

A TAXONOMIC REVIEW OF THE NATAL MEMBERS OF THE GENUS
OXALIS L.

BY
RENEE ANSURIA MOODLEY

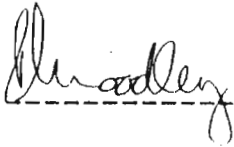
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DECLARATION

I, RENEE ANSURIA MOODLEY, declare that, to the best of my knowledge, this topic is not registered at another university.

A handwritten signature in cursive script, appearing to read "R. Moodley", written over a horizontal dashed line.

MS. R.A. MOODLEY

(Candidate)

A handwritten signature in cursive script, appearing to read "E.F. Hennessy", written over a horizontal dashed line.

PROF E.F. HENNESSY

(Supervisor)

TO KAVANDRAN

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ABSTRACT

A review of the Natal species of Oxalis is presented. Seven species are recognised. This includes the five recorded by Ross (1972). Two other species were found to occur in Natal; O. corymbosa D.C. a common weed of urban parks and O. pes-caprae L. whose distribution appears to be confined to the Pietermaritzburg region.

Gross morphology of all taxa as well as anatomical and micromorphological data of the species are presented. The breeding systems of O. corniculata and O. semiloba were investigated in some detail.

Areas requiring further study are mentioned.

Finally, a key, based upon gross morphological characters, was constructed and complete descriptions and illustrations of the species are given.

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1. GENERAL INTRODUCTION

According to Cronquist (1981), the order Geraniales consists of five families and 2 600 species. The three largest families are:

- i) Oxalidaceae (900 spp.),
- ii) Balsiminaceae (900 spp.) and
- iii) Geraniaceae (700 spp.)

Cronquist (l.c.) states that the close relationship between the families Geraniaceae and Oxalidaceae are evident. Linley and Baker (1972) also support this view. Cronquist (l.c.) and Metcalf and Chalk (1950) note that although the tribe Geranieae and the genus Oxalis are distinctive, they are connected by a series of smaller genera. In fact the family Oxalidaceae was formerly treated as a division of the Geraniaceae by Bentham and Hooker (1862). The main features distinguishing the Oxalidaceae from the Geraniaceae are its five-styled flowers, its arillate seeds and the lack of stipules (Lucas, 1971; Heywood, 1978).

1.1 Oxalidaceae

This family consists of seven or eight genera and about 900 species. Distribution is widespread in the tropical and sub-tropical latitudes, but members are often found at high altitudes (Cronquist, l.c.).

Members of this family are generally herbaceous, usually with hard, few-scaled bulbs. Leaves usually occur in a basal rosette. The leaflets, usually three, are borne on long petioles. Leaves often exhibit sleep movements, with the leaflets folded at night. Stomata are of the paracytic (rubiaceous) type. Members of this family commonly accumulate soluble and crystalline oxalates in their vegetative parts (Bailey, 1900; Compton, 1976; Cronquist, l.c.).

The inflorescence consists of solitary flowers or few- to many-flowered umbels. The flowers are perfect and regular and usually close at night or in cloudy weather. Flowers are often heterostylous and sometimes cleistogamous and reduced. The calyx is five parted and imbricate in aestivation : the five petals are hypogynous, clawed and either free or connate; contorted in aestivation. The ten stamens are monadelphous; the five opposite the petals are shorter. Often the outer (longer) filaments are thickened and nectarifous below or a nectary gland may be borne at the base of the outer (longer) filaments; the filaments are shortly connate at the base. Anthers are two-celled and introrse. Pollen is binucleate and commonly tricolpate or tricolporate. The five styles are filiform with papillate stigmas. Ovaries are deeply 5-lobed with five chambers; each with few to many ovules attached to a central axis. Ovules are epitropous and more or less pendulous with the micropyle pointing

upwards and outwards or anatropous or sometimes hemitropous, bitegmic, tenuinucellar with nuclear endosperm development. Fruit are capsular or fleshy with one to many, commonly seven, pendulous seeds with copious fleshy albumin. Commonly seeds possess a basal aril that aids in seed expulsion. Embryos are large, straight or curved, spatulate with two cotyledons embedded in the usually copious, oily, fleshy endosperm (Sonder, 1860; Bailey, l.c.; Exell, 1963; Compton, 1976; Cronquist, l.c.).

In ancient times, species of Oxalis were called Oxys or Oxus, notably by Pliny the elder. The word oxalis is derived from the Greek words oxys and hals - meaning acid and salts respectively. Thus the plant owes its name to the acidity of the foliage, which also gives it its common (English) name - sorrel (Bailey, l.c.; Salter, 1944).

1.2 Phytochemistry and Physiology

Oxalic acid appears to be a non-functional and undesirable end-product of plant metabolism. It may be slowly oxidized to carbon dioxide or decarboxylated to formate and carbon dioxide. In Oxalis, however, oxalic acid is not completely inert (Millerd; et al, 1963b).

Hall (1978) reports that Oxalis is among the minority of higher plants that are ammonium plants. An ammonium

plant is one that retains the ammonium ion unchanged and therefore has a very acidic (oxalate type) of calcium sap.

The cell sap in the leaves and shoots of Oxalis is rich in oxalic acid. The sap pH is almost 2.0. This implies that the acid is uncombined and is confined within the cell vacuoles. Oxalic acid in Oxalis constitutes about 16% of the dry weight (Millerd; et al, 1963a; Bonner and Varner, 1965).

The immediate precursor in the non-green shoots of O. pes-caprae is glyoxalate which is derived by the action of isocitrase on isocitric acid. It is still not clear, however, whether isocitrase is present in all oxalic acid producing cells (Bonner and Varner, l.c.).

Emergent white shoots of O. pes-caprae utilize carbohydrates from the starch-filled bulb for formation of oxalic acid that rapidly accumulates in the shoots. With the exception of the bulb, it seems that oxalic acid is the compulsory end-product of the metabolism of growing tissues of this plant (Millerd, et al, 1963a).

In Oxalis species; oxalate is derived as shown in Figure 1:

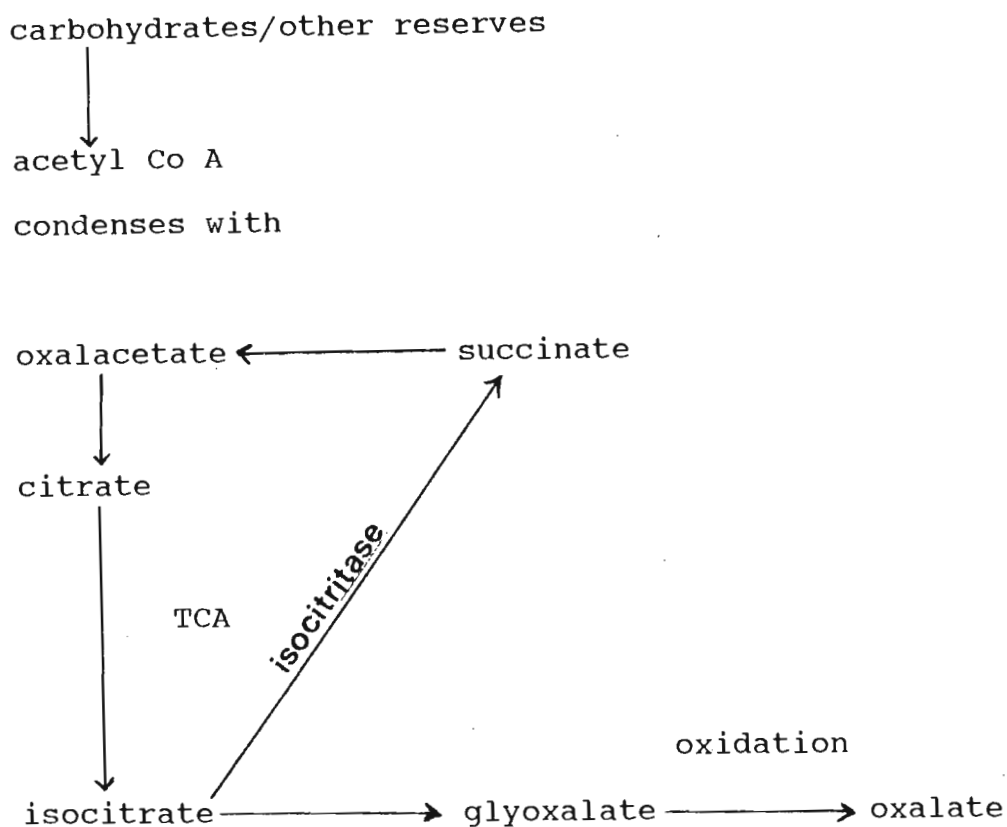


Figure 1. The metabolic derivation of oxalate.

Many species of Oxalis are found to be shade tolerant. Shade tolerant (or shade) leaves morphologically, physiologically and chemically maximise light-harvesting capacity and minimise the synthetic and maintenance costs of soluble proteins and components of the electron transport chain which would be superfluous at low light intensities. For example, the ratio of chlorophyll :

soluble proteins is seven times more in shade than sun leaves. Shade leaves are thinner and of lower specific leaf weight than sun leaves and shade plants invest a higher proportion of their dry weight in their leaves.

A reduced mesophyll thickness in shade leaves implies a smaller volume and surface area per unit leaf area. The chloroplasts of shade leaves are larger with larger grana and less stroma lamellae and more chlorophyll per chloroplast (Ludlow, 1981).

Maximum carbon dioxide assimilation is lower in shade plants than sun plants. This maximum is reached at a lower light intensity in the shade plant. Figure 2 shows that the maximum, for shade plants, is at 1/10 full daylight (von Denffe, et al, 1976).

Lower light saturation point and light-saturated rate of photosynthesis may arise from lower mesophyll conductances; although stomatal densities and stomatal conductances are usually also lower in shade leaves. The lower light compensation point of shade leaves results from the greatly reduced dark respiration rate (von Denffe et al, 1976; Ludlow, 1981).

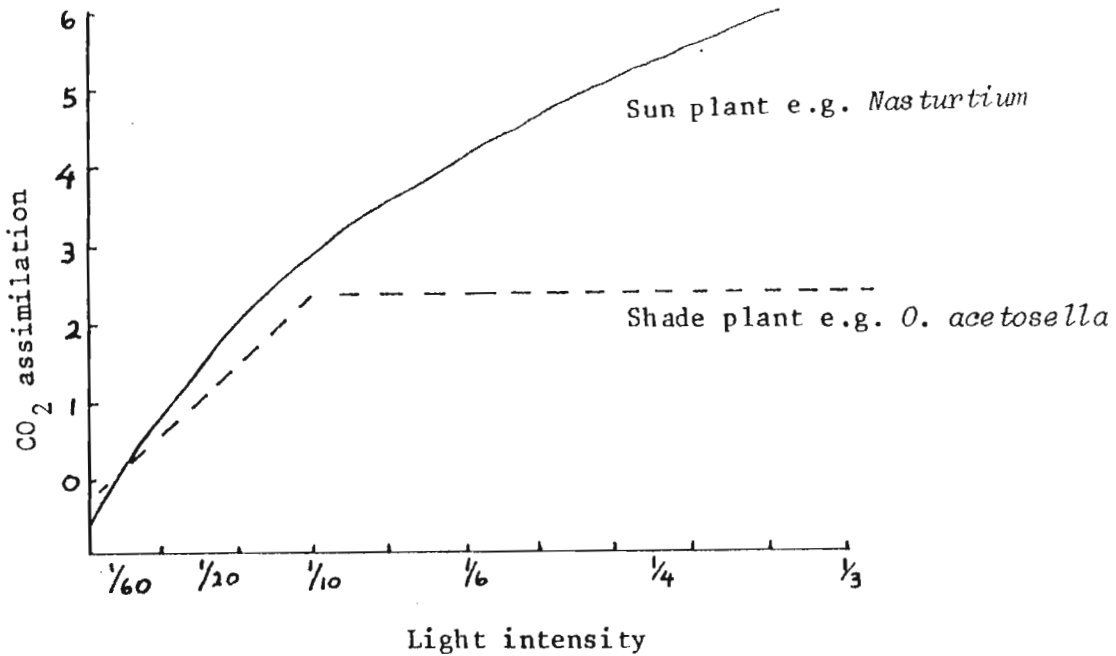


Figure 2. Maximum carbon dioxide assimilation in sun and shade plants at different light intensities. (Based on von Denfee *et. al.*, 1976).

Street and Opik (1970) report that nastic movements also occur in response to external stimuli, nastic growth movements involving unequal growth on opposite sides of an organ, nastic variation movements resulting from turgor changes. Where stimulation is due to changes in environmental conditions, the direction of response is detected by the ORGANISM and NOT the stimulus. Geo-, photo-, hapto- and chemonastic movements are known.

In *Oxalis* the diurnal rhythm of leaves and flowers are said to be nyctinastic i.e. affected by light (Lowson, 1959). The diurnal movements of leaves of some species which take up "sleep" positions at night may be due to photonasty in the petiole or lamina.

Many diurnal leaf movements are, however, mediated by turgor changes in the leaf or leaflet bases or petioles rather than differential growth. Von Denffe (1970) states that the pedicels and peduncles of Oxalis species are thermonastic and that in O. acetosella the leaves have pulvini which implies that "sleep" movements are the result of changes in thermonastic turgor.

The flowers of tulip (Tulipa) and crocus (Crocus) show thermonasty, responding to an increase in temperature by increasing growth on the upper side of the perianth segments so that the flowers open; cooling accentuates growth on the lower surfaces, thus closing the flowers (Figure 3). It is possible that a similar reaction occurs in the flowers of Oxalis spp.

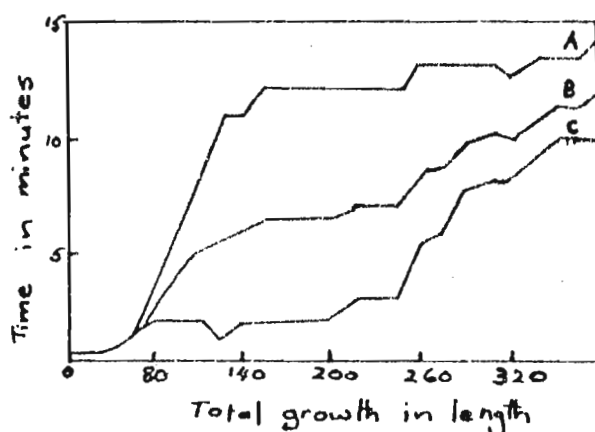


Figure 3. Curves to illustrate the course of growth on the two sides of a perianth segment of Crocus as a result of thermonastic stimulation. A : inner side, B : middle zone, C : outer side (From Street and Opik, 1970).

Under natural conditions this reaction causes the flowers to open by day and close by night.

The physiological basis of nastic movements is still puzzling, but it is known that nastic movements, like tropisms, are auxin controlled. It is sometimes difficult to distinguish between tropisms and nastic movement, hence the view is advanced that the only fundamental difference between organs showing tropic or nastic reaction to the same type of stimulus is that the organ showing the nastic reaction determines that the curvature must occur in a FIXED direction, irrespective of the direction of the stimulus (Street and Opik, 1970).

1.3 The Genus Oxalis

The genus Oxalis with about 800 species is the largest in the Family Oxalidaceae. According to Dyer (1975) this genus is distributed in Africa and Tropical and South America, but mostly in South Africa.

There are more than 200 South African species in Namaqualand and South Western Cape but a few have reached Natal and the Eastern Transvaal. In the Cape Province they are the harbingers of winter, appearing almost everywhere. Plants of this genus flower in all seasons. The deep-seated bulbs are so sensitive to changes of season that, in the Cape Province, even before the first

autumn rains have fallen, the early flowering species break through and start flowering (Nat. Botanical Garden of S.A., 1980).

The only other genus of this family to occur in neighbouring countries but not South Africa is Biophytum.

Oxalis spp. are suitable subjects for pot culture (window boxes and hanging baskets) or alpine gardens. The species cultivated are mainly from the Andes of Chile and Peru, Brazil and Mexico. Some of those cultivated are: O. deppei which has four leaflets and is thus known as the "goodluck plant" or "lucky clover", O. martiana (Goldnet sour clover), O. braziliensis, O. acetosella (Irish Shamrock), O. purpurea (Grand Duchess Oxalis), O. pescaprae (Burmuda Buttercup which is actually indigenous to South Africa), O. bowei (giant pink clover) and O. herrerae (succulent Oxalis) (Graf, 1978). Bailey (1900) outlines the following method of cultivation:

"Three bulbs are planted in a triangle per 4" flower pot just below the soil surface. The soil ingredient should consist of proportional amounts of loam leaf soil and sand to give a good porous medium. As root size increases, bulbs are re-potted into 5" or 6" pots. When well rooted periodical watering with organic fertilizer would help development of good, substantial flowers".

Salter (1944) states that these plants need a summer resting period with water in early autumn or late summer and also throughout winter. In Natal, a summer rainfall region, only O. pes-caprae, indigenous to the Cape winter rainfall regions, appears to require a summer resting period.

1.4 Economic Uses

Besides being used as ornamentals; Oxalis spp. have other uses the world over. In America the Indians use Oxalis as greens or pot-herbs. In the Andes of Peru and Colombia; the Oca plant (O. tuberosa) is the third major tuber crop. In some parts of the Andes its as important as the potato and is propagated from tubers. Post-harvest tubers are allowed to mellow in the sun, for several days, in order to get rid of the calcium oxalate. Tubers are then consumed raw, dried, boiled, candied or powdered to give body to soups (Schery, 1954; Milne and Milne, 1967).

In North East America the wild Oxalis spp. are used as salad, relish, pickles and condiments (Scherry, l.c.) Altshul (1973) reports that one H.S. Gentry noted that the leaves of O. corniculata are eaten by the natives of Mexico.

Oxalis is also used in other domestic and medicinal capacities. Chopra et al (1958) report that, in India,

O. corniculata is used as an anti-dysenteric drug and as an antiseptic.

Shamrock (O. acetosella) is of great significance to the Irish. On St Patrick's Day (17 March) the shamrock is worn by Irishmen all over the world. Figure 4 explains the significance of the shamrock.

Closer to home; Wright (1963) states that the leaves of Oxalis spp. can be used to clean copper and brass ornaments as well as remove ink stains from clothes. Sotho's use 'bodila-ba-thaba' (O. corniculata) as a lotion for washing snake-bites. O. semiloba is used as an antimycotic by the Zulus; crushed leaves are rubbed into the mouths of infants afflicted with thrush.

Many Oxalis spp. are considered as weeds and thus need to be controlled. Two herbicides used to control Oxalis are:

- i) Silvex (2-(2,4,5,-trichlorophenoxy) propionic acid)
- ii) Zytron (0-(2,4-dichlorophenyl)-0-methylisopropyl-phosphoamidothioate.

(King, 1966)

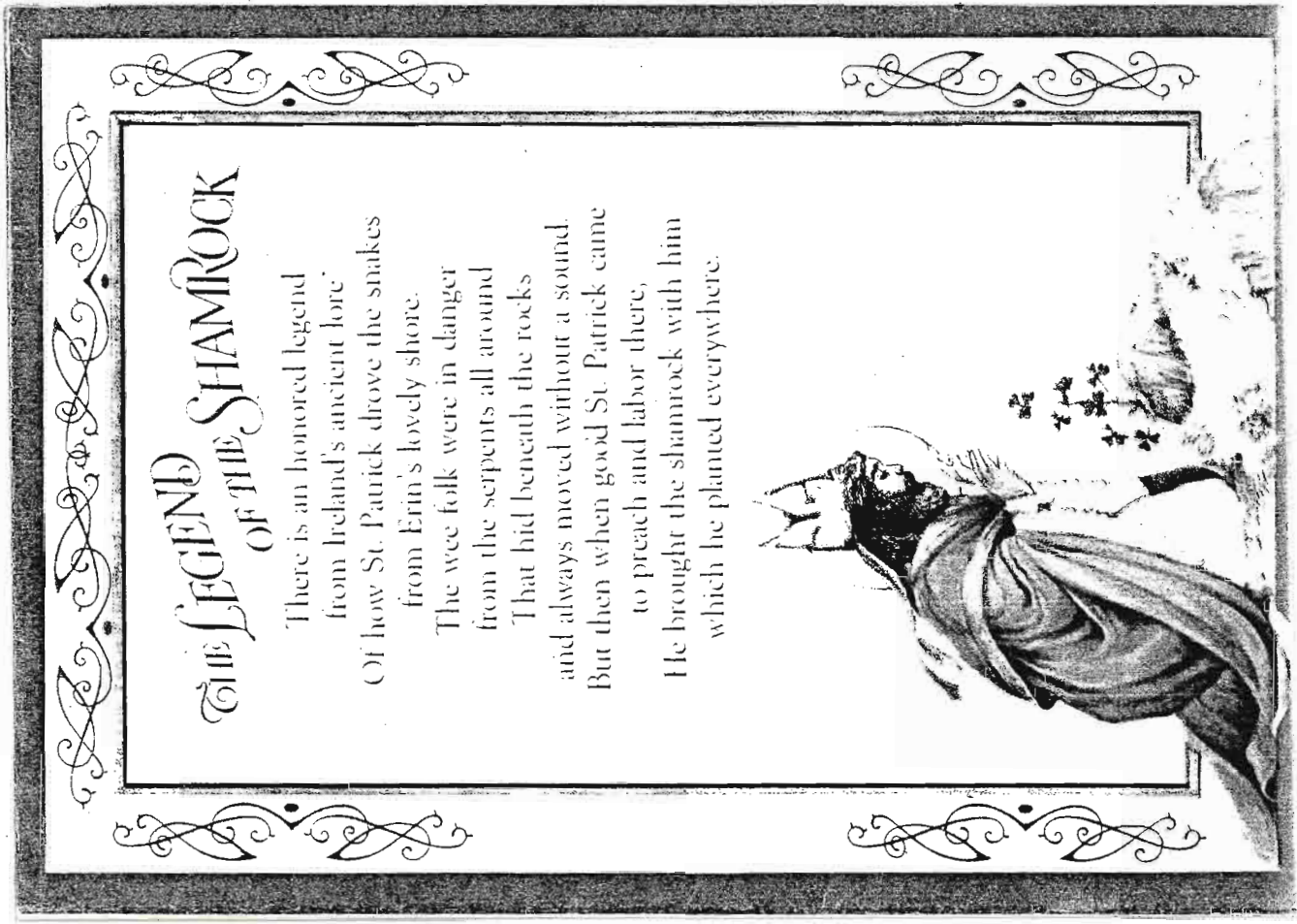


Fig. 4. The significance of the shamrock to the Irish.

Like many other dicots, Oxalis spp. are susceptible to certain fungal and viral diseases. Pirone et al (1960) lists the fungal and viral diseases of ornamental Oxalis spp:

- i) Leaf spots (Cercospora oxalidiphila, Phyllosticta gluttulatae, P. oxalidis, Ramularia oxalidis, Septoria acetosella). These are not important hence there is no need for control measures.
- ii) Rust (Puccinia sorghi) : Oxalis is the alternate host to maize rust which is extremely destructive to maize. On Oxalis the rust first forms neat yellowish dots near the leaf margins, later pale yellow pustules break out on the leaf. Not much damage is caused on Oxalis.
- iii) Red-rust (Puccinia oxalidis) : a serious disease of Oxalis spp. causing 100% loss. All foliage is killed within two weeks. The alternate stage of this rust is on Mahonia (Berberidaceae). By 1960 no control had been established.
- iv) Root rot (Thielaviopsis basicola).
fungi
- v) Seed smut (Ustilago oxalidis).
- vi) Curly top (Ruga verrucosans).
virus

1.5 Historical Background

The genus Oxalis was thus named by Linnaeus. According to Salter (1944); Jacquin in 1794 stated that a species of Rumex was known as Oxalis by the ancient herbalists and that the genus Oxalis L. was initially called oxys by Pliny the Elder.

Linnaeus (1753) placed the genus Oxalis into his class X: Decandria; sub-class : Pentagynia. Linnaeus was responsible for the descriptions of 13 species of Oxalis. Of these 13 only seven species occur in South Africa. These are:

- | | |
|------------------------|--------------------------|
| 1) <u>O. purpurea</u> | 2) <u>O. flava</u> |
| 3) <u>O. incarnata</u> | 4) <u>O. pes-caprae</u> |
| 5) <u>O. hirta</u> | 6) <u>O. corniculata</u> |
| 7) <u>O. stricta</u> | |

Of these seven only O. corniculata and, more recently, O. pes-caprae have been found in Natal. Neither is indigenous in the province.

