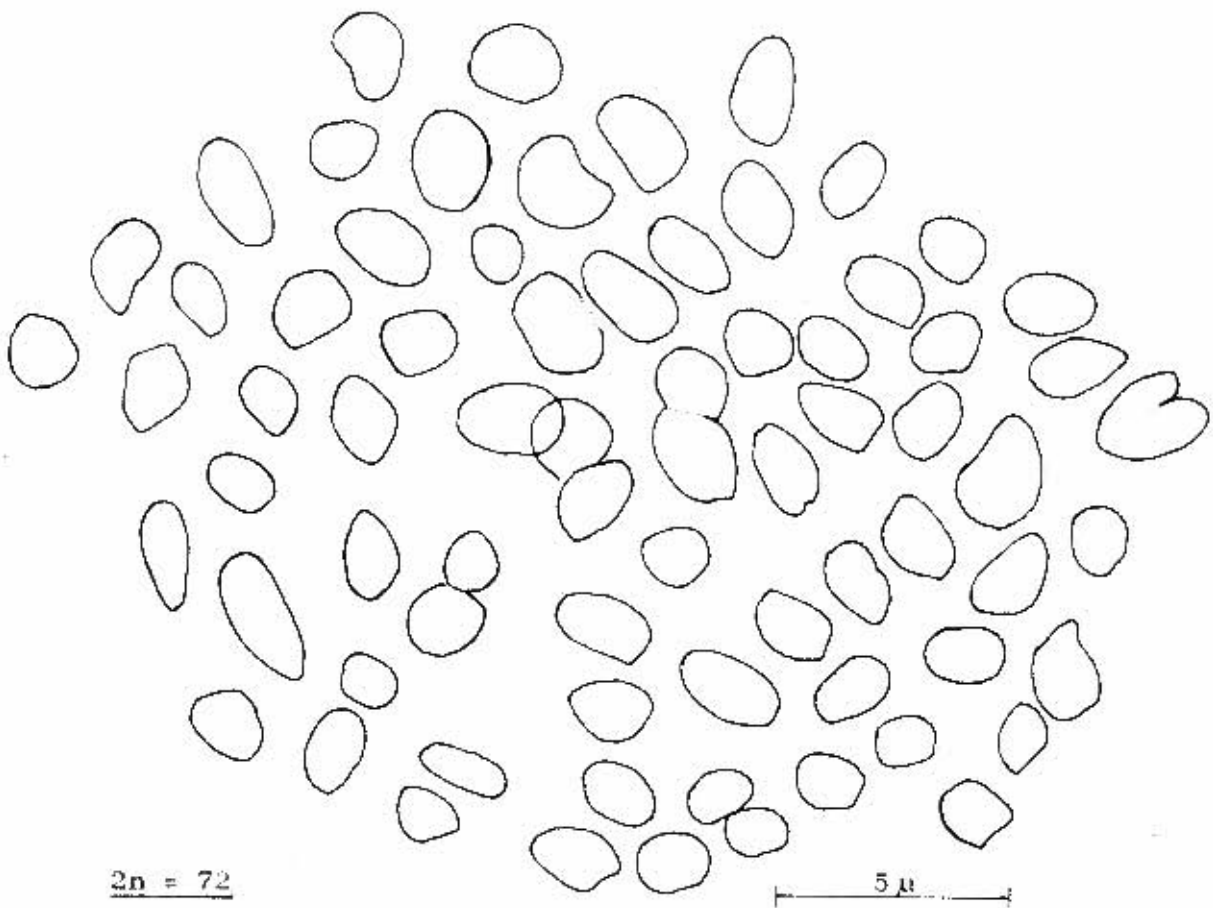


Fig. C 16 : E. buchanani Bolus Chromosomes from a specimen collected near Nelspruit, E. Transvaal (Hall 38).

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