The extreme plasticity of some of the species as well as the failure to recognise heterostyly in the genus led to much confusion in the naming of the different species. Classification was also made difficult by the indistinctness, caused by blurring and overlap, of some of the species.

Perhaps the first real attempt to study this genus was made by Jacquin (l.c.). His study was based upon plants grown under uniform, artificial conditions. Some South African species were included in his account. Unfortunately Jacquin (l.c.) failed to recognise the heterostylous nature of this genus. Thus today only 21 of the species placed by him in this genus, according to Salter (l.c.), can be upheld.

In 1824 De Candolle in his Prodromus I described one new species, namely O. corymbosa. Zuccharini, in 1824, published a description of the same taxon under the name O. martiana. However in his article, Zuccharini made mention of De Candolle's work. Thus the name of O. corymbosa takes priority.

In 1835 Ecklon and Zeyher published their Enumeratio Plantarum I. Included in this publication was the first description of O. smithiana; a species named in honour of Dr Smith. Ecklon and Zeyher (l.c.) recognised two varieties of this species based upon flower colour. O. smithiana var. α possessed white flowers while O. smithiana var. β possessed mauve flowers. According to Salter (l.c.), however, Enum. Plantarum I was fraught with inadequate descriptions, much synonymy and misidentifications.

O. obliquifolia was first named and described by Steudel in Pl. Schimp. Abyss., sect III in 1843. His description was considered invalid since it was published prior to the Linnaean Classificatory System. It was therefore redescribed by A. Richard in Tent. Fl. Abys. in 1847.

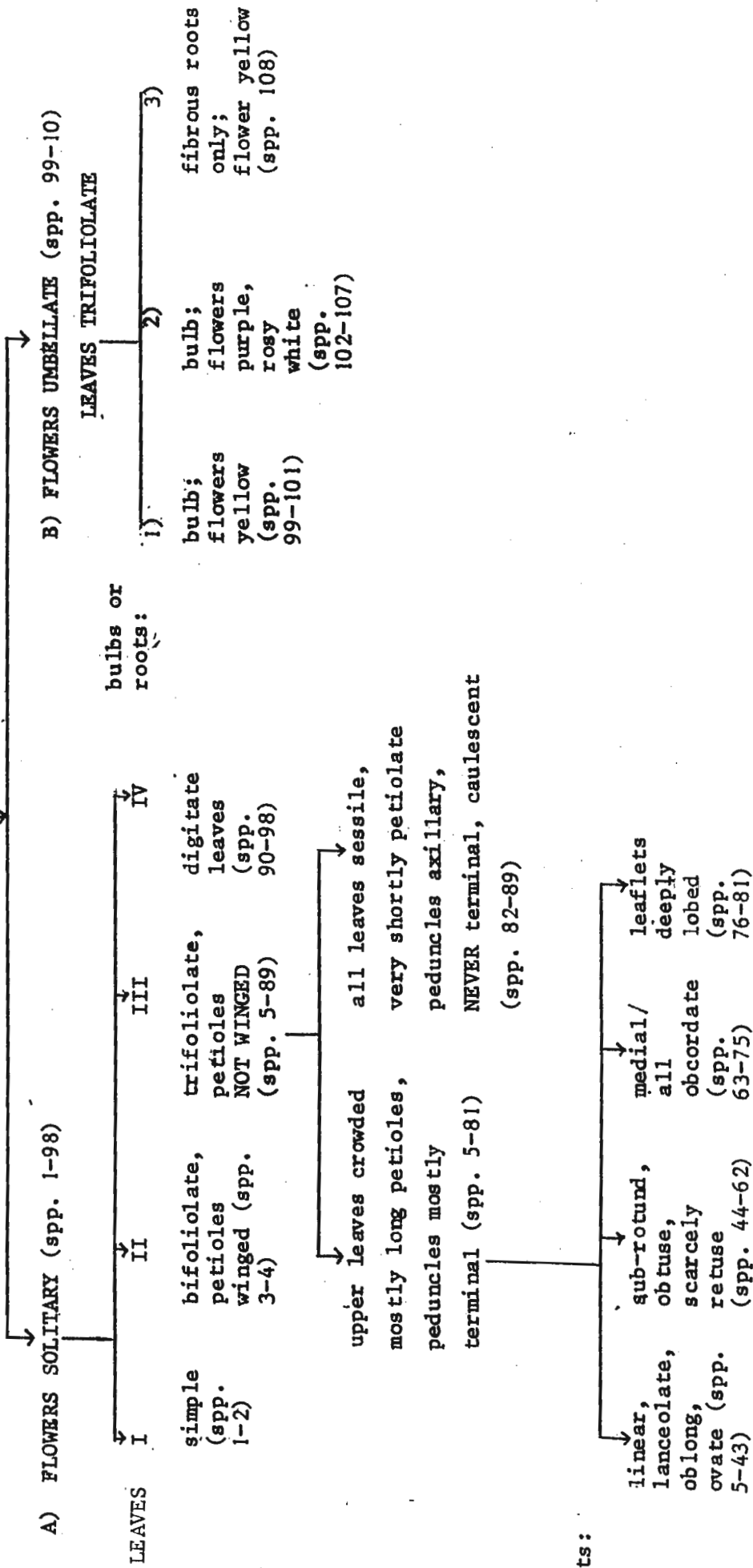
Sonder, in Flora Capensis I (1860), upheld only nine of Ecklon and Zeyher's species. He recognised a total of 108 species; 47 of which he regarded as new. Salter (l.c.) however, reduced 28 of Sonder's new species to synonymy. One draw back to Sonder's descriptions of new species is that he did not designate any type specimens. One of his new species, of relevance to this dissertation, was O. semiloba. Sonder (l.c.) based all his work upon dried specimens.

Sonder (l.c.) was a "splitter". His classification followed along the lines of Figure 5.

Thus among the 93 trifoliolate species of Oxalis Sonder (l.c.) described 84 species that bore solitary flowers and nine species that bore flowers in umbels.

Only four of the seven species occurring in Natal are mentioned by Sonder (l.c.). Two of these four species are listed under synonyms.

Oxalis



leaflets:

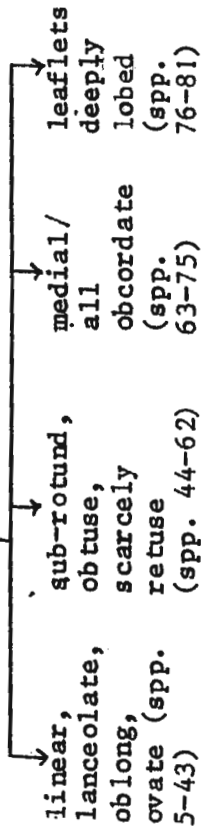


Fig. 5. Summary of Sonder's Classification

Sonder (l.c.) recognised two varieties of O. smithii based upon leaflet shape and flower colour. These two varieties were named:

- a) O. smithii var. α latiloba
- b) O. smithii var. β angustiloba

The flower colour of his var. α latiloba (mauve to white) overlapped into his var. β angustiloba. Only white flowers, however, occurred in var. α angustiloba.

Sonder (l.c.) grouped Ecklon and Zeyher's O. smithiana, O. tristis and O. gracicaulis as well as E. Meyer's O. bisulca under O. smithii var. α latiloba and Ecklon and Zeyher's O. candida, O. numerosa and E. Meyer's O. numerosa under O. smithii var. β angustiloba.

Thunberg in his "Dissertation on Oxalis" (1781) described three new species (Salter, l.c.). He had overlooked Linnaeus' name and description of O. pes-caprae and re-named it O. cernua. This later led to much confusion. Apart from the descriptions of the three new species.

Thunberg's work according to Salter (l.c.), was unremarkable. O. pes-caprae (sp. 101) was listed as a synonym for O. cernua by Sonder (l.c.).

O. semiloba (sp. 105), as previously stated, was first described by Sonder (l.c.). O. corniculata (sp. 108) is

the only species of Oxalis in South Africa to possess a fibrous root system.

No mention was made by Sonder (l.c.) of O. latifolia and O. corymbosa. These two introduced species could have therefore been introduced into South Africa at a later stage.

Sonder's work on Oxalis was the most comprehensive work on the South African members of this genus for the nineteenth century and there was a lull in the determination of new species after his publication.

At the beginning of this century, however, herbarium workers, in order to file poorly dried specimens, haphazardly named, as new species, those specimens that did not fit into Sonder's (l.c.) key. The climax of this trend, according to Salter (l.c.), was reached in Engler's Bot. Jharb. (1927) and Pflanzenreich-Oxal. (1930) in which between 50-60 "new" South African species were described. According to Salter (l.c.), Engler's work was inadequate since it was not based upon properly collected specimens, it was arranged without regard for natural affinities and no type specimens were consulted. As a result, at least two-thirds of his work had to pass into synonymy (Salter, l.c.).

Knuth (1930) divided the genus Oxalis into 37 sections, based mainly upon stem, leaf and flower characters. In 1942 Salter had divided the South African species into eleven sections and 14 sub-sections using characters of stems, leaves, flowers and bulbs (Bayer, et al, 1978). In 1944 Salter, in his analysis of the species, divided the genus into 24 artificial groups "solely for the purpose of printing". In 1950 Adamson and Salter stressed, once again, the importance of bulb morphology in species identification.

Salter's comprehensive work pointed out some of the problems in this genus. He stated that the genus does not lend itself to exact systematic classification. Salter (l.c.) also acknowledged that his extensive collection is far from complete (Bayer, et al, l.c.).

1.6 Motivation

- a) Salter (l.c.) based his work mainly upon the specimens that occur in the Cape Province since they occurred in abundance there. No collections were made, by Salter, of specimens east of Port Elizabeth and only dried specimens were studied from these localities. Salter (l.c.) stated that "although the species occurring in the Eastern Province, Natal, Orange Free State and Transvaal are comparatively few, they form complex groups" which he, without

field study, treated cursorily. Thus it was decided to undertake a re-evaluation of the status of the known taxa in Natal and to investigate the infrageneric limits.

- b) The projected new research gives consideration to anatomy, morphology, micromorphology and pollinator syndromes of the Natal taxa, in addition to the re-definition of the infrageneric limits of these taxa.
- c) Proper delimitation of species, utilizing modern taxonomic and statistical methods, posed a challenge. Trimorphic heterostyly has been observed in this genus but has not been studied in all taxa, thus this provided another area for investigation.
- d) The proposed study lays the foundation for a more comprehensive taxonomic revision of this genus in South Africa to be undertaken, later, as a contribution towards the revised Flora of Southern Africa. Without a proper understanding of floral and vegetative morphology, anatomy and pollination biology, such as is provided by this study, no valid taxonomic conclusions can be drawn.

1.7 Aims and Objectives

- a) How many infrageneric taxa are present in Natal?
- b) Are current circumscriptions of these taxa valid?
- c) What is the pollination biology of these taxa?

1.8 Methodology

- a) Survey of modern and archaic literature.
- b) Light microscopy to investigate anatomy, morphology, heterostyly and pollen viability.
- c) Scanning Electron Microscopy to investigate morphology of the reproductive organs as well as pollen and seed micromorphology.
- d) Photography of specimens in the field and in the herbarium.
- e) Mensuration of floral and vegetative parts.
- f) Statistical comparison of the taxa under review.
- g) Documentation, by means of illustrations, of specimens.

- h) Mapping of distribution of taxa.
- i) Observations on taxa in the field in order to study pollinator syndromes.
- j) Investigations on preserved materials, including some herbarium Type specimens.
- k) Construction of keys to the taxa.

2. MATERIALS AND METHODS

2.1 Morphology

Herbarium sheets from six herbaria; namely BOL, NBG, NH, NU, PRE and UD-W, were examined. Approximately 230 specimens were examined. Of these 165 specimens, collected in Natal, were examined in greater detail. Specimens received from BOL consisted mainly of specimens collected in the Cape Province and Transvaal. These specimens were examined in detail in order to compare them with the Natal specimens.

Fresh specimens were collected from the wild and to this purpose field trips to the Albert Falls region, Estcourt, Greytown, Richmond and World's View (in Pietermaritzburg) were undertaken. Material was collected for scanning electron microscopy (SEM), anatomical studies and, to some extent, studies on the breeding systems of the species.

Information from the labels of the specimens collected in Natal; as well as the collectors' names and numbers, the herbarium where housed and the degree reference were recorded on index cards.

This system provided a flexible means in order to; compile ecological notes, construct distribution maps, plan field trips to coincide with maximum flowering and fruiting periods, draw up citations and provide a list of

Table 2. The mean measurements (mm) of the morphological characters of the Natal species of *Oxalis*.

Character	C.R.		bulb		rhizome	petiole		leaflet		bract	sepal		corolla		Stamen		Gynoec		Fruit	
	1	w	1	w		1	w	1	w		1	w	1	w	1	w	1	w	1	w
<i>O. corniculata</i>	0	0	0	0	(stolon) 5.9	40.0	0.4	10.7	14.0	2.7	3.9	1.1	6.8	4.2	1	4.5	1	4.8	14.4	2.
<i>O. smithiana</i>	17.5	4	14.0	8.9	55.3	75.5	0.8	17.4	19.8	3.0	6.8	1.9	17.8	5.8	1	7.0	1	7.6	10.0	3.
<i>O. obliquifolia</i>	-	-	12.7	8.5	32.4	47.5	0.6	8.7	11.2	4.2	5.7	2.0	16.8	6.4	1	8.5	1	8.7	7.0	3.
<i>O. corymbosa</i>	-	-	26.7	24.3	0	189.	-	25.6	28.5	2.3	4.8	1.6	13.9	5.5	1	5.5	1	0	0	0
<i>O. semiloba</i>	56.5	-	14.5	8.9	55.3	100.	1.4	18.4	21.7	4.1	5.8	1.6	15.8	5.9	1	7.5	1	9.1	5.9	3.
<i>O. pes-caprae</i>	-	-	25.0	10.0	37.0	119.	-	21.1	19.9	1.5	6.3	2.0	20.9	5.2	1	-	1	-	0	0
<i>O. latifolia</i>	24.7	9.3	10.0	11.8	0	114.	1.5	26.2	33.1	3.0	5.5	1.4	14.3	5.9	1	6.1	1	0	0	0

C.R. = contractile root
gynoec. = gynoeceum
ped = peduncle
pedi = pedicel
1 = long
m = mid
s = short
- = not measured
0 = not present

} applicable only for stamens and gynoecia

collectors cited in the appendix (Schrire, 1984).

Various morphological characters of the specimens collected in Natal were closely examined and measured using a Wild Heerbrug dissecting microscope and a hand lens. Measurements of individual specimens were recorded on data sheets similar to Table 1. The mean measurements for each species were recorded in Table 2. These measurements were used in species descriptions, in pictorial representations in the form of polygonal graphs of the interspecific differences as well as in statistical comparisons with species occurring outside Natal. These measurements were also used for the statistical comparison of the two varieties of *O. smithiana* that occur in Natal.

In order to maintain uniformity the following standards were set:

- a) Only mature fruit and leaves were measured,
- b) petiole lengths were taken as the distance from the petiole base to the centre of the trifoliolate leaf,
- c) corolla lengths were measured from the base of the calyx to the apex of the petal,
- d) fruit lengths were measured from the calyx base to the apices of the persistent styles,

- e) gynoecia lengths from mature flowers were measured from the calyx base to the apices of the stigmas and
- f) all width measurements were taken across the widest part of the organ.

Specimens preserved in F.A.A. (Table 3) as well as parts of dried herbarium specimens were examined using a Philips SEM 500 Scanning Electron Microscope (SEM). Untreated, dried herbarium specimens were fixed on to brass stubs with double sided tape and then finely coated with gold using a Polaron sputter coating unit.

Prior to mounting and gold coating, specimens preserved in F.A.A. were: first washed in distilled water, then dehydrated for ten minutes at each step in 70%, 100% and absolute ethanol. The material was then critical point dried and treated in the same manner as the dried herbarium specimens.

Photographs were taken at magnifications varying from 20x to 2 500x. The beam spot size was 1 250 Å.

SEM was used to study leaf, petal, reproductive organs and fruit surfaces.

Drawings of morphological characters were also made in order to emphasise certain morphological differences.

The distributions of the different taxa in Natal were plotted on maps using the one-degree square system proposed for South Africa and modified by Leistner and Morris (1976).

2.2 Anatomy

Temporary mounts were made of leaves, petioles and peduncles/scapes. Transverse sections of fresh specimens were mounted on a glass slide in a droplet of water and viewed with a Nikon compound light microscope. Sections were stained with phloroglucinol for three minutes and then with 25% HCL for 30 seconds; staining with 25% HCL enhanced the lignified areas (Kupicha, 1975). Other sections were stained with safranin to emphasise lignified tissue. Plan drawings were made of the anatomy of the various organs investigated.

2.3 Breeding systems

2.3.1 Pollen viability

In some cases fresh pollen grains were placed on a glass slide and stained with 1% aniline blue in lactophenol. These grains were then observed using a compound microscope. Viable grains stained a dark blue whilst inviable grains remained empty and clear.

A more sensitive and specific stain for pollen viability is Alexander's stain (Table 4). Fresh pollen grains from different flowering stages were placed on a glass slide and stained with Alexander's stain, a cover slip was placed over the grains and the slide was gently heated over a flame. The slide was then viewed with the compound microscope. Viable grains stained red whilst inviable grains stained green. The percentage viability of the number of grains counted was then calculated.

2.3.2 Test for pollen food reserve

Squashed, fresh pollen grains of different species were mounted on a glass slide and then stained with iodine in order to determine whether the food reserve consisted of starches. The slides were viewed with a compound microscope.

2.3.3 Stigma receptivity

Excised stigmas of all species of Oxalis, in Natal were placed in a drop of 5% H₂O₂. Bubbling of the H₂O₂ indicated that the stigmas were receptive. Stigmas from selected floral stages (Fig. 26) were thus tested for receptivity.

2.3.4 Self-compatibility

Colonies of O. obliquifolia, O. semiloba and O. corniculata were observed to determine whether these species were self-compatible. It was observed that it takes approximately 5-7 days for a bud (stage 1) to develop into a mature flower (stage 4). Stage 1 buds of inflorescences were covered with white tissue paper and tied with a strand of grass. Tissue was used because other materials proved to be too heavy for the peduncles.

After day 7 the tissue was removed in order to determine whether any fruit had formed.

2.3.5 Flowering and fruiting trends

Personal observations and herbarium specimens were used to determine flowering and fruiting trends.

2.3.6 Pollinators

Pollinators observed on O. corniculata and O. semi-loba were caught using pill vials as insect nets proved to be unwieldy. The insects were killed by placing a wad of cottonwool soaked either in amyl acetate or ethyl acetate over the mouth of the container. The insects were then identified. Pollen taken from their pollen baskets were examined using the SEM in order to determine whether the pollen was indeed that of the Oxalis spp. concerned.

2.3.7 Distances seeds were projected from a specific point

Mature seeds of O. corniculata and O. semiloba were used to determine the distance seeds are projected from the fruit.

In the case of O. corniculata arillate seeds were placed at a specific point on a sheet of white paper. The arils were then pricked with a sharp needle and the distances travelled marked.

In the case of O. semiloba seeds were projected from a specific point in a more natural manner. Light from a 100W bulb was shone upon seeds placed at the pre-determined point. The aril dehydrated, and split and the seed was projected away from the point.

This method was not successful for O. corniculata as the aril remained intact upon dehydrating and adhered to the seed.

2.4 Synonymy

Synonyms of the existing species of Oxalis were taken from "Index Kewensis". No type specimens of the synonymous species were studied.

Table 3. Chemical proportion for one litre of F.A.A.

95% ethanol	500 ml
37% formaldehyde	100 ml
acetic acid	50 ml
distilled water	350 ml

Table 4. Recipe for Alexander's stain

95% ethanol	10 ml
malachite green	10 mg
distilled water	50 ml
glycerol	25 ml
phenol	5 g
chloral hydrate	5 g
acid fuchsin	50 mg
orange G	5 mg
glacial acetic acid	1-5 ml

3. MORPHOLOGY

3.1 Introduction

The earliest and easiest means of plant identification utilized was plant morphology. The earliest taxonomic works were based largely upon morphological characteristics; in fact Linnaeus' monumental works were based mainly upon morphological characters. Today morphology is still widely used in the formation of keys since in the field, morphological characters are most easily recognised; without the necessity for sophisticated and or bulky equipment.

The advent of electron microscopy opened up a whole new field of research - especially Scanning Electron Microscopy (SEM). With SEM, the study of micromorphology of pollen and seeds was made possible.

Phylogenetic relationships, based wholly upon morphological characters should, however, be treated with caution since the possibility of parallel or convergent evolution is ever present. Phylogenetic interpretations should thus include all aspects, for example: morphology, anatomy, palynology, etc. of a plant.

3.1.1 Leaf Morphology

Leaves of this genus are, generally digitately trifoliolate. In some species, however, e.g. O. fruticosa and O. ptychochala, the petioles of palmately compound leaves have lost their leaflets in development and thus form phyllodes (Metcalf and Chalk, 1979). In all the Natal species of Oxalis the leaves are digitately trifoliolate; variation does occur in the shape of the leaflets' apical margins as well as in the venation.

Leaflet size in the a Natal species, at this stage does not appear to be taxonomically important since leaflet size is highly plastic and variable within each species.

3.1.2 The Cuticle and Epidermis

The cuticle generally has an important role as a structural element as it holds the cellular tissues compact and firm. It also functions as the boundary layer between the plant and the environment. Functions ascribed to the cuticle are: i) water conservation, ii) prevention of loss of plant components through leaching, iii) protection of the plant from injury due to wind and physical abrasion, frost and radiation, iv) cuticles provide the first potential

barrier to attacks by fungi, insects or other pathogens.

Thus to broadly summarise; the function of the cuticle is: i) physiological, ii) chemical and iii) anti-pathogenic (Martin and Juniper, 1970).

Martin and Juniper (l.c.) indicated that more wax and cutin occur on sun rather than shade leaves. Cutler et al (1982) reported that the dominant primary alcohols in the leaf cuticular wax of O. corniculata is, however, taxonomically unimportant since it resembles the wax of other, unrelated families (Martin and Juniper, l.c.).

Many members of this genus are shade plants and Duddington (1969) reported that in many shade plants, e.g. O. acetosella, the outer side of the epidermal cell walls are notably convex. He, like Haberlandt (1914) and Martin and Juniper (l.c.), postulated that this convexity enables these cells to act as convex lenses, thus focussing light into the cell interior and the chloroplasts within. Metcalf and Chalk (1979) also suggested a similar function for the papillae of O. carnosa which also, they postulated, are responsible for the removal of water from the leaf surface.

Shade leaves, according to Duddington (l.c.) become rounder in poor light, flatten in bright light and simultaneous orientate with the leaf edges towards the light thus presenting a small surface area.

Esau (1960) reported that the stomata of Oxalis spp. are sunken and that the epidermal cells are deeper than wide and therefore appear nearly isodiametric. The walls of these cells are not wavy.

Martin and Juniper (l.c.) reported that the frequency of stomata occurrence in most species is greater in the ab- rather than the adaxial surface e.g. in O. acetosella 37 stomata occurred per square millimeter in the abaxial surface as compared to zero per square millimeter of adaxial leaf surface.

3.1.3 Heterostyly

Perhaps the most interesting morphological feature of this genus is the fact that it is tristylous. This means that flowers may have short, medium or long styles. Forty plant families have been found to be distylous; occurring most frequently in the Linaceae, Primulaceae, Plumbaginaceae, Gentianaceae, Boraginaceae and Rubiaceae. Tristyly, on the other hand, is rare; occurring only in the Families Oxalidaceae, Lythraceae and Pontederiaceae. This

feature of the genus Oxalis is further investigated in a later chapter.

3.1.4 Bulbs

Bulbs are uncommon in dicots. Members of the genus Oxalis however, do possess true bulbs. Of those Oxalis species occurring in South Africa; O. corniculata, a weed introduced from Europe, is the only species without a bulb.

A bulb is a short specialized underground shoot. The stem, itself remains very small whilst storage occurs in the large fleshy scales that cover and overlap the stem. The scales consist of scale-leaves or the fleshy bases of foliar leaves. Buds are present in the axils of the scales and during spring one or more develop, at the expense of the storage material, into a flowering axis surrounded by foliage leaves and perhaps a number of scale leaves. Adventitious roots occur at the base of the bulb (Lowson, 1959).

The fragile appearance of the leaves and flowers of Oxalis spp. would indicate that the plant is an annual. But every South African species has a deep-seated, well protected bulb in soil. This bulb enables the plant to survive even the most unfavourable conditions. Thus it is mainly the

presence of this bulb that enables Oxalis species to survive in wide range of habitat, from very dry to very moist conditions.

Bulbs are common in monocotyledons but are rare in dicotyledons. The resting organ of Oxalis is, however, a true bulb. Its seasonal behaviour in the various species is not uniform. However, the function in all species is to provide food for the aerial parts and to produce a new bulb for the following season.

The annual cycle of events of the Cape species O. purpura, with one of the simpler bulbs is described thus by Levyns (1974):

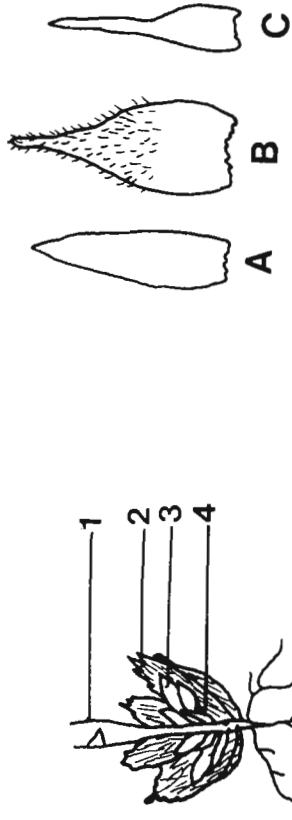
"Soon after the early winter rains have fallen, the plants appear above the ground. By June, they are in full flower. Below the soil level is a short, stout rhizome bearing a few delicate, scale-like leaves. At its base is the bulb from which the season's growth has just emerged. Fine roots are visible on the stem and at the base of the bulb (Figure 6a).

Externally, the bulb consists of hard, dark brown protective scales; sticky without and polished within. If these scale leaves were gently opened out, one would see the rhizome running down the

Fig. 6. Sub-surface changes in *Oxalis purpurea*

Fig 6a. 1-4 in June showing:

- 1. rhizome; 2. nutritive scale (pale brown);
- 3. bud (white); 4. protective scale (dark brown, sticky, polished inside).

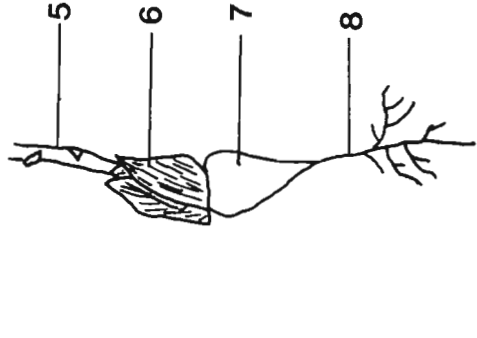


6a. June

- A. Thin evanescent outer scale.
- B. Hard protective scales for the following year.
- C. Nutritive scales for the following year.

Fig 6b. 5-8 in August showing:

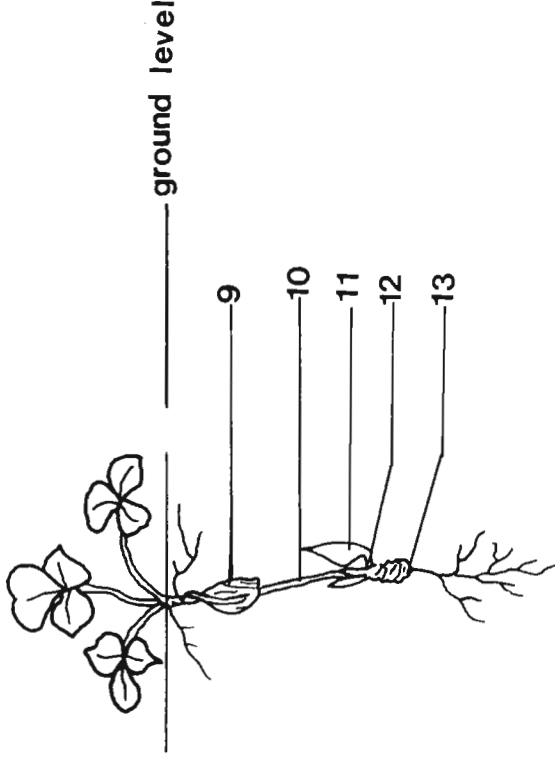
- 5. rhizome; 6. protective scales of bulb; 7. contractile root; 8. roots.



6b. August

Fig 6c. 9-13 in October showing:

- 9. old protective scales remaining at original position; 10. intercalary growth of stem; 11. following year's bulb; 12. withered nutritive scales of the present year; 13. contracted contractile root.



6c. October

(Adapted from Levyns, 1974)

centre of the bulb. The rhizome narrows suddenly, as it enters and continues to the base where a number of fleshy brown leaves arise. These leaves have been modified as food storage organs, the reserves being gradually used up throughout the growing season. In June, there is still a considerable amount of food in them.

In the axil of one of these storage leaves is a small white bulb - an early stage in the development of the next year's bulb. At the base of the old bulb are fine branching roots which supply the plants with water and mineral substances in solution (Figure 6a).

Even at this stage in the development of the following year's bulb, differentiation has occurred. Three types of leaves may be recognized. The outermost leaves (A) are thin and evanescent, disappearing before the new bulb is mature. The next leaves (B) are hairy and in due course give rise to the hard protective scales. The innermost leaves (C) are the future food storage leaves (Figure 6a).

Two months later, there appears a conspicuous fleshy white adventitious root just below the bulb. It is widest just below the bulb, tapering downwards until it merges into the finely branched root system seen previously (Figure 6b).

Two months later, the part played by the fleshy root becomes apparent. The green aerial leaves begin to senesce and the growing season is near its end. Below the ground the old protective leaf scales, now at the end of their functional life remain in their original position. Below them a thin functional stem develops. At the lower end of this rhizome occur the old, depleted food-storage leaves. Below them lies the contractile root. It, the contractile root, is at this stage wrinkled, dry and greatly diminished in size with concertina-like folds on the surface (Figure 6c). The anchoring roots below the contractile root are strong enough to resist the pull exerted by the contractile root. The pull, due to shrinkage, obviously affects the parts above the root and draws the developing bulbs deeper into the soil.

A break, at this point, between the photosynthetic leaves and the new bulb would be disastrous. The danger is averted by the development of an interpolated stem (Fig. 6c). The growth in the length of the stem keeps pace with the shrinkage of the contractile root and essential connections are thus maintained".

3.2 RESULTS

3.2.1 Bulbs and contractile roots

A similar cycle of events, as above, occurs in the bulbous species of Oxalis in Natal. These events, however occur at different times for the different species.

Basically bulbs (Figure 7) consist of similar components; namely outer protective scales, inner nutritive scales and a bud that develops into the following year's bulb. The overall morphology of the bulbs of the different species as well as the colour of the outer protective scales, however differs and in Natal, at least, appear to be species specific.

The only two bulbous species in Natal that did not possess rhizomes were O. corymbosa and O. latifolia (species indigenous to South America). The four other bulbous species present in Natal all possessed rhizomes. These rhizomes provided the following year's bulb with nutrients. Bulbs or bulbils developed along the length of the rhizome or on stalks, in the case of O. latifolia. These bulbs or bulbils broke off from their parent plants to grow into new plants. Thus the rhizome is important for vegetative reproduction.

Fig 7. Bulb morphology of *Oxalis* spp. in Natal
(not drawn to scale)

1. *O. smithiana*
2. *O. obliquifolia*
3. *O. corymbosa*
4. *O. semiloba*

A = evanescent scale
 B = future protective scale
 C = future nutritive scales

5. *O. pes-caprae*
6. *O. latifolia*

(insets = overall bulb morphology)

bl = bulbil
 cr = contractile root
 db = developing bulb
 db1 = developing bulbil
 ns = nutritive scale
 p = petiole
 pe = peduncle
 ps = protective scale
 vs = vascular strand

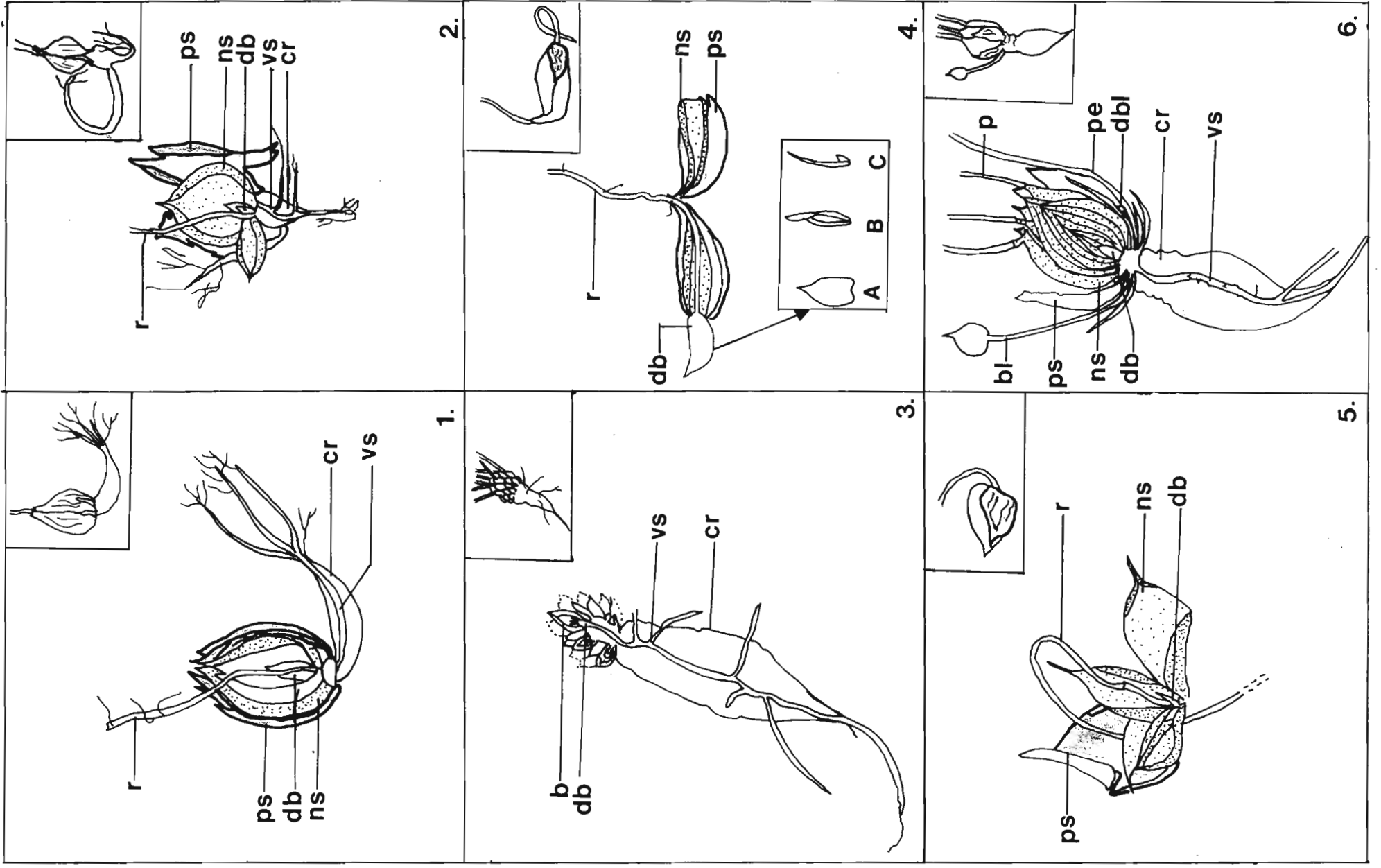
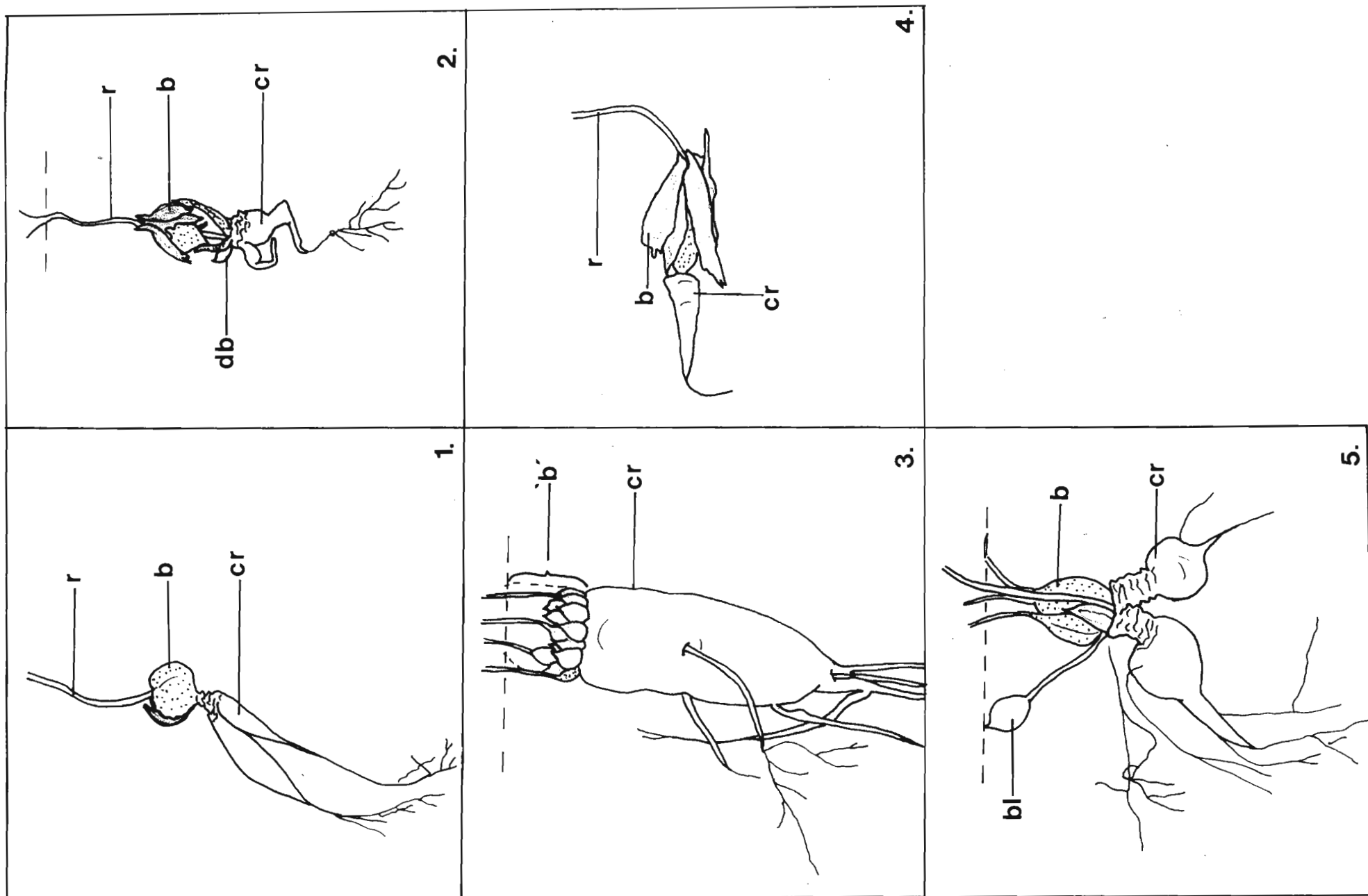


Fig 8. The contractile roots of some of the Natal species of Oxalis (not drawn to scale)

- 1. O. smithiana
- 2. O. obliquifolia
- 3. O. corymbosa
- 4. O. semiloba
- 5. O. latifolia

b = bulb
 bl = bulbil
 cr = contractile root
 db = developing bulb
 r = rhizome
 --- = soil level



All bulbous species of Oxalis developed adventitious contractile roots at their bases (Figure 8). Unfortunately none of the specimens of O. pes-caprae that were collected possessed a contractile root. The size and overall morphology of these structures was very plastic. Occasionally branched contractile roots were observed. The plasticity of these contractile roots appeared to depend upon environmental conditions.

3.2.2 Morphology of abaxial surfaces of leaflets

Leaflet morphology and venation varied amongst the different species in Natal (Figure 9). The overall leaflet morphology was, in many cases, species specific.

Leaf epidermal peels and transverse sections of the leaflets of the different species of Oxalis confirmed that the outer walls of the epidermal cells were convex and in transverse sections appeared deeper than wide. In addition the stomata in all species, were sunken. In the case of O. latifolia, however, stomata were not deeply sunk.

Fig 9. Abaxial surface morphology and venation
leaflets (pubescence not shown)

1. O. corniculata X2
2. O. smithiana X3
3. O. obliquifolia (median leaflet) X3
- 3a. O. obliquifolia (lateral leaflet) X3
4. O. corymbosa X2
5. O. semiloba X2
6. O. pes-caprae X1
7. O. latifolia X2

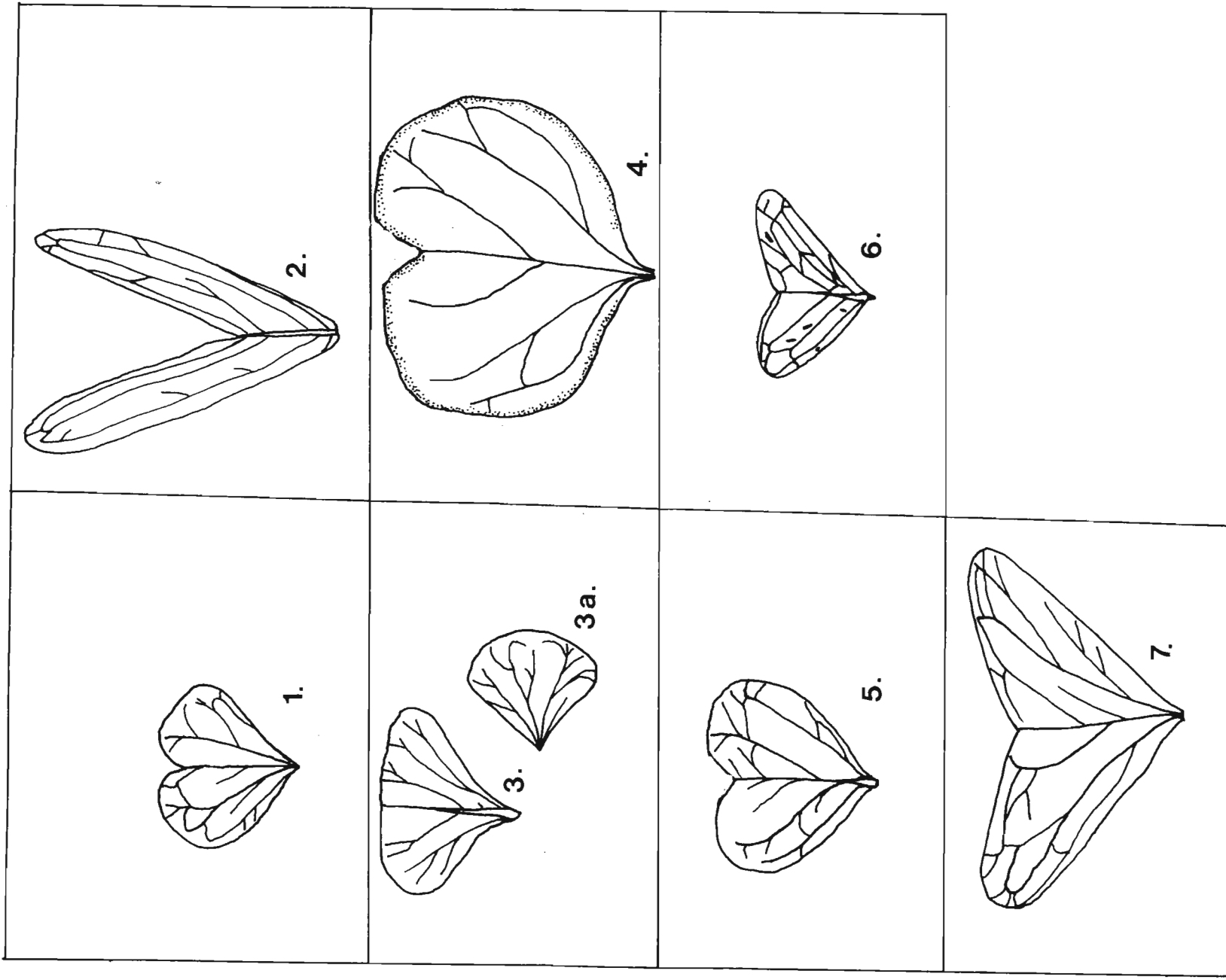
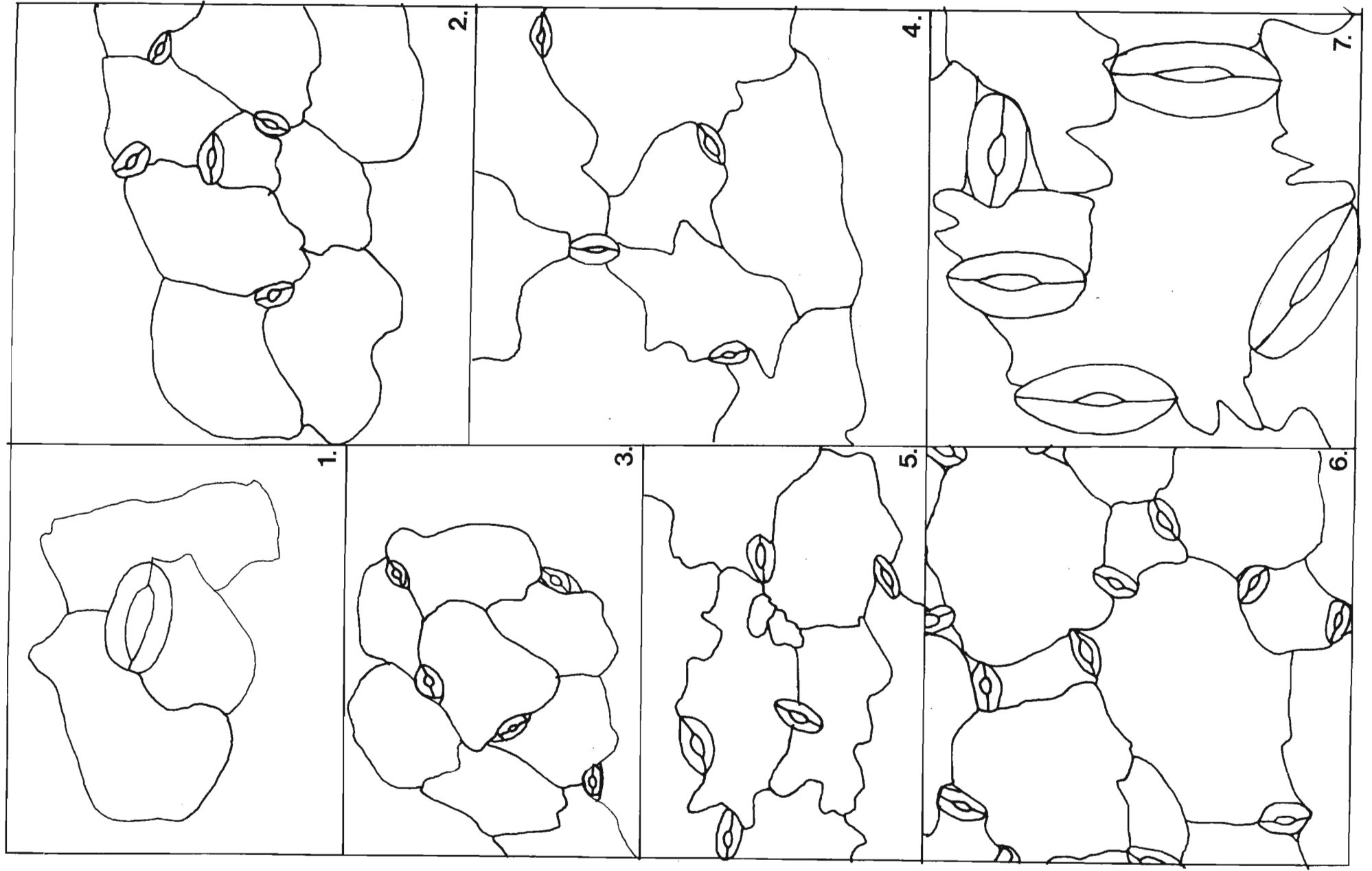


Fig 10. Stomata arrangement on the abaxial surfaces of leaflets of some Oxalis spp. based on epidermal peels (not drawn to scale)

1. O. smithiana
2. O. obliquifolia
3. O. corymbosa
4. O. semiloba
5. O. pes-caprae
6. O. latifolia



According to Esau (1960), the walls of the cells of Oxalis spp. are not wavy. This was only true for some of the species investigated (Figs. 10 and 11). The cell walls of O. corniculata, O. smithiana and O. obliquifolia were almost regular (smooth). The cell walls of O. corymbosa, O. semiloba and O. pes-caprae were slightly wavy. The cell walls of O. latifolia, however, were very wavy, as can be seen in Figs 10.7 and 11.7.

Bailey (1900) and Cronquist (1981) state that the stomata of Oxalis spp. are of the paracytic type. The present investigation, however, indicated that, in Natal at least, the stomata are of the anomocytic type.

As previously stated, leaflet sizes of all the Oxalis spp. in Natal was found to be very plastic.

In the case of O. corniculata, plants growing in shady or less disturbed sites had larger leaflets than those growing in sunnier, more frequently disturbed sites. In addition, plants growing singly under optimum conditions of shade and moisture, had larger leaves and were more erect than colonies of plants. Plants growing in colonies tended to have a mat-forming habit.

Fig 11. Morphology of abaxial surface of leaflets

.1. *O. corniculata* : X1472
1 bar = 10 um

.2. *O. smithiana* : X1984
1 bar = 10 um

.3. *O. obliquifolia* : X800
1 bar = 10 um

.4. *O. corymbosa* : X1728
1 bar = 10 um

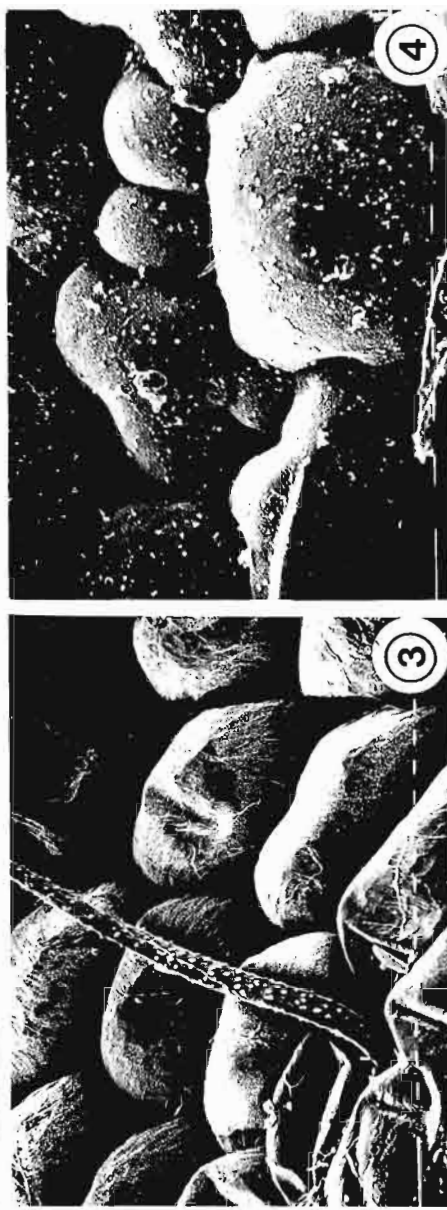
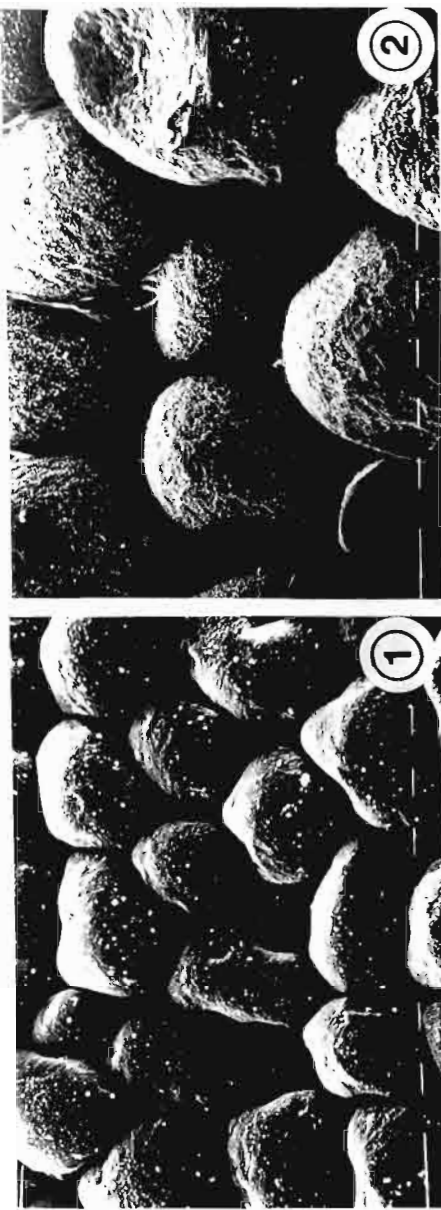
.5. *O. semiloba* : X1536
1 bar = 10 um

.6. *O. pes-caprae* : X1152

.7. *O. latifolia* : X400
1 bar = 10 um

s = stoma

t = trichome



In the other species of Oxalis investigated, the leaflets of plants growing in moist, shady conditions were larger than those growing in sunny, drier conditions. However, if the habitat was shady, but dry then the leaflets, although larger than those growing in open, sunny areas, were smaller than those growing in shady moist areas.

In some species of Oxalis, plasticity was also exhibited by the degree of leaflet lobing. This phenomenon was best observed in specimens of O. smithiana in which the degree of lobing varied from slight to very deep.

The factors responsible for this variation appear to be variations in the environment or micro-environment.

Leaflets of all species except O. obliquifolia, exhibit sleep movements. O. latifolia (fig. 12) is an example of a species showing sleep movements.

Fig 12. A colony of *O. latifolia* at night with leaflets showing sleep movements.



3.2.3 Floral Morphology

3.2.3.1 Petal Morphology (Figure 13)

In all species, the throat regions of the corollas are shown.

The epidermal cells of the throat regions of the petals of O. corniculata and O. semiloba were brick-shaped. The epidermal cells in this region of the other species of Oxalis were fusiform. It was observed that the epidermal cells of O. semiloba were very small when compared with the other species.

The throat region of O. corniculata (Figure 13.1) was glabrous, whilst in all other species this region was more or less pubescent or papillate.

O. smithiana (Figure 13.2) and O. obliquifolia (Figure 13.3) were moderately pubescent with glandular trichomes. O. corymbosa (Figure 13.4) was sparsely pubescent with stalked glandular and a few uniseriate, eglandular trichomes. This type of pubescence also occurred in the mouth region of O. corymbosa. The throat region of O. semiloba (Figure 13.5) was very sparsely pubescent with a few, small, stalked glandular

Fig 13. Corolla petal throat morphology

.1. *O. corniculata* : X800
1 bar = 10 um

.2. *O. smithiana* : X1600
1 bar = 10 um

.3. *O. obliquifolia* : X800
1 bar = 10 um

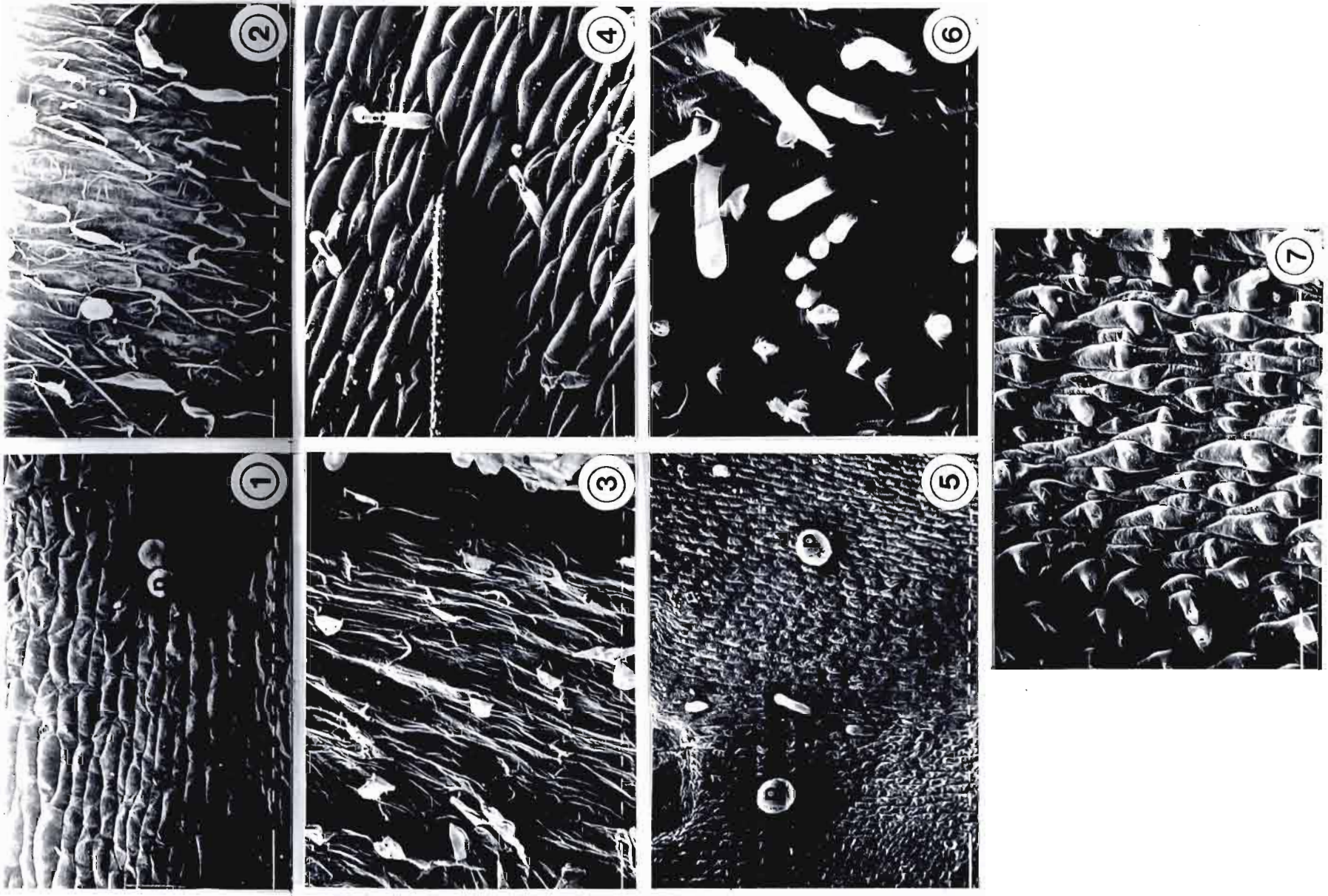
.4. *O. corymbosa* : X2048
1 bar = 10 um

.5. *O. semiloba* : 1280
1 bar = 10 um

.6. *O. pes-caprae* : X736
1 bar = 10 um

.7. *O. latifolia* : X1056
1 bar = 10 um

p = pollen grains



trichomes that were either stalked or sessile (Figure 13.6), the stalked glandular trichomes were long and thick. O. latifolia (Figure 13.7) was densely papillate.

3.2.3.2 Pollen Morphology

The pollen grains of all species were radiosymmetrical and tricolpate with reticulate ornamentation (Figure 14). Grains appeared circular in both equatorial and polar views.

The grains of O. corniculata (Figure 14.1) were smaller than all other species, except O. corymbosa (Figure 14.4). The colpi on the pollen grains of O. corniculata were indistinct; in addition, the lumina were smaller than in the other species.

The ornamentation on the colpi of the other species, excluding O. corniculata, (Figures 14.2-14.7) appeared to be species specific.

It was found that the pollen of all anther lengths, in each species, was of a uniform size.

The similarity of the pollen grains within this genus was an indication of the cohesiveness of this genus in Natal.

Fig 14. Pollen morphology

.1. *O. corniculata* : X9500
1 bar = 10 um

.2. *O. smithiana* : X2875
1 bar = 10 um

.3. *O. obliquifolia* : X3500
1 bar = 10 um

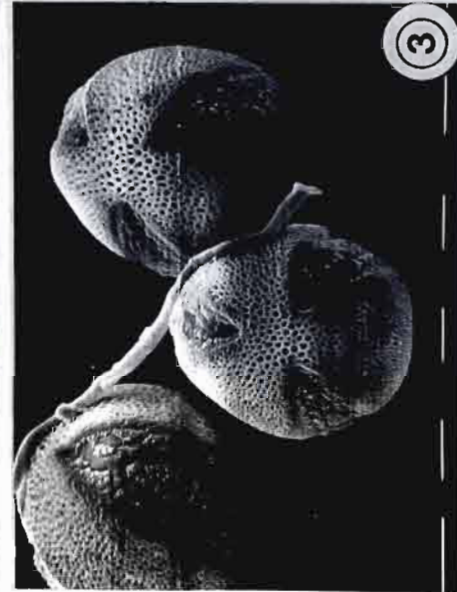
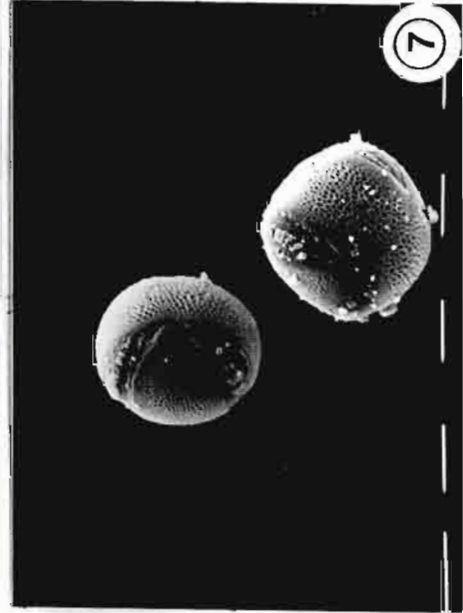
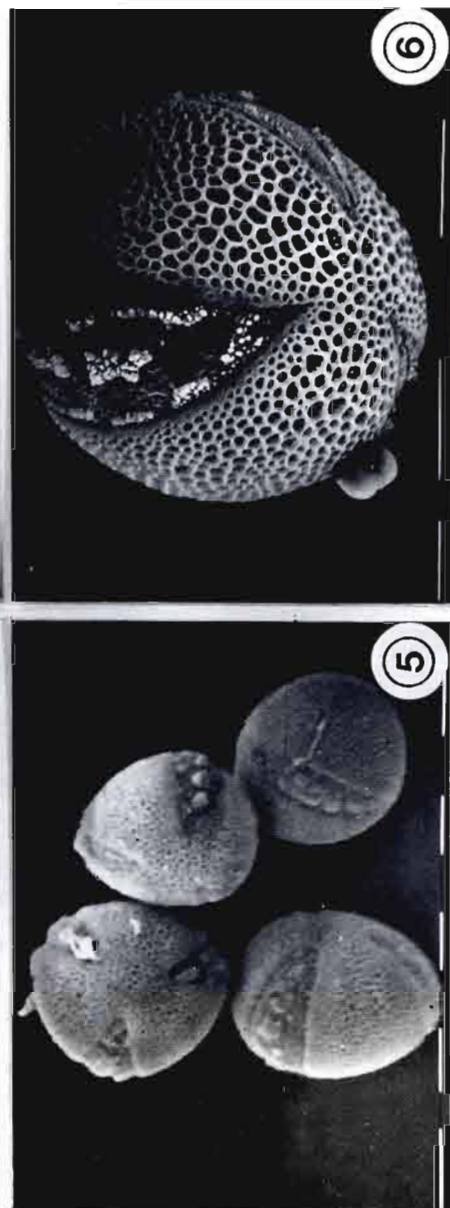
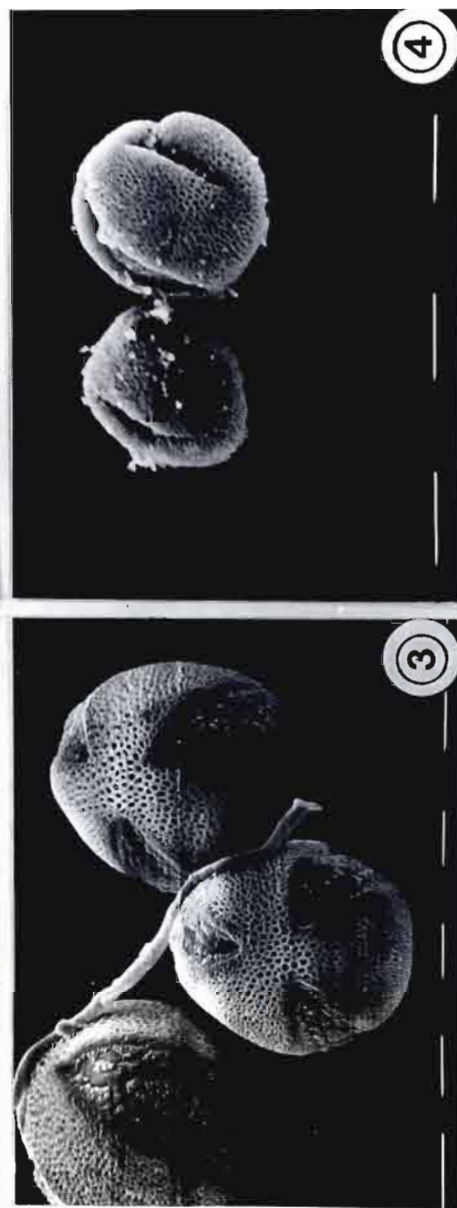
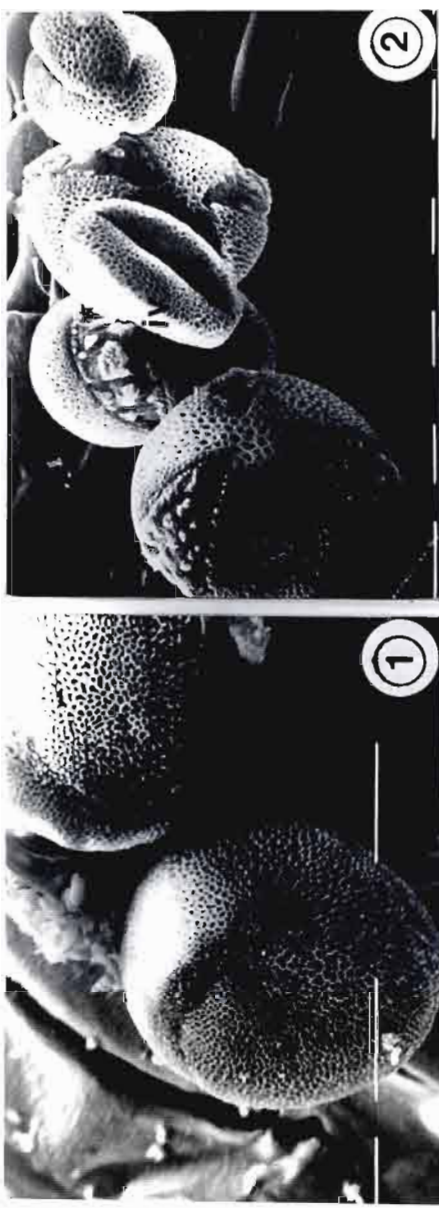
.4. *O. corymbosa* : X4500
1 bar = 100 um

.5. *O. semiloba* : X3125
1 bar = 10 um

.6. *O. pes-caprae* : X7000
1 bar = 10 um

.7. *O. latifolia* : X3500
1 bar = 10 um

iv = inviable



3.2.3.3 Stigma and style morphology

Representative stigmas, from each species were investigated (Figure 15).

All stigmas investigated were papillate (Figures 15.1-15.7). The stigmas of O. pes-caprae had extremely small papillae (Figure 15.6).

Stylar pubescence in all species consisted of a mixture of glandular and eglandular trichomes. In most cases there were more upward pointing, eglandular trichomes than glandular trichomes. Glandular trichomes were mainly stalked.

In the case of O. smithiana (Figure 15.2) there appeared to be equal amounts of glandular and eglandular trichomes. The styles of O. corymbosa (Figure 15.4) were densely pubescent with long, eglandular trichomes. Styles of O. corniculata (Figure 15.1) were also densely pubescent but with shorter, eglandular trichomes.

The upper half of the ovaries of O. pes-caprae were densely pubescent with eglandular trichomes (Figure 15.6).

Fig 15. Stigma and style morphology

.1. *O. corniculata* (l.s.) : X400
1 bar = 10 um

.2. *O. smithiana* (m.s.) : X224
1 bar = 100 um

.3. *O. obliquifolia* (.s.) : X240
1 bar = 100 um

.4. *O. corymbosa* (m.s.) : X208
1 bar = 100 um

.5. *O. semiloba* (l.s.) : X224
1 bar = 100 um

.6. *O. pes-caprae* (s.s.) : X100
1 bar = 100 um

.7. *O. latifolia* (m.s.) : X224
1 bar = 100 um

a = anther

c = corolla

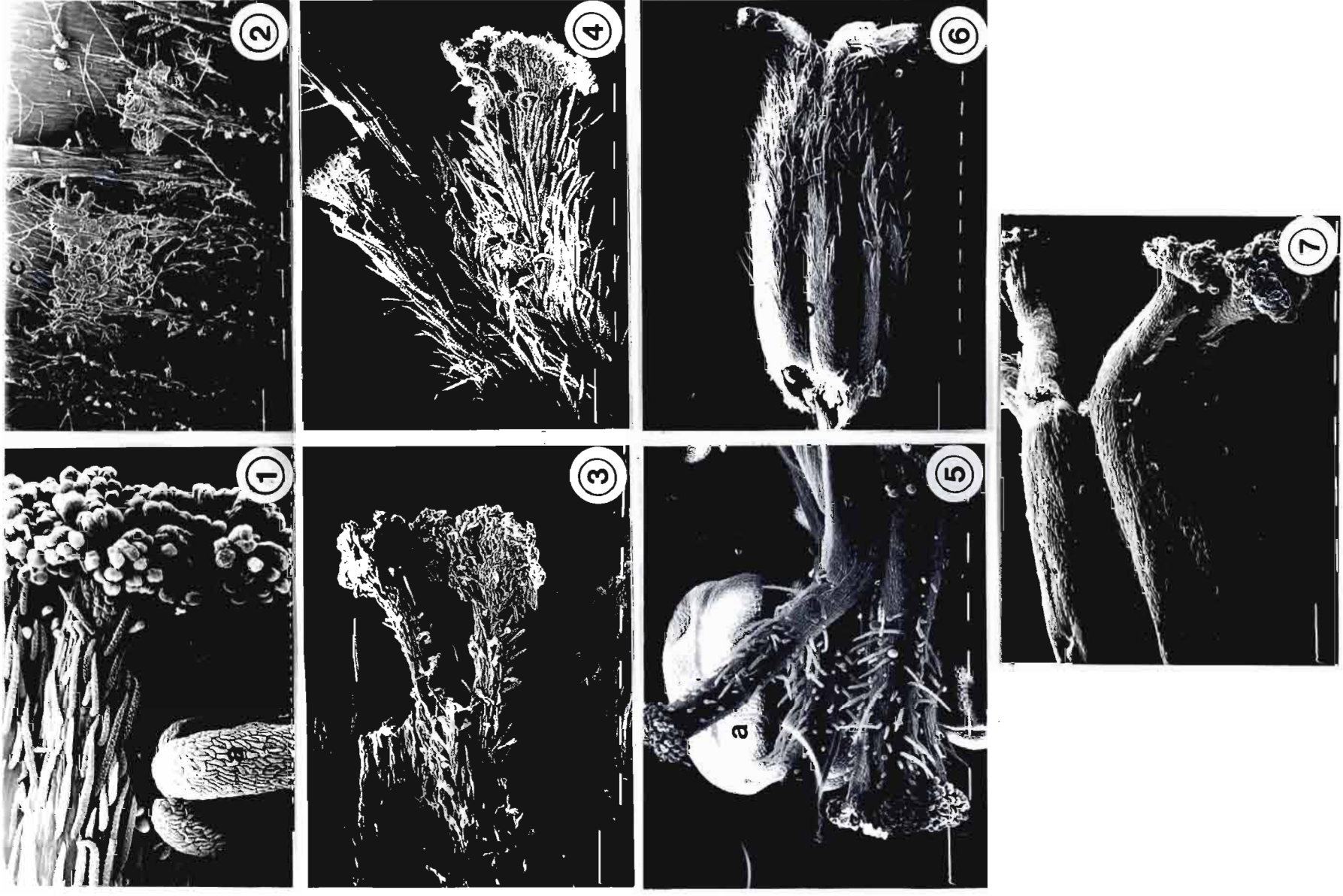
f = filament

o = ovary

l.s. = long styled

m.s. = mid styled

s.s. = short styled



The styles of O. latifolia (Figure 15.7) were sparsely pubescent with stalked glandular and short upward pointing, uniseriate, eglandular trichomes.

The purpose of the eglandular trichomes is perhaps to trap pollen that falls from the anthers and present it to the pollinator. The glandular trichomes may have a secretory function and may also regulate the diurnal and photonastic opening and closing of the flowers.

3.2.3.4 Seed morphology

Figure 16 shows the seeds of the seed producing species in Natal. Figures 16.1-16.4 show the overall morphology of the seeds either with or without the aril whilst figures 16.1a-16.4a show seed coat details. Seed coat ornamentation was species specific, thus providing taxonomically distinct characters.

O. obliquifolia (Figure 16.3) was the only species in which the seed apex was ovate. The other species (Figures 16.1; 16.2; 16.4) were apically acute.

Fig 16. Seed morphology and seed coat detail

.1. O. corniculata seed morphology : X304
1 bar = 100 um.

.1a. O. corniculata seed coat detail X1600
1 bar = 10 um.

.2. O. smithiana seed morphology : X112
1 bar = 100 um.

.2a. O. smithiana seed coat detail : X432
1 bar = 10 um

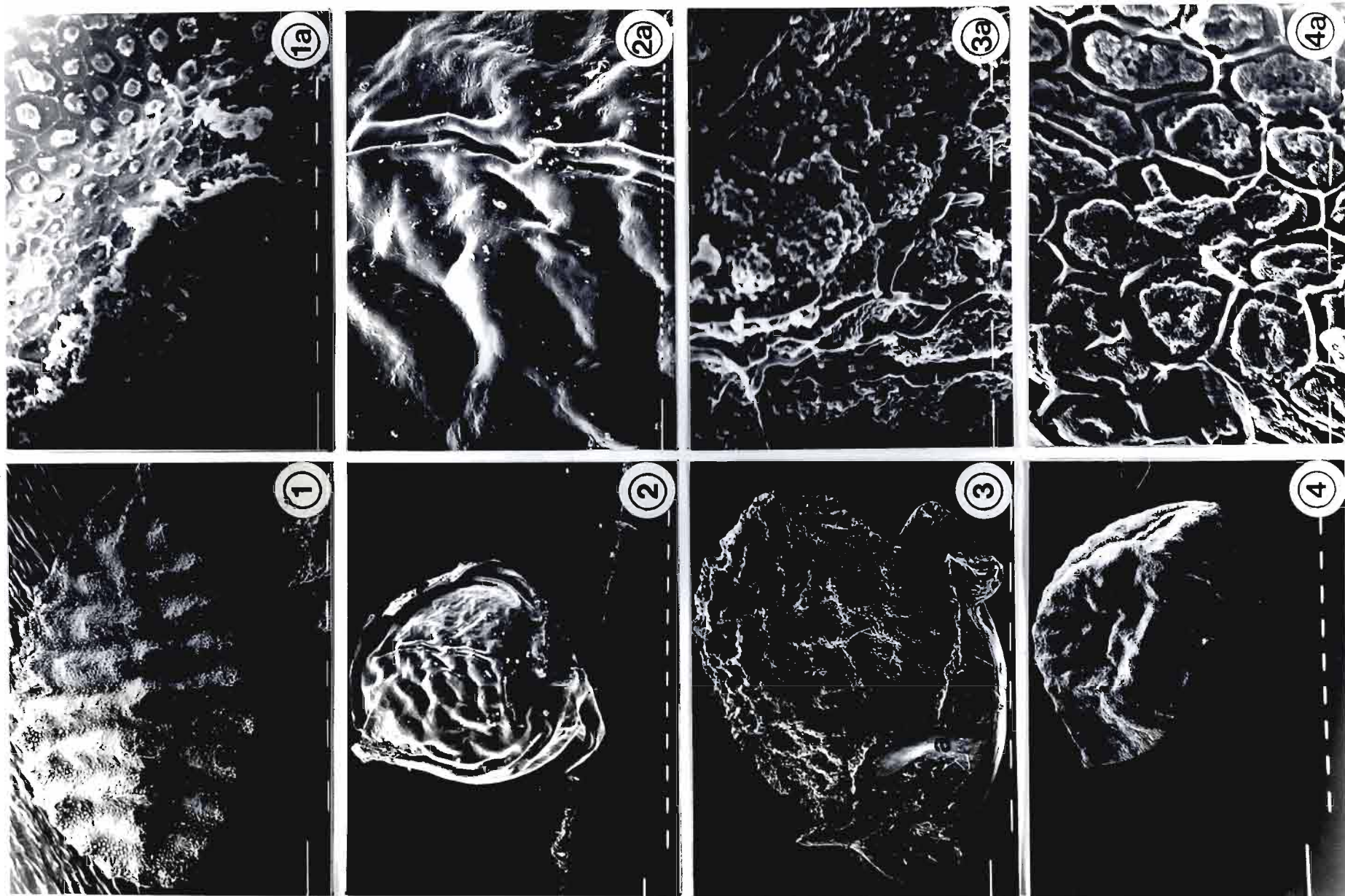
.3. O. obliquifolia seed morphology : X216
1 bar = 100 um

.3a. O. obliquifolia seed coat detail : X3250
1 bar = 10 um

.4. O. semiloba seed morphology : X84
1 bar = 100 um

.4a. O. semiloba seed coat morphology : X3250
1 bar = 10 um

a = aril



Surface details of the seed coats indicated that the seed surface of O. smithiana (Figure 16.2a) was smooth whilst those of the other three species (Figures 16.1a; 16.3a; 16.4a) were verrucose.

The seed coat surface of O. corniculata (Figure 16.1a), O. obliquifolia (Figure 16.3a) and O. semiloba (Figure 16.4a) consisted of more or less hexagonal cells within which verruca occurred. Verruca morphology differed between species. O. corniculata had simple verruca. The verruca of O. semiloba was more complex. The verruca of O. obliquifolia was the most complex completely obscuring the walls of the cells.

The seeds of O. corniculata were dorsiventrally flattened whilst the seeds of the other three species were rounded.

3.2.4 The utilization of morphological characters as an aid to species distinction

Polygonal graphs were used to graphically illustrate the quantitative morphological differences of the species of Oxalis in Natal. The graphs were based only upon quantitative data. Lengths and widths of various morphological characters were measured, in millimeters and the averages of these results were utilized in the construction of the polygonal graphs. A zero result implied that that particular character was absent from that species. The androecial and gynoecial lengths of O. pes-caprae were not included in the polygonal graphs as insufficient material was available for study.

3.2.4.1 Discussion of the polygonal graphs

Figures 17a and 17b

A. Average lengths of bulbs

The overall length of the "bulb" of O. corymbosa was the longest (26.7 mm). However the "bulb" of O. corymbosa actually consisted of numerous small, sessile bulbils, average length of the bulbils being 5.3 mm. O. pes-caprae possessed the next longest bulb (25 mm) according to Salter (1944). O. latifolia possessed the shortest (10.0 mm) bulbs. O. corniculata

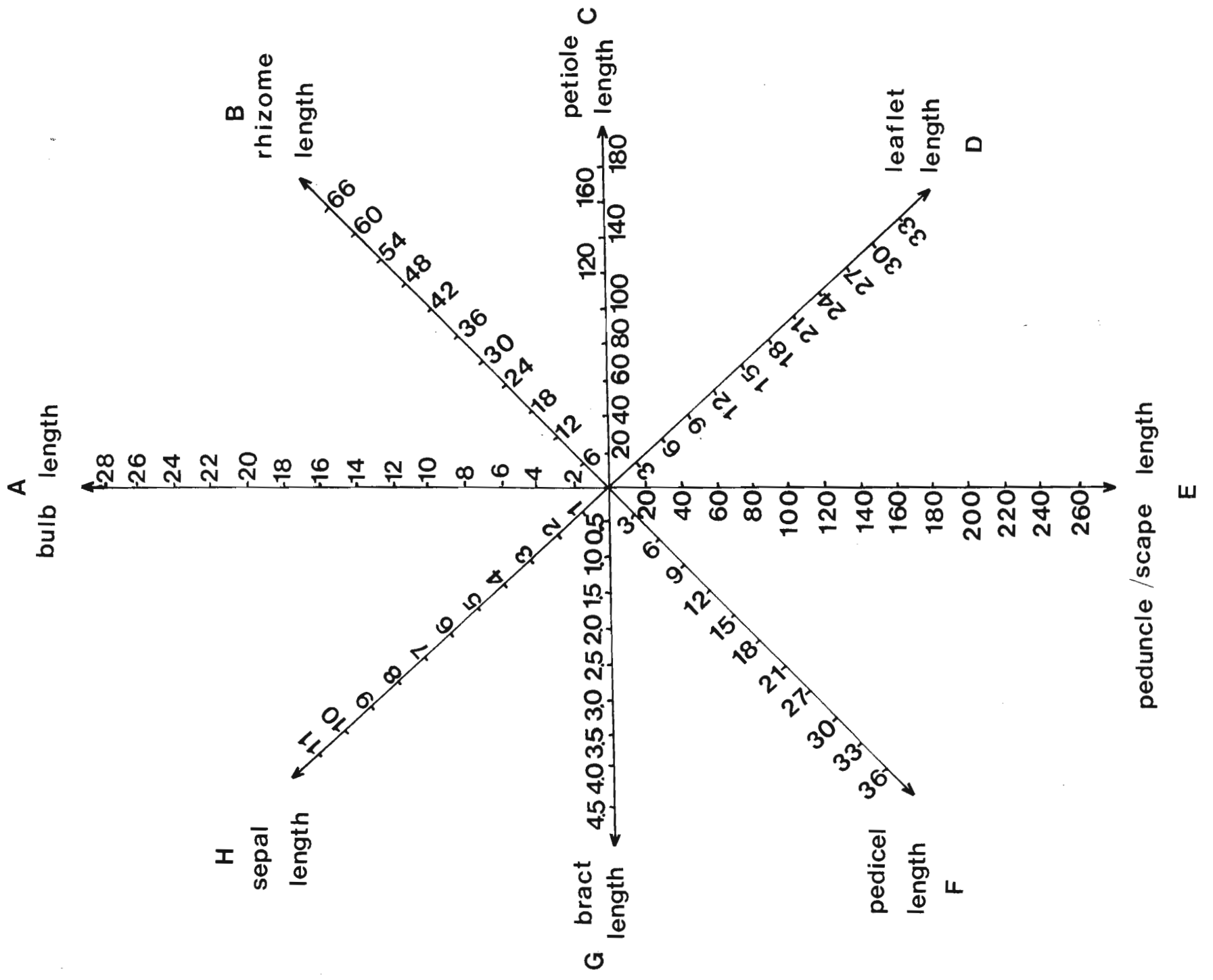


Fig 17a. Polygonal Graph Master Plan (I) (arms A - H)

was the only species of Oxalis in Natal that did not possess a bulb. The average bulb lengths of O. semiloba, O. smithiana and O. obliquifolia were 14.5 mm, 14 mm and 12.7 mm respectively.

B. Average lengths of rhizomes

O. corniculata, whose main form of propagation is by means of a creeping stem, had the longest (59.6 mm) stems. Rhizomes of O. semiloba and O. smithiana were equally long (55.3 mm). O. obliquifolia had the shortest rhizome (32.4 mm). All specimens of O. corymbosa and O. latifolia (the two species introduced from South America examined, lacked rhizomes.

C. Average lengths of petioles

It was found that O. corymbosa had the longest average petiole lengths (189.8 mm) whilst O. latifolia had the second longest average length (114.8 mm). O. corniculata possessed the shortest (40.0 mm). The average lengths of the petioles of O. obliquifolia and O. smithiana were short (47.5 mm and 75.5 mm respectively). That of O. semiloba was more or less intermediately long (100.4 mm).

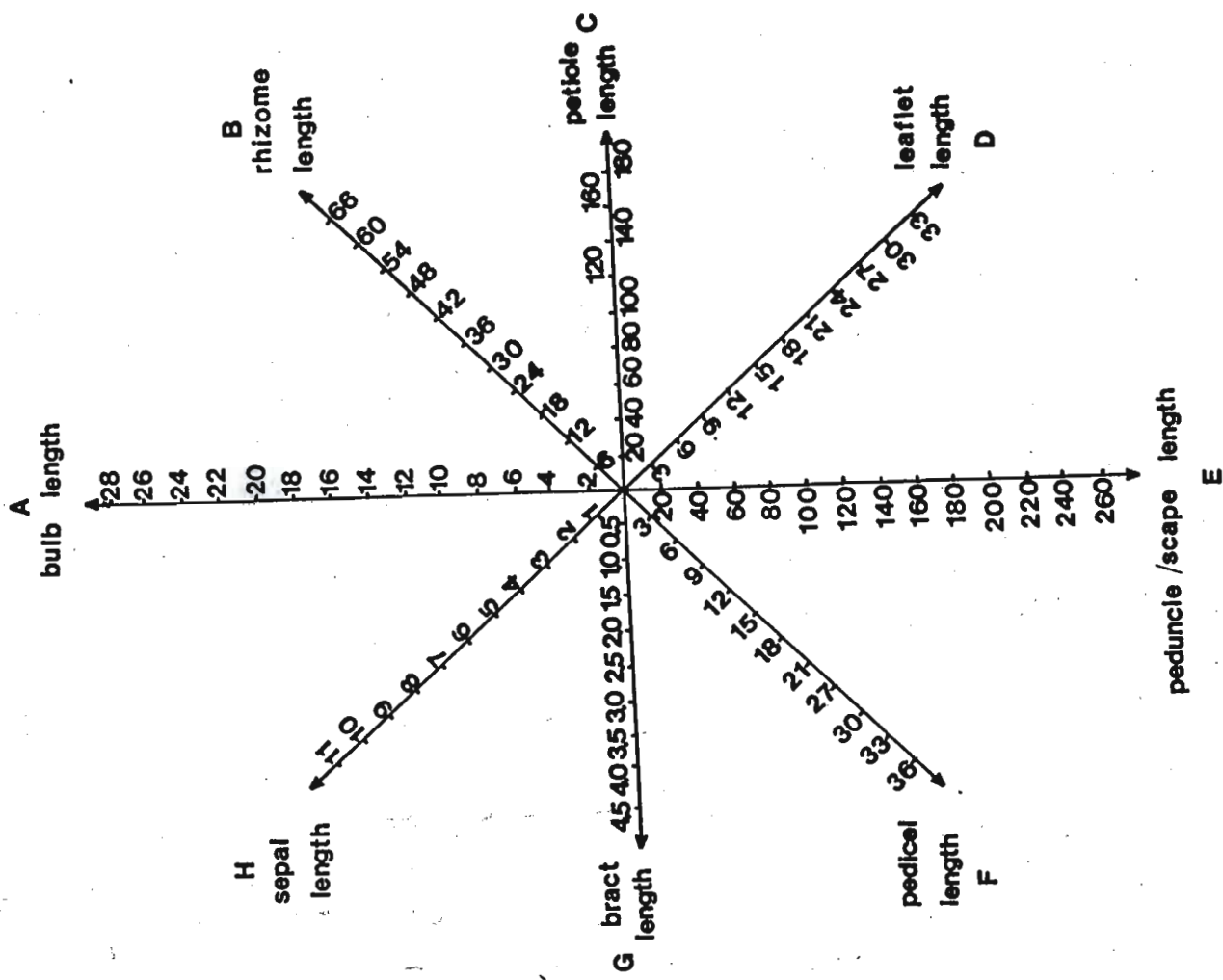
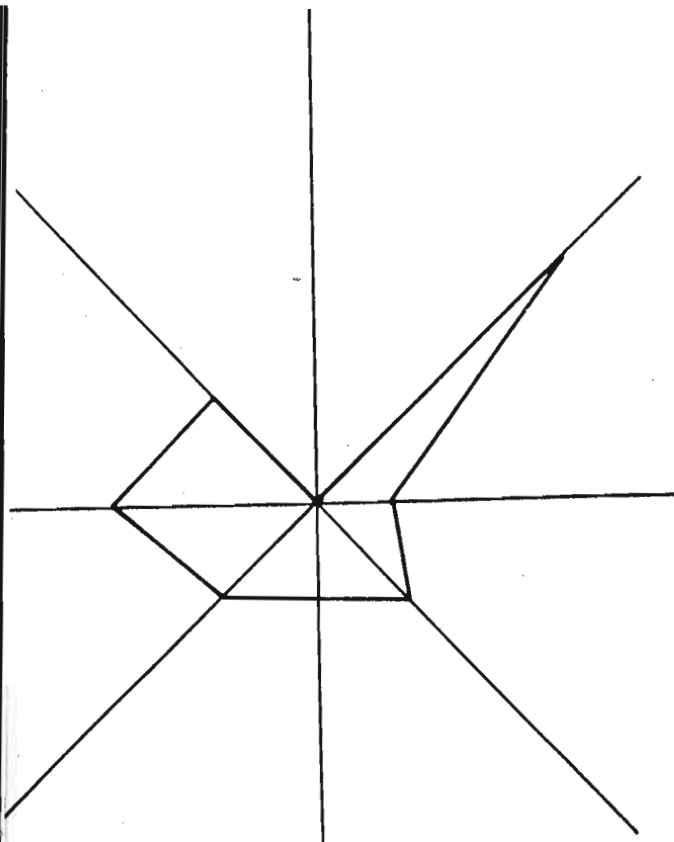
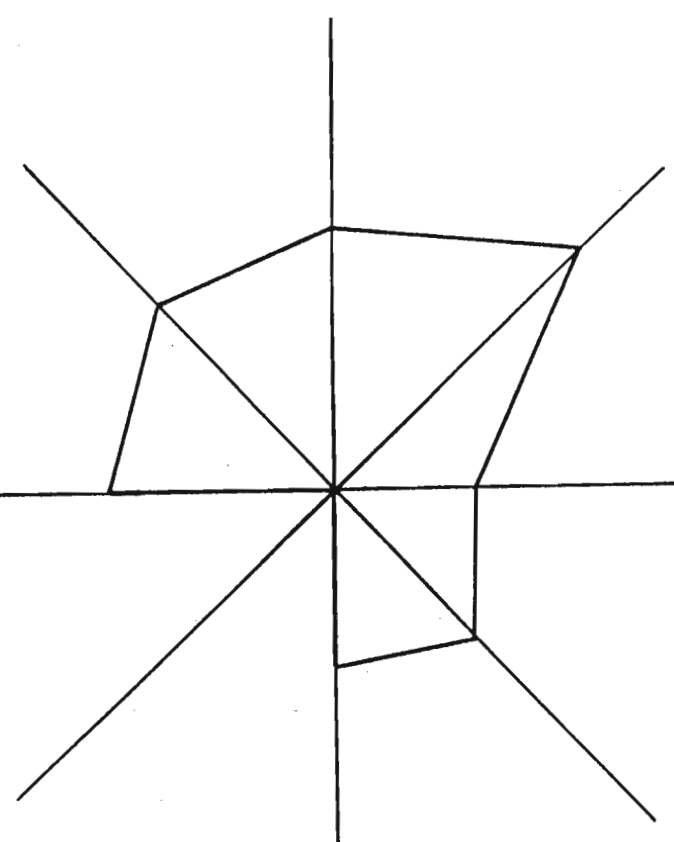


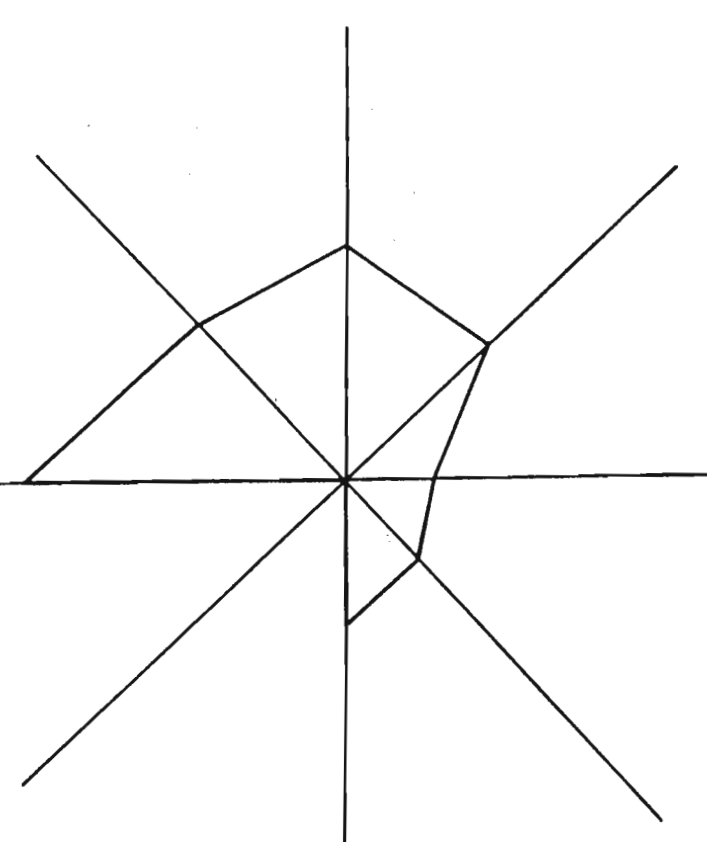
Fig 17b. Polygonal graphs (I) of *Oxalis* spp.



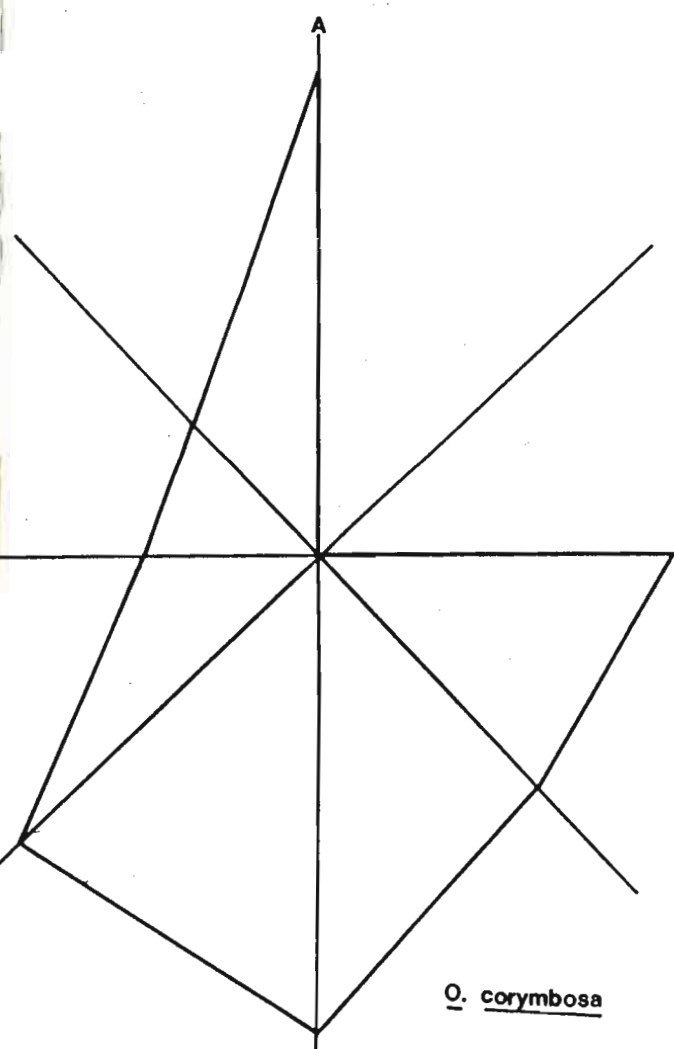
Q. corniculata



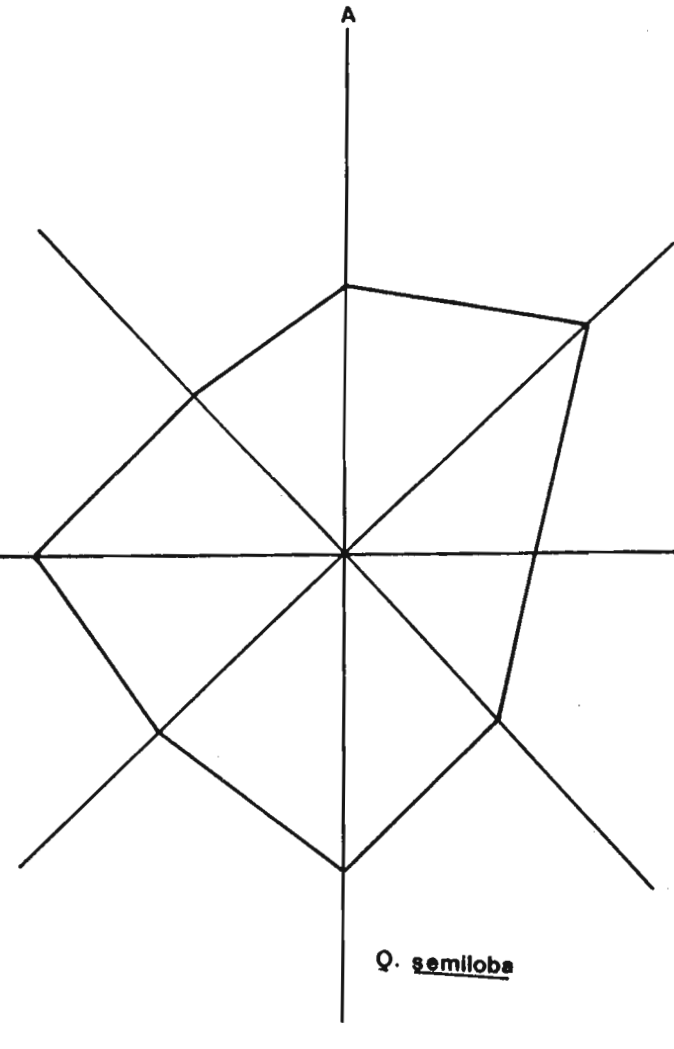
Q. smithiana



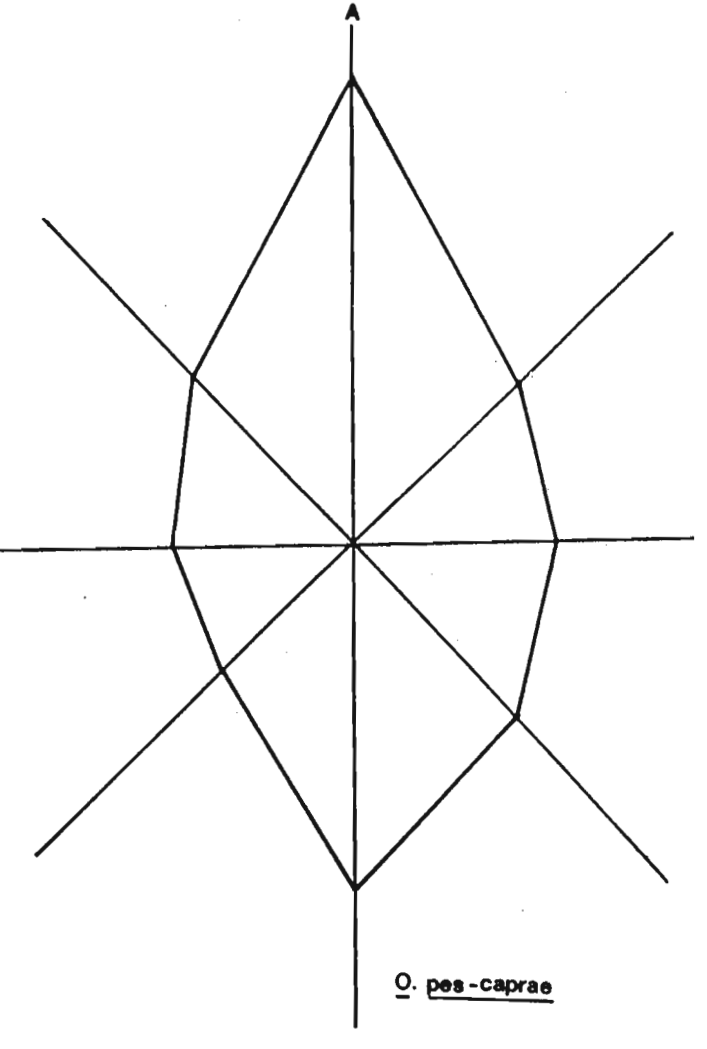
Q. obliquifolia



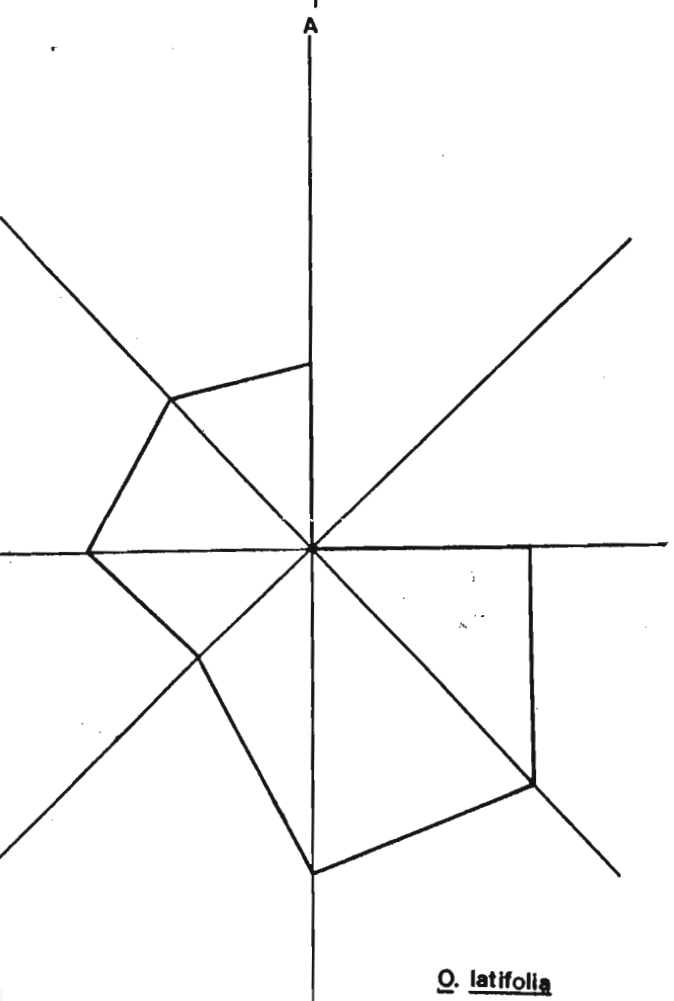
Q. corymbosa



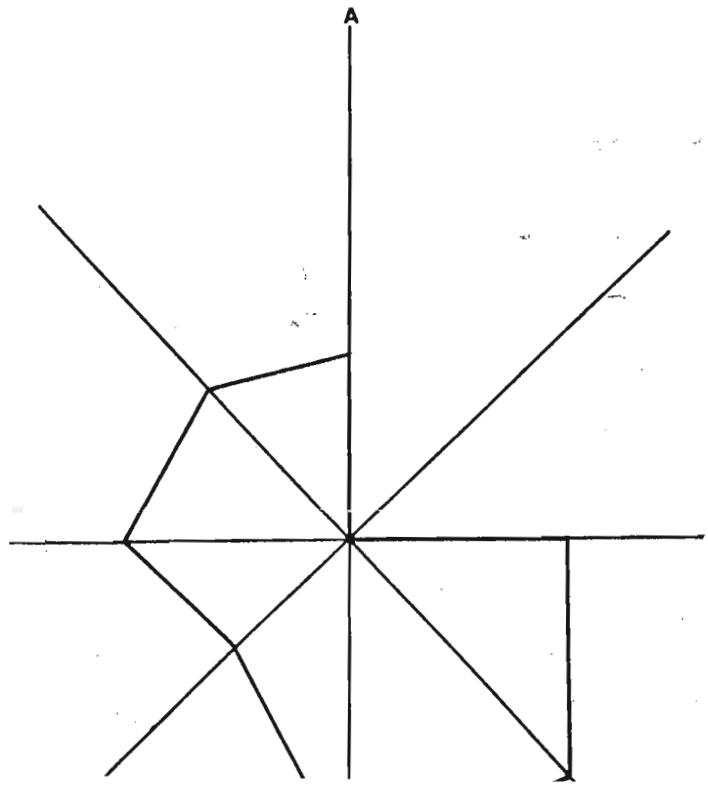
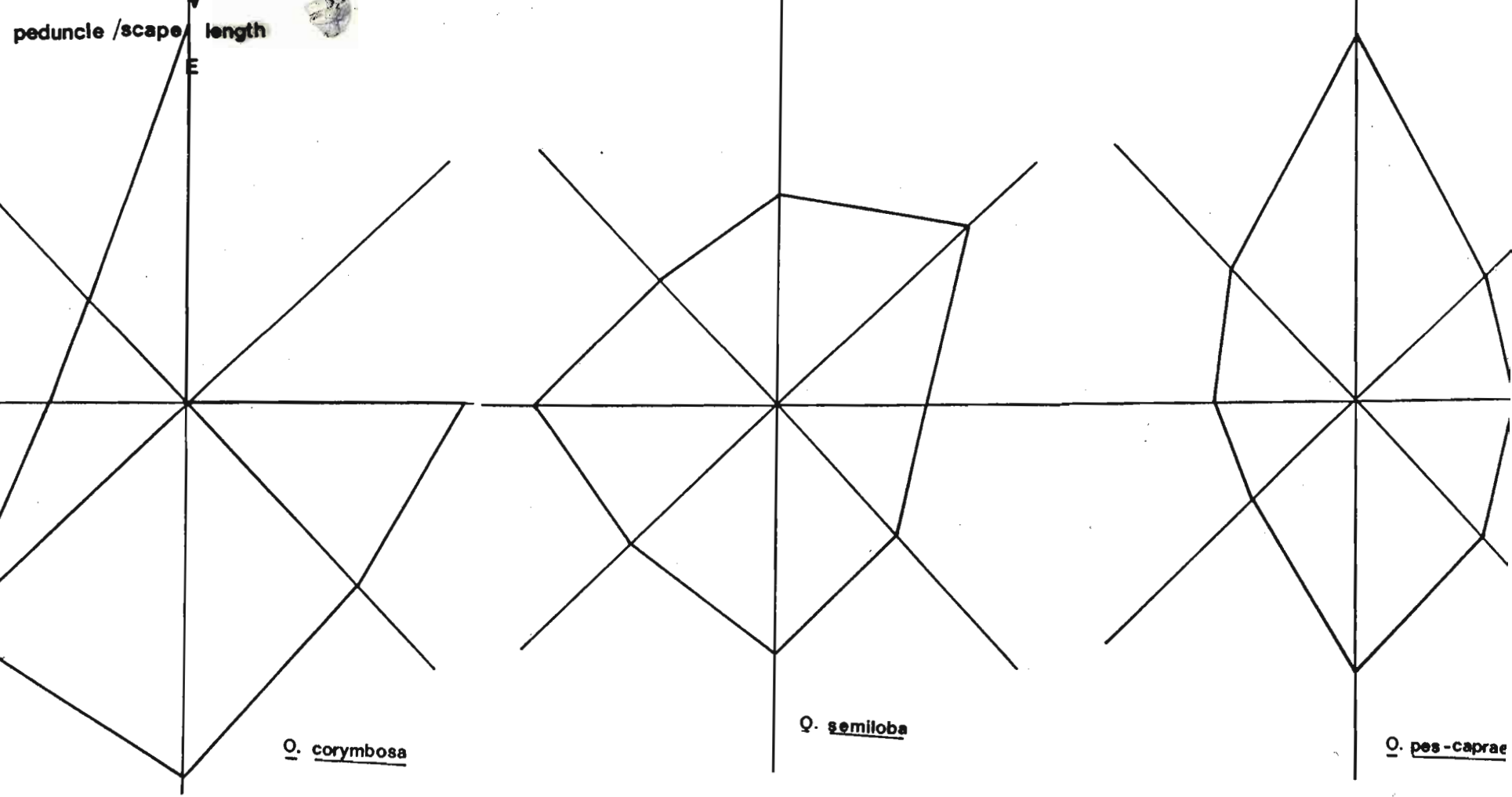
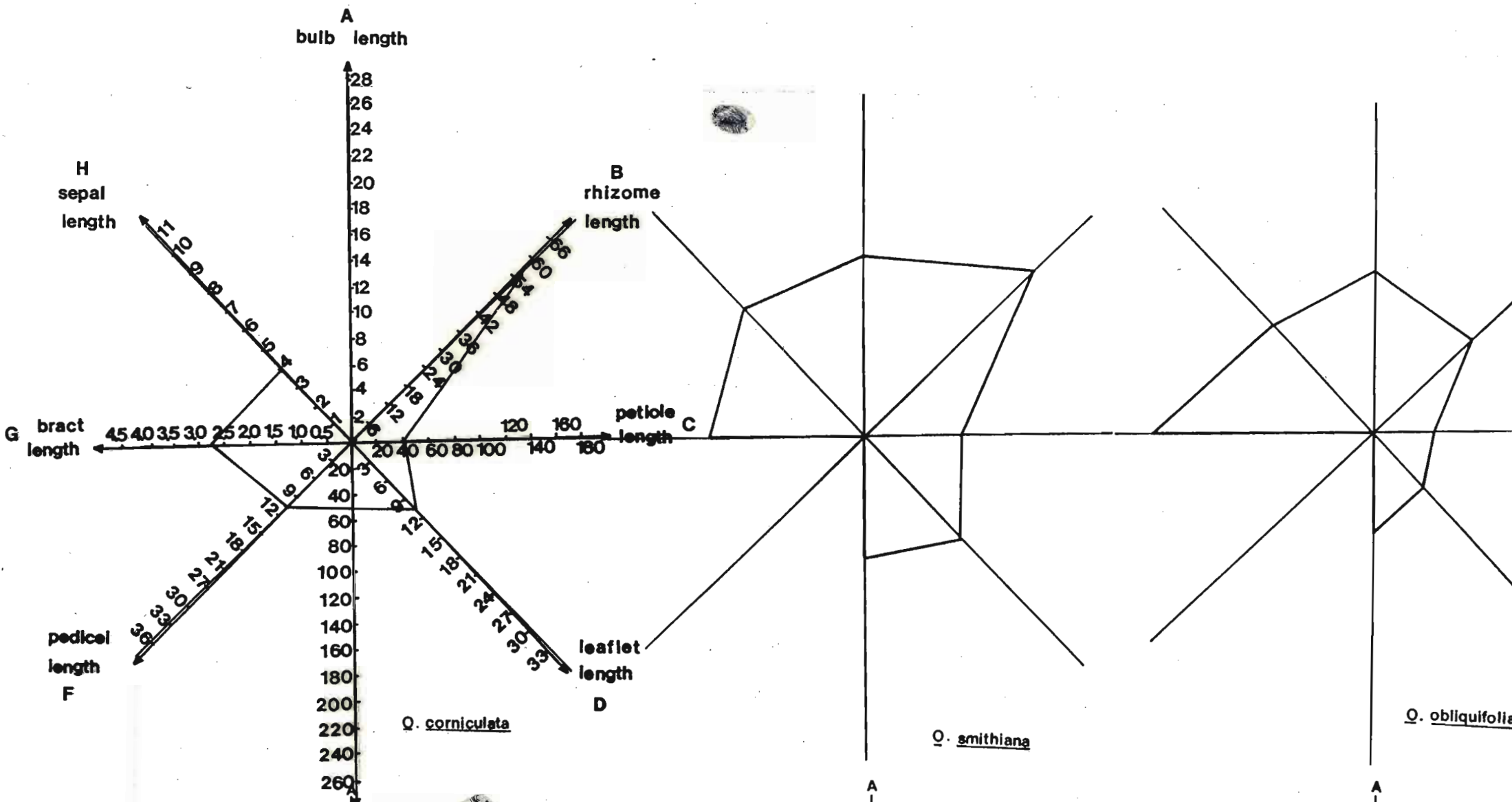
Q. semiloba

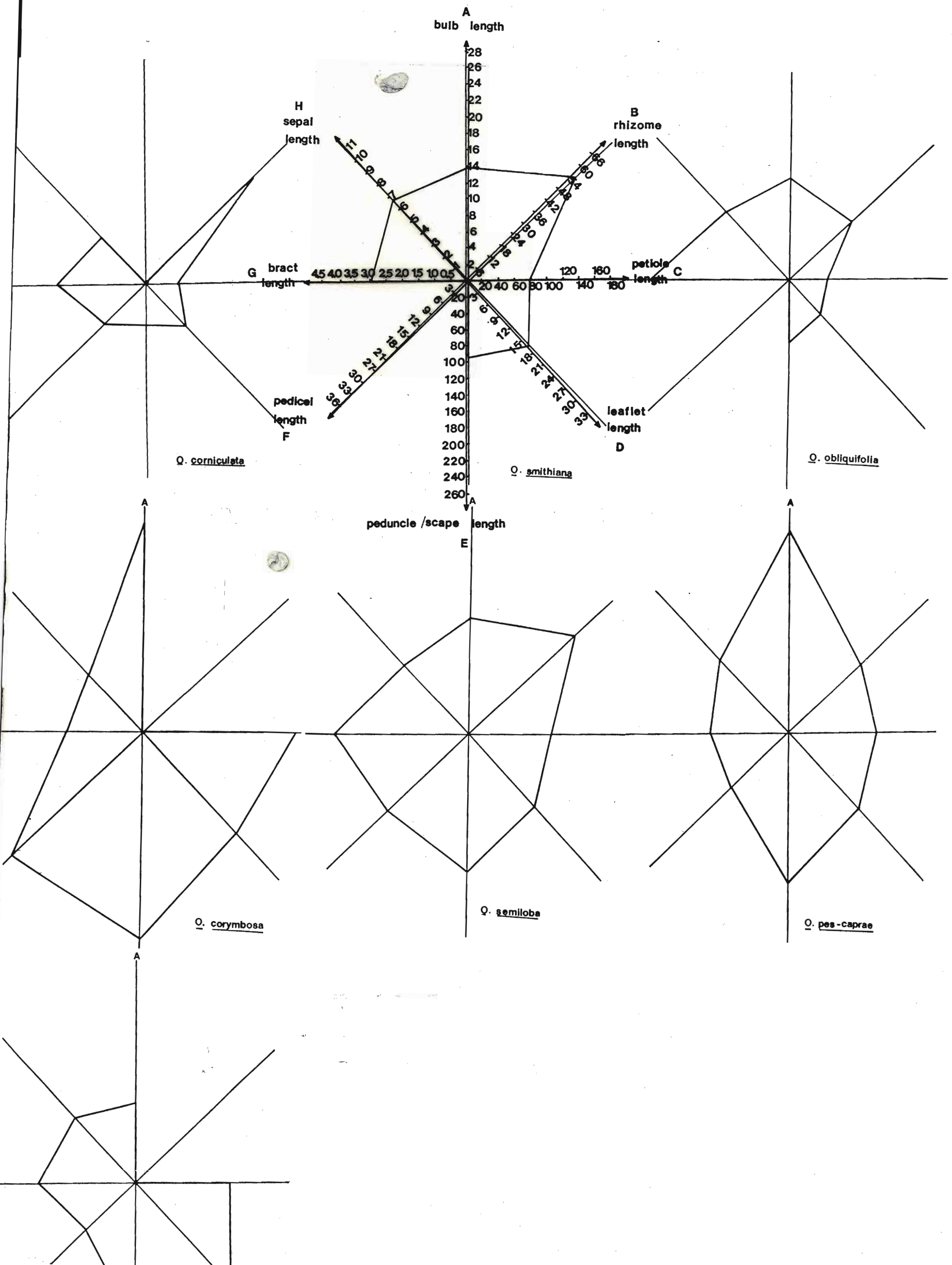


Q. pes-caprae



Q. latifolia





A
bulb length

H
sepal
length

B
rhizome
length

G
bract
length

C
petiole
length

F
pedicel
length

D
leaflet
length

Q. corniculata

Q. smithiana

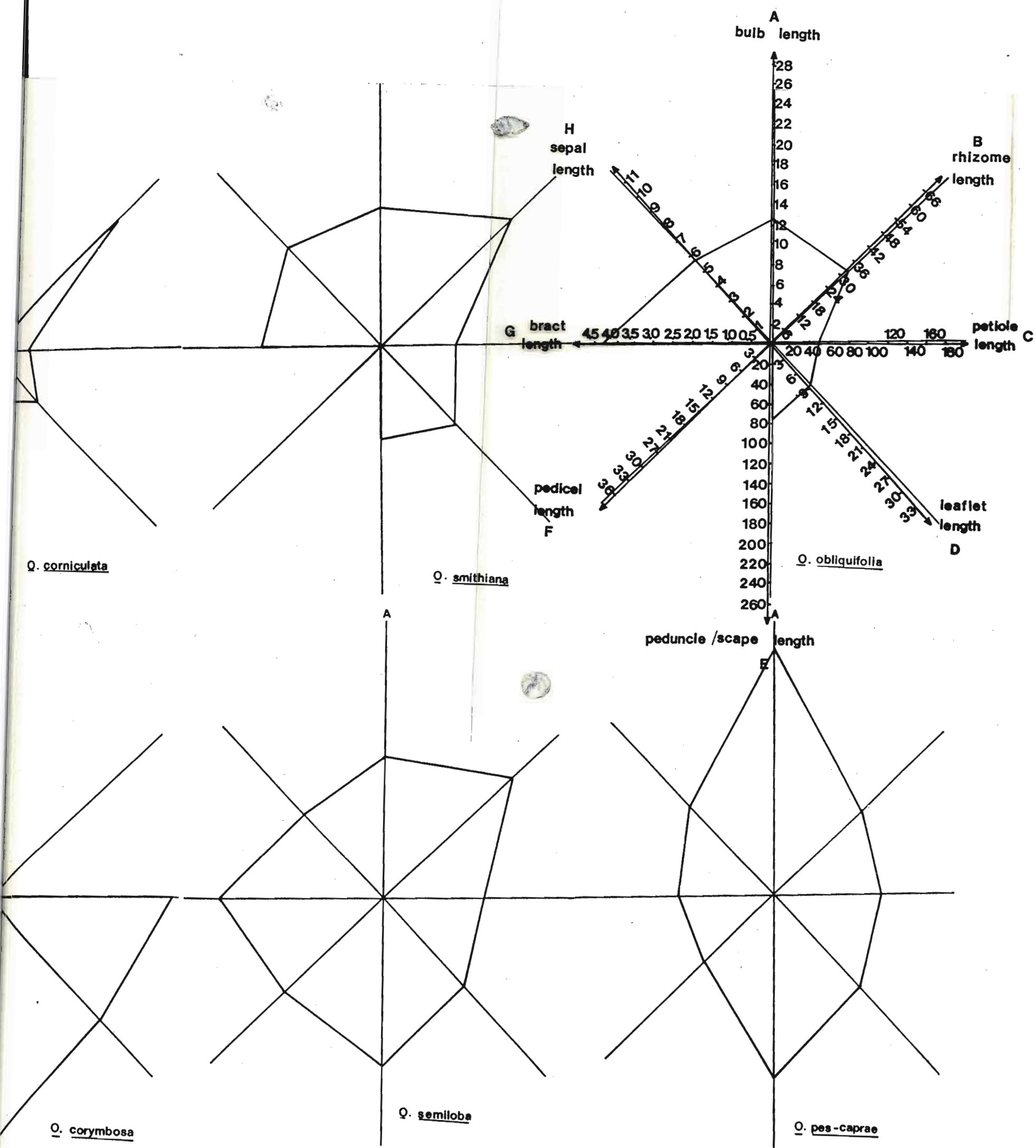
Q. obliquifolia

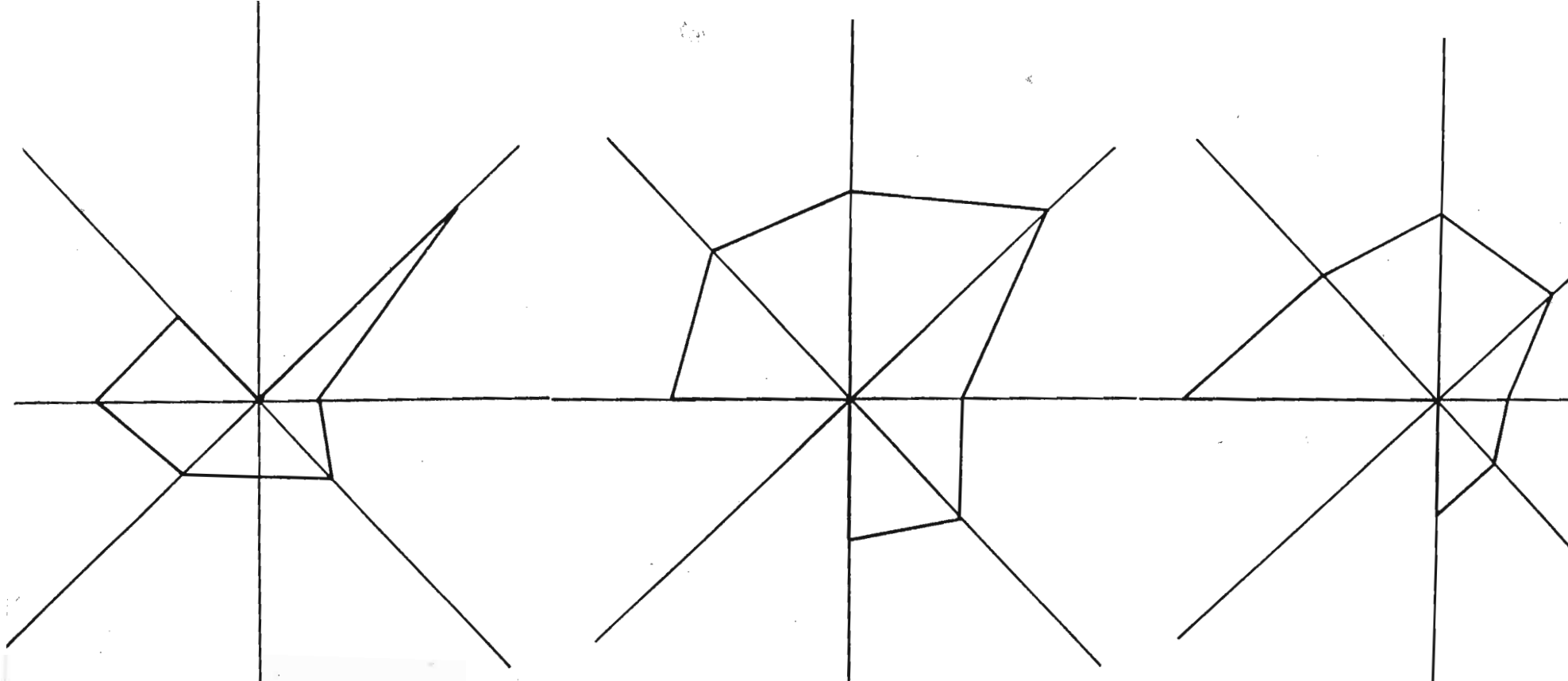
A
peduncle /scape
length
E

Q. corymbosa

Q. semiloba

Q. pes-caprae

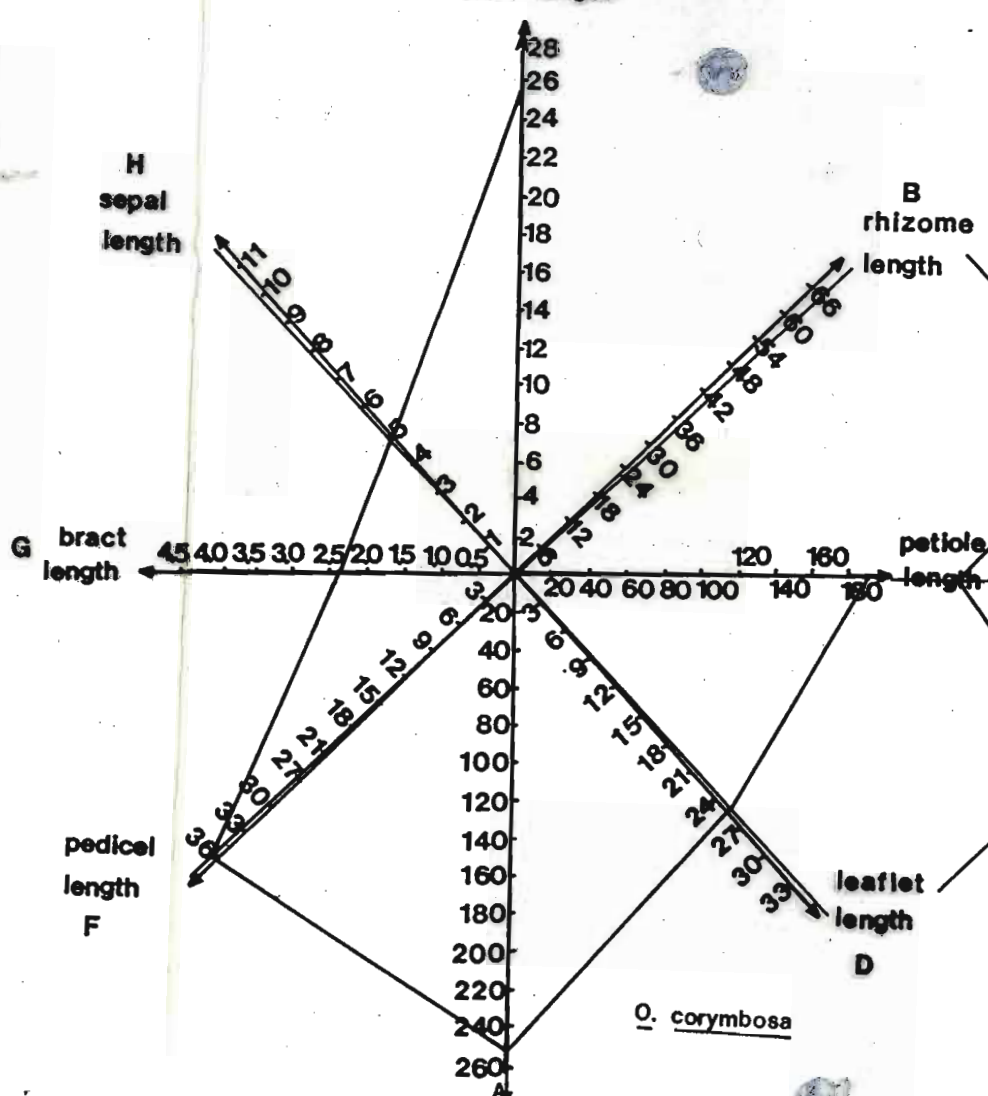




Q. corniculata
bulb length

Q. smithiana

Q. obliquifolia



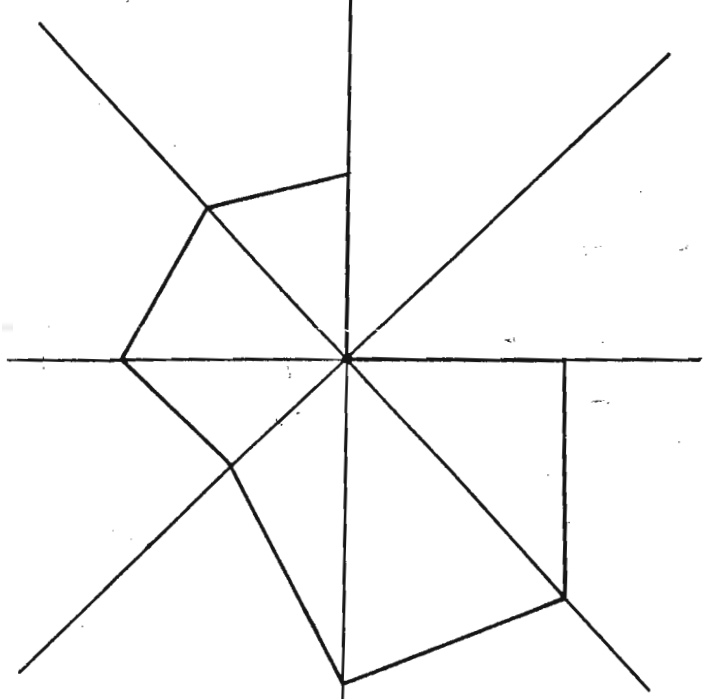
Q. corymbosa

Q. semiloba

Q. pes-caprae

peduncle /scape length

Q. latifolia



Q. corniculata

Q. obliquifolia

Q. smithiana
bulb length

H
sepal
length

B
rhizome
length

G
bract
length

C
petiole
length

F
pedicel
length

D
leaflet
length

Q. corymbosa

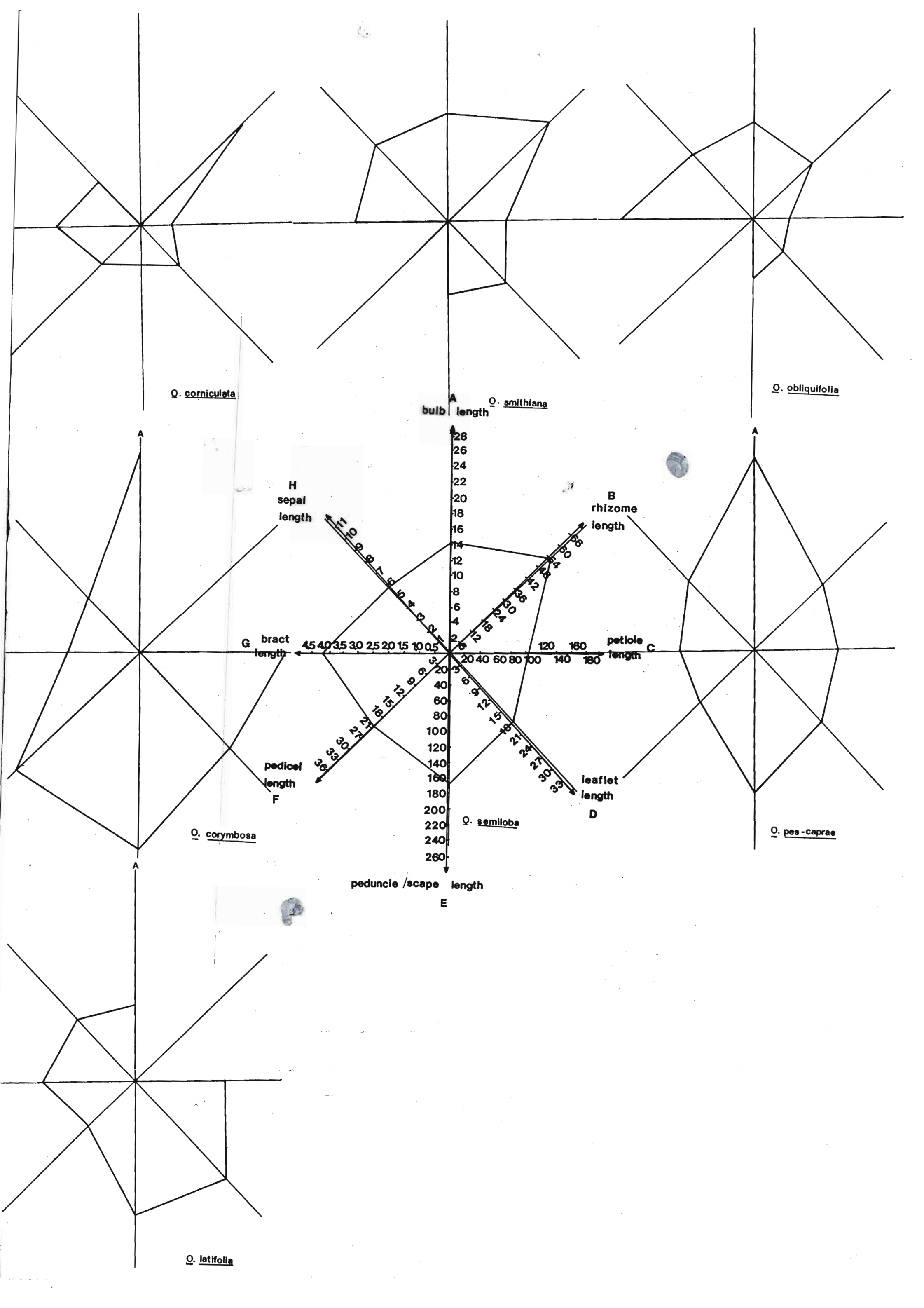
Q. semiloba

Q. pes-caprae

peduncle /scape length

E

Q. latifolia



Q. corniculata

Q. smithiana

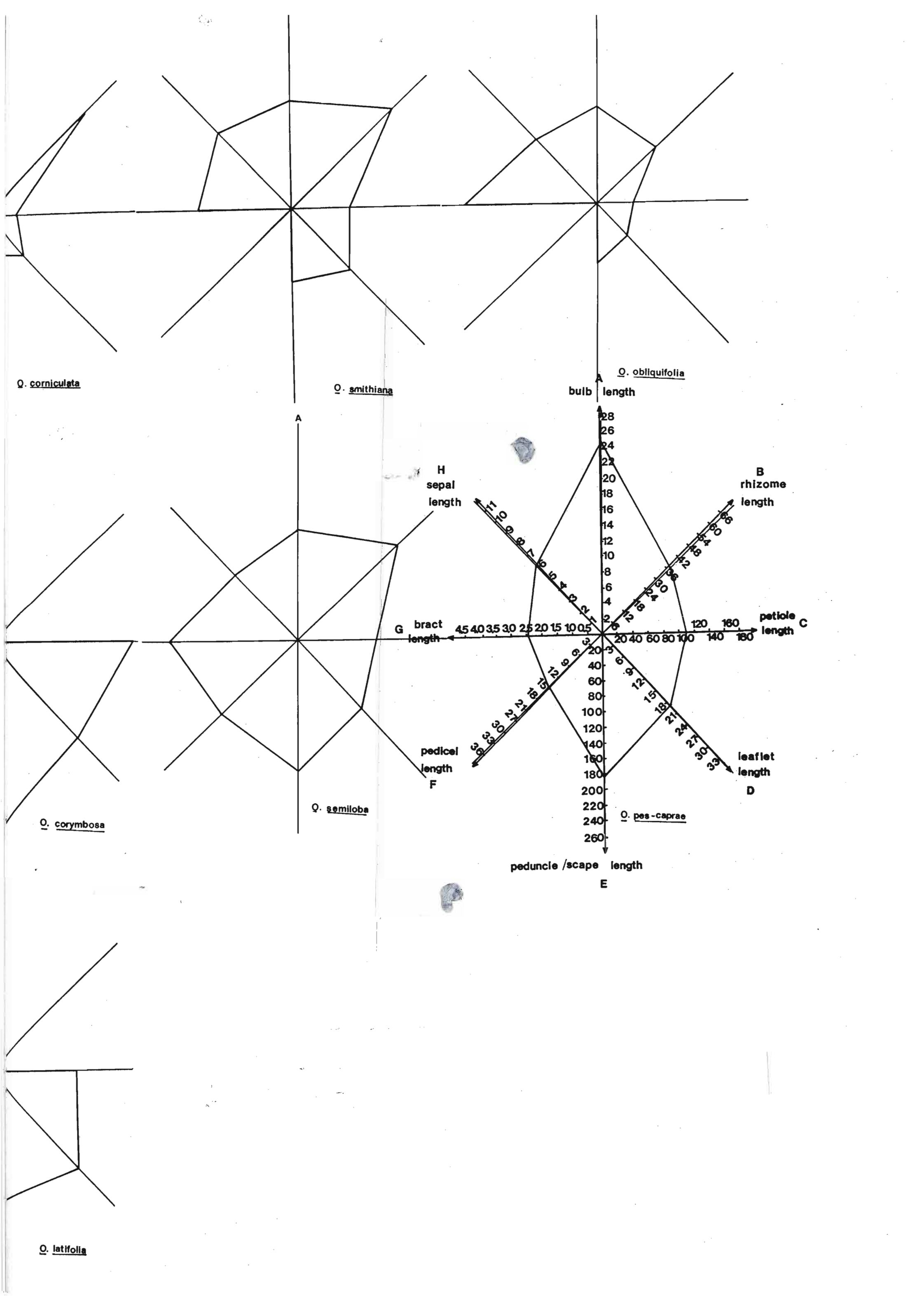
Q. obliquifolia

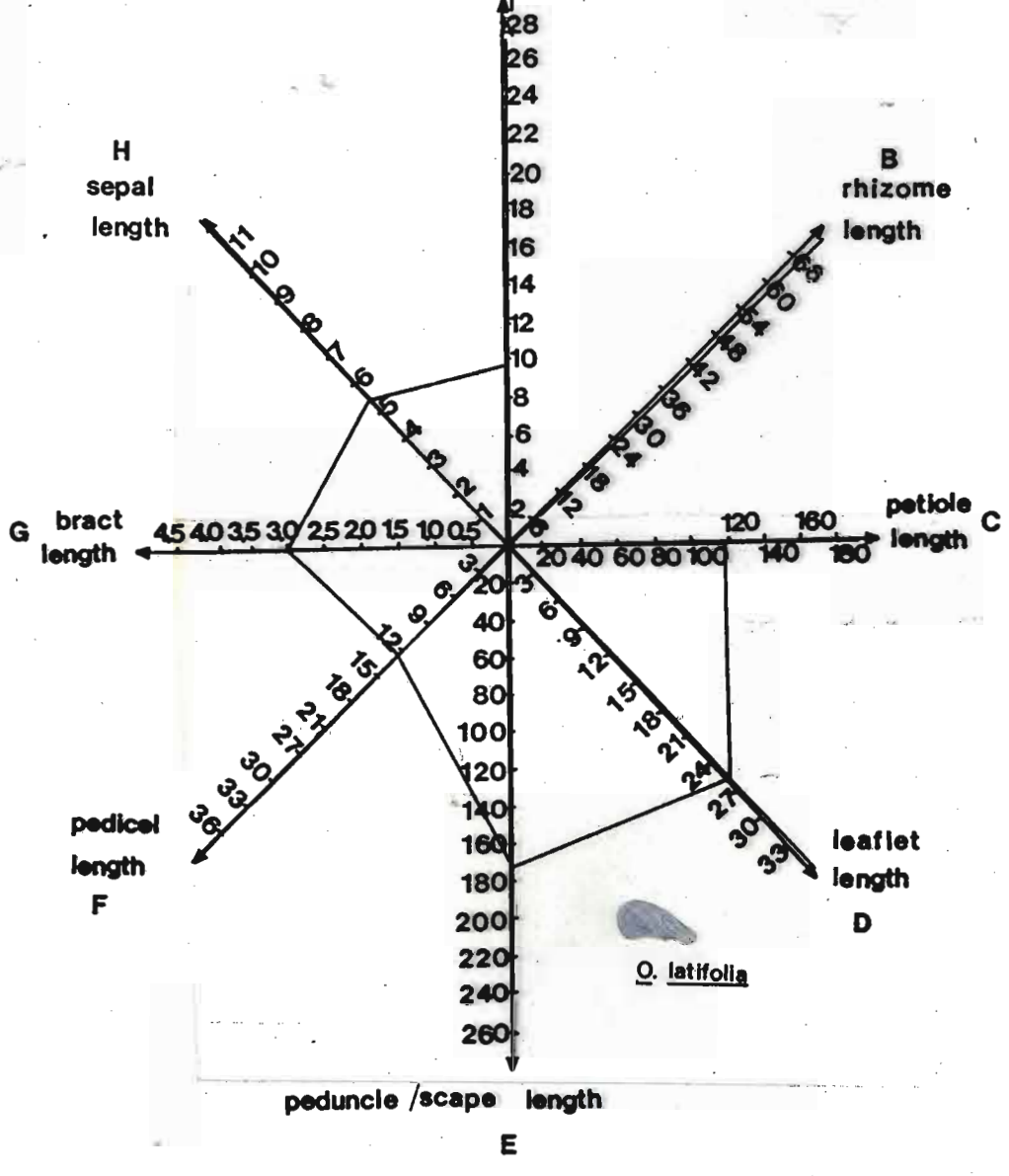
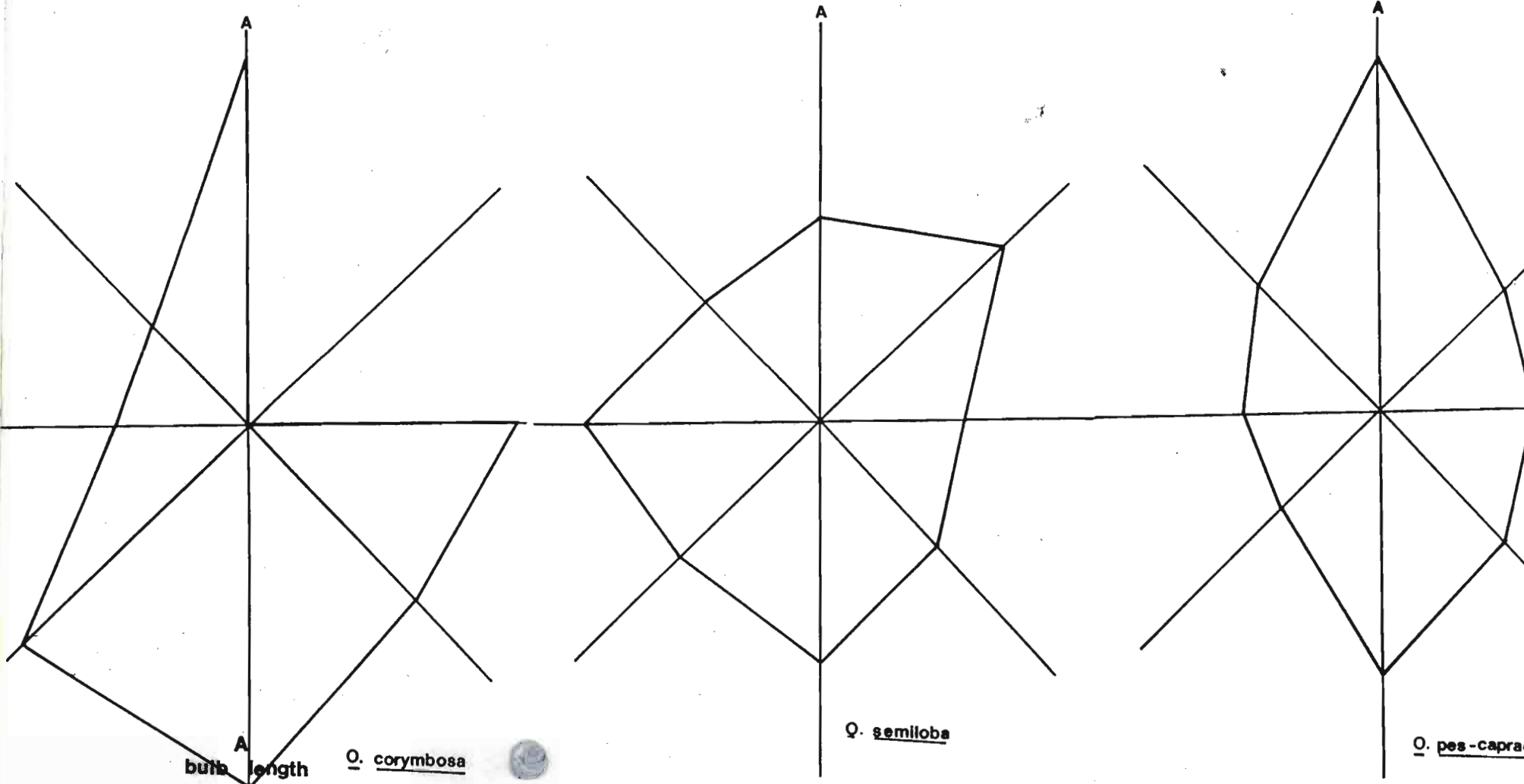
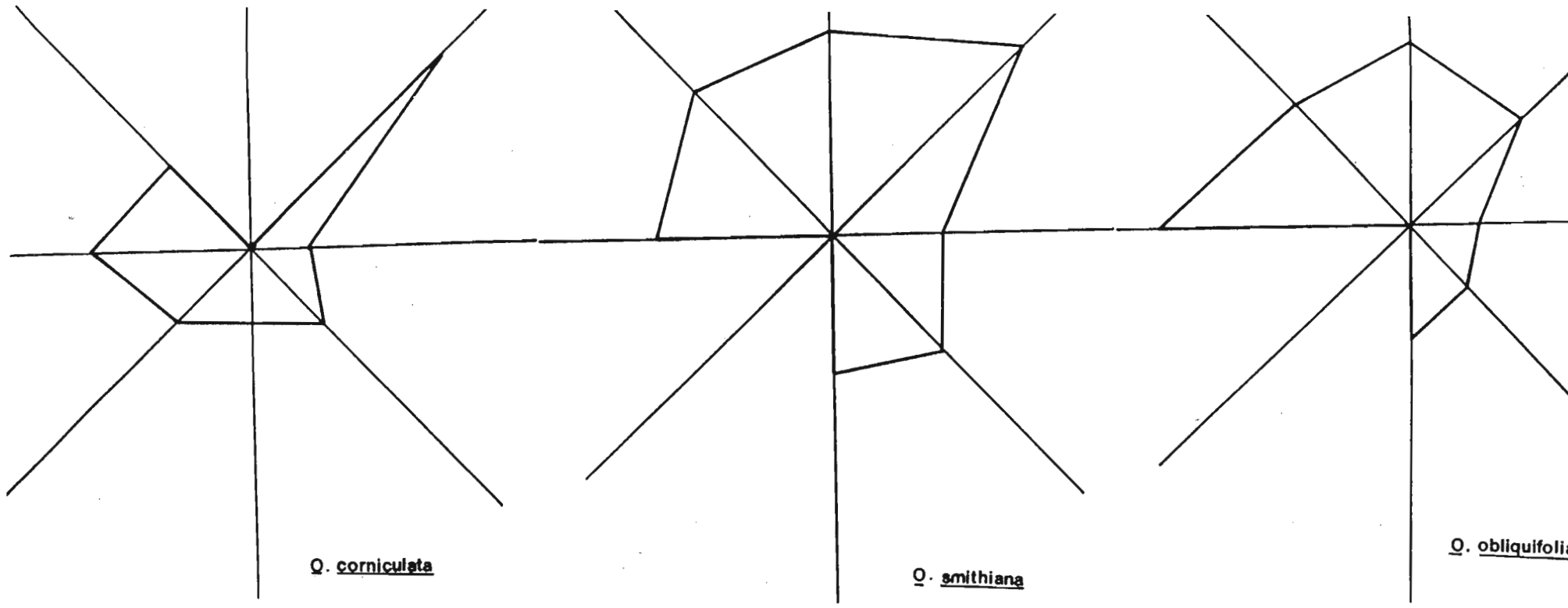
Q. corymbosa

Q. semiloba

Q. pes-caprae

Q. latifolia





D. Average lengths of leaflets

The leaflets of O. latifolia had the longest average length (26.2 mm) whilst O. obliquifolia had the shortest (8.9 mm). It should be noted that the apical leaflets of O. obliquifolia were 2.3 mm broader than the lateral leaflets. O. corymbosa had the second longest leaflets (25.6 mm). The average lengths of leaflets of O. corniculata was 10.7 mm. O. pes-caprae, O. smithiana and O. semiloba were more or less intermediate; measuring 19.0 mm, 17.4 mm and 18.4 mm respectively.

E. Average lengths of peduncles or scapes

O. obliquifolia and O. smithiana possess scapes which bear solitary flowers. The scape length of O. obliquifolia was 77.1 mm whilst that of O. smithiana was 95.6 mm.

The other five species of Oxalis in Natal possess peduncles which bear numerous umbellate pedicels. O. corymbosa had the longest peduncle length (254.5 mm) whilst O. corniculata had the shortest (50.1 mm). The peduncle length of O. corniculata was shorter than the scape lengths of O. obliquifolia and O. smithiana. The scape lengths of these latter two species, however,

were shorter than the peduncles of O. corymbosa, O. latifolia, O. pes-caprae and O. semiloba. Peduncle lengths of the latter three species were 171.6 mm, 187.3 mm and 170.1 mm respectively.

F. Average lengths of pedicels or inflorescence branches

The inflorescence branches of O. corymbosa gave rise to pedicels. Flowers of O. corymbosa were borne upon these pedicels. O. corymbosa was the only Oxalis species in Natal which possessed a compound umbel. The average length of the pedicels were 21.5 mm.

O. corymbosa had the longest inflorescence branch length (33.3 mm) whilst O. corniculata had the shortest pedicel length (10.8 mm). The pedicel length of O. latifolia (12.4 mm) was shorter than that of O. semiloba and O. pes-caprae (20.6 mm and 14.7 mm respectively).

G. Average lengths of bracts

All Natal species of Oxalis are bracteate.

Bract lengths fell into two categories:

- i) greater than 4 mm and
- ii) less than or equal to 3 mm.

The bracts of O. obliquifolia and O. semiloba fell into the first category; having lengths of 4.2 mm and 4.1 mm respectively. The other species fell into the second category. The average bract lengths in the second category were: O. latifolia and O. smithiana 3.0 mm; O. corniculata 2.7 mm; O. pes-caprae 2.4 mm and O. corymbosa 2.3 mm.

H. Average lengths of sepals

Sepals lengths of the different species of Oxalis in Natal ranged between 3.9 mm and 6.8 mm. O. smithiana had the longest average sepal length. O. corniculata had the shortest sepal length. The average sepal length of O. pes-caprae, at 6.2 mm, was slightly shorter than that of O. smithiana. The sepal lengths of O. semiloba (5.8 mm), O. obliquifolia (5.7 mm) and O. latifolia (5.5 mm) were almost equal. The average sepal length of O. corymbosa was 4.8 mm.

Figures 18a and 18b

I. Average lengths of corollas

O. corniculata had the shortest average length (6.8 mm). The corollas of O. corymbosa, O. latifolia, O. semiloba, O. obliquifolia and O. smithiana varied from 13.9 mm to 17.8 mm. O. pes-caprae had the longest average length (20.9 mm).

J. Average lengths of long stamens

Average lengths varied from 8.5 to 5.5 mm. O. obliquifolia had the longest (8.5 mm). The long stamen length of O. semiloba was 7.5 mm; of O. smithiana was 7.0 mm and of O. latifolia was 6.1 mm. O. corymbosa had the shortest length (5.5 mm).

K. Average lengths of short stamens

The average lengths of O. corniculata (3.1 mm), O. corymbosa (3.0 mm) (introduced weeds) were almost equal. The stamen lengths of these species were shorter than those of O. smithiana (3.8 mm), O. semiloba (3.9 mm) and O. obliquifolia (4.3 mm). O. obliquifolia had the longest average length whilst O. corymbosa and O. latifolia had the shortest.

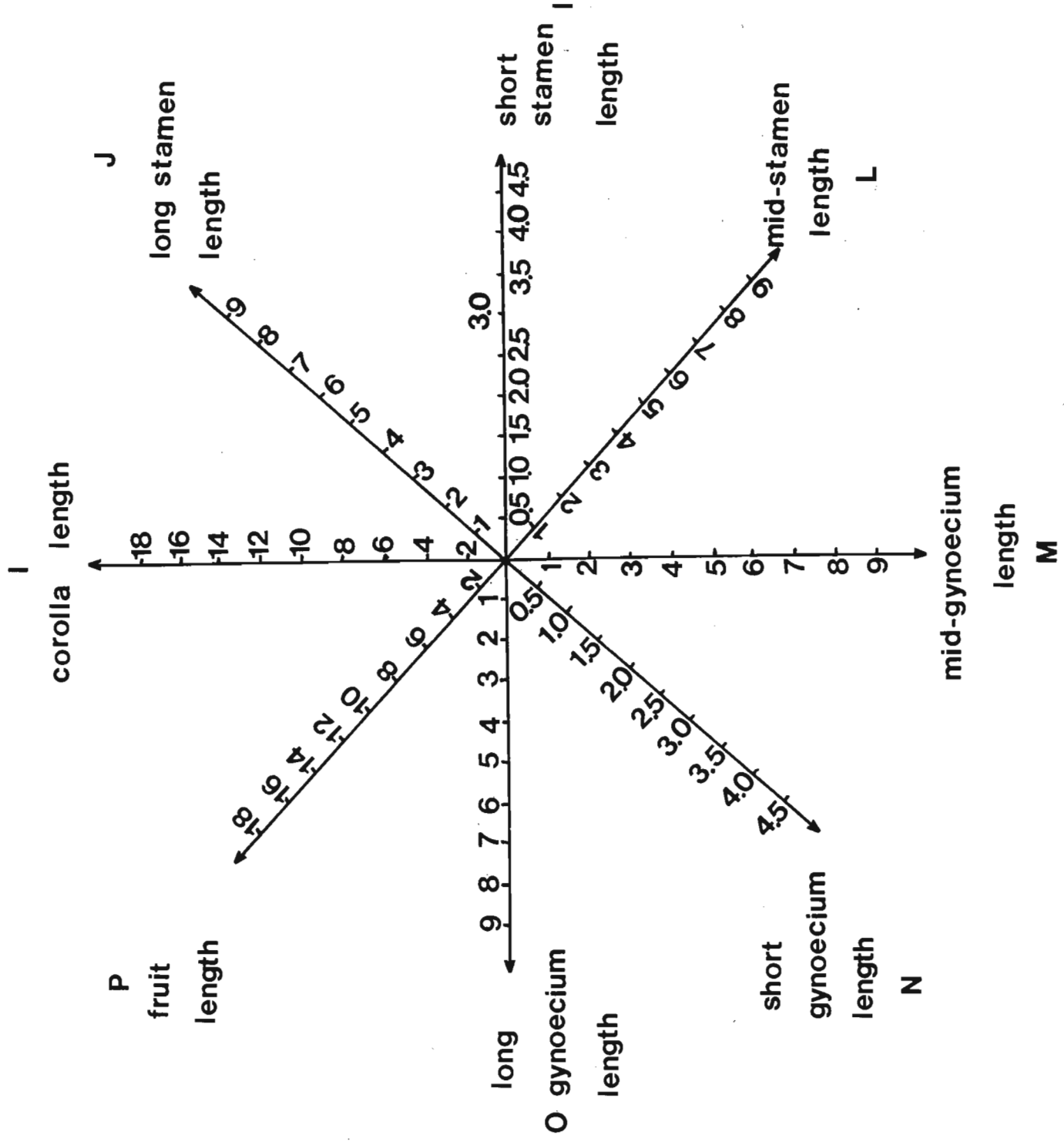


Fig 18a. Polygonal Graph Master Plan (II) (arms I - P)

L. Average lengths of mid-stamens

Findings of the present investigation indicated that there is the chance that only the mid-gynoecial forms of O. corymbosa and O. latifolia were introduced into Natal. Thus no flowers with mid length stamens occur in Natal.

All three gynoecial and hence all three stamen lengths exist, in Natal, for O. obliquifolia, O. semiloba and O. smithiana. The average lengths of the mid-stemans of these species were 5.9 mm, 5.4 mm and 5.3 mm respectively.

The average mid-stamen length of O. corniculata was 4.5 mm.

M. Average lengths of mid-gynoecia

All Natal species of Oxalis studied possessed the mid-gynoecial forms. O. obliquifolia had the longest length (6.4 mm) whilst O. corymbosa had the shortest (4.0 mm). The mid-gynoecial lengths of O. smithiana and O. semiloba exceeded 5.0 mm; being 5.3 mm and 5.5 mm respectively. The mid-gynoecial length of O. latifolia, however, was slightly less than 5.0 mm; being 4.6 mm.

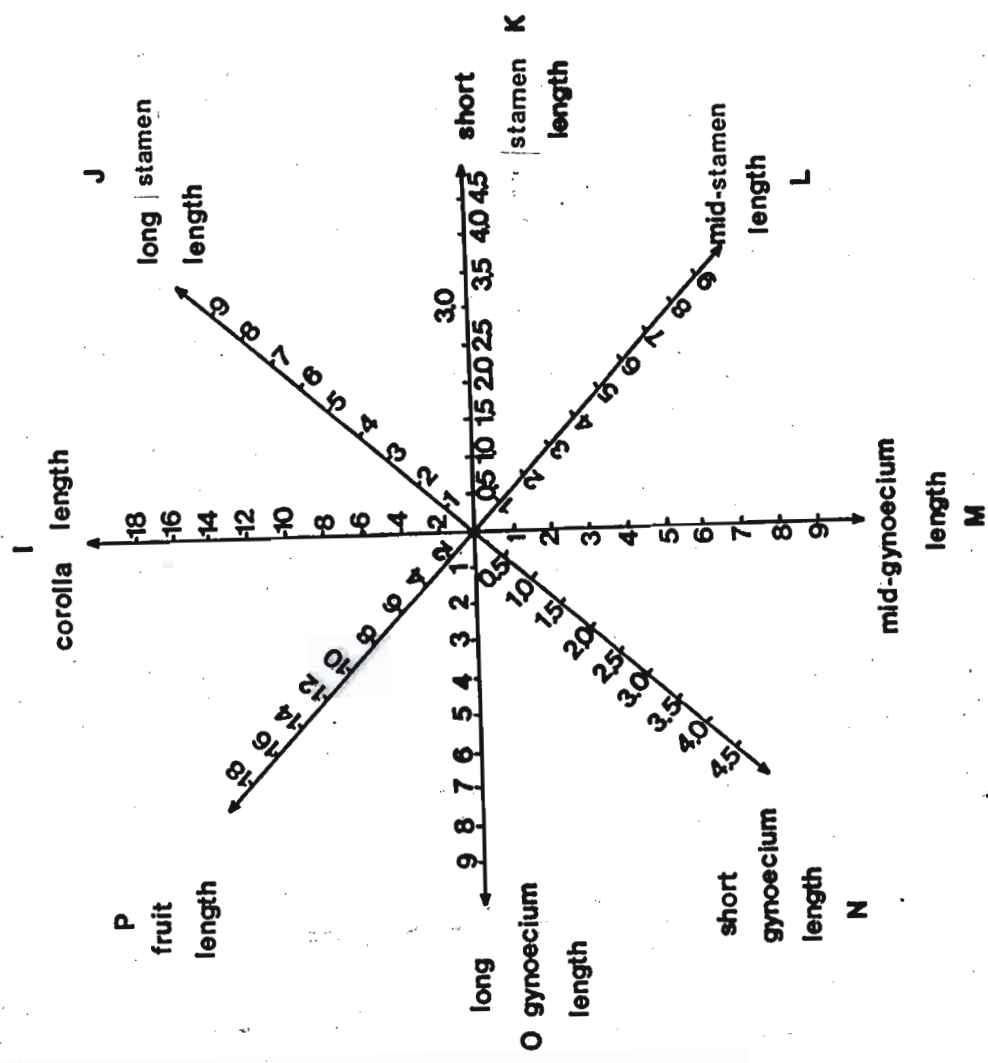
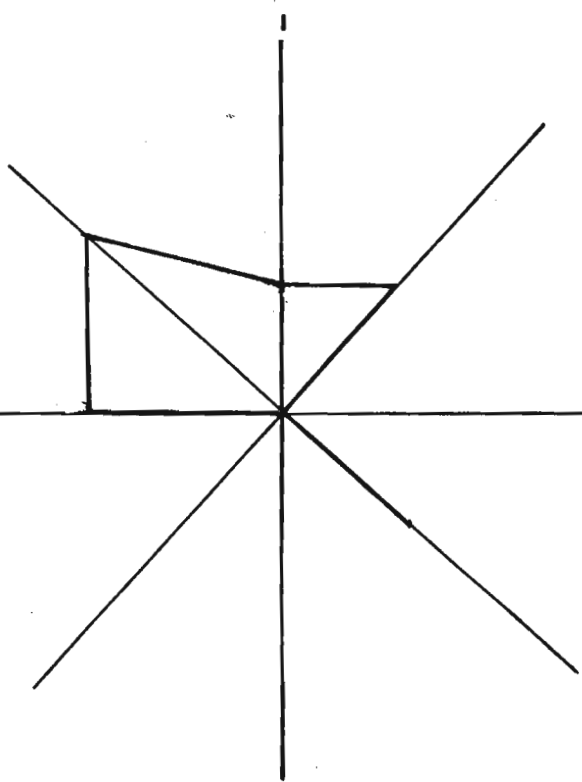
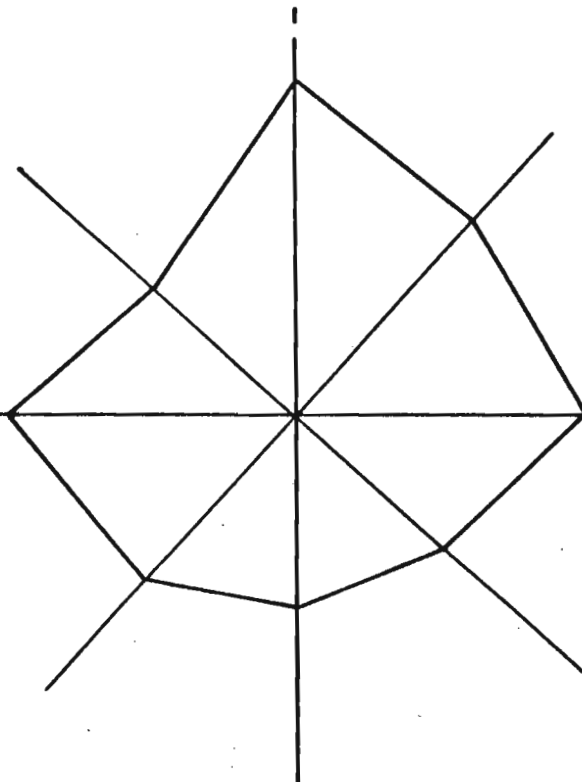


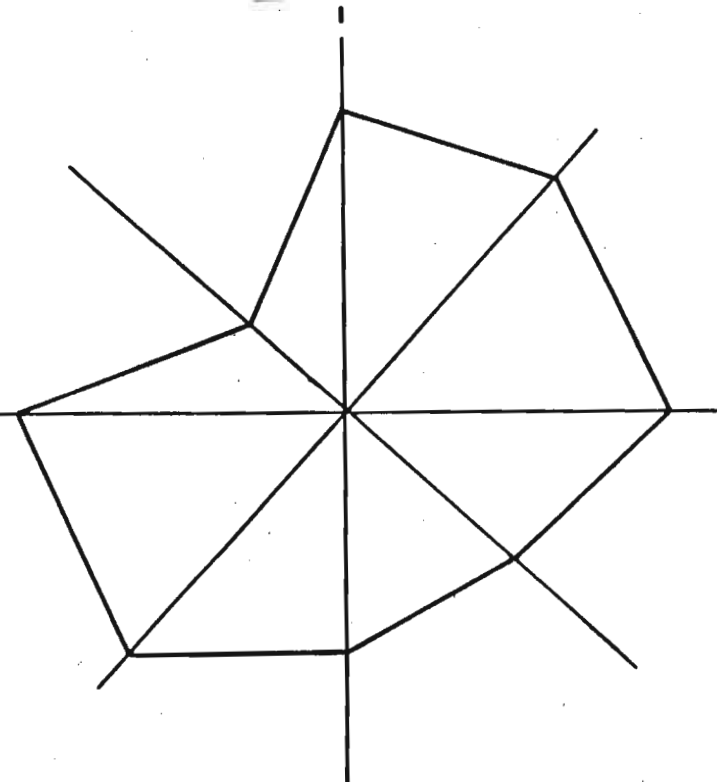
Fig 18b. Polygonal Graphs (II) of *Oxalis* spp.



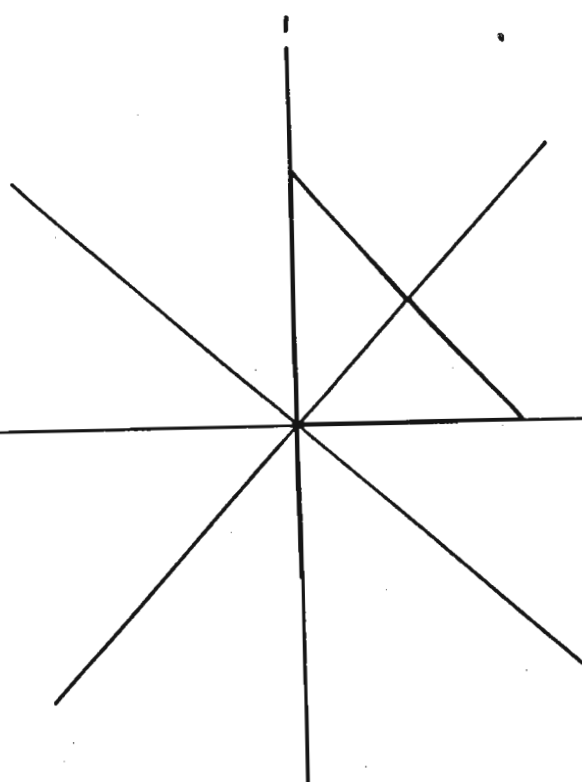
Q. corniculata



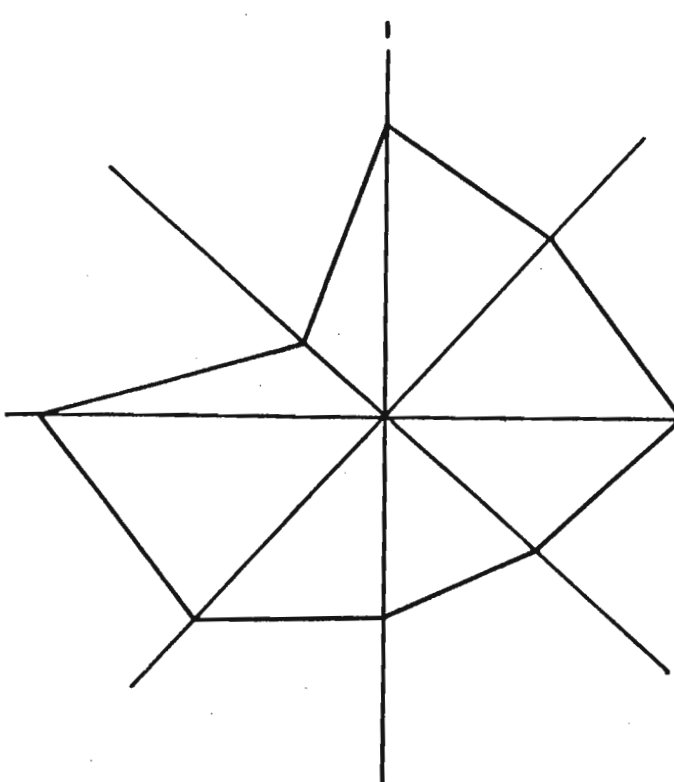
Q. smithiana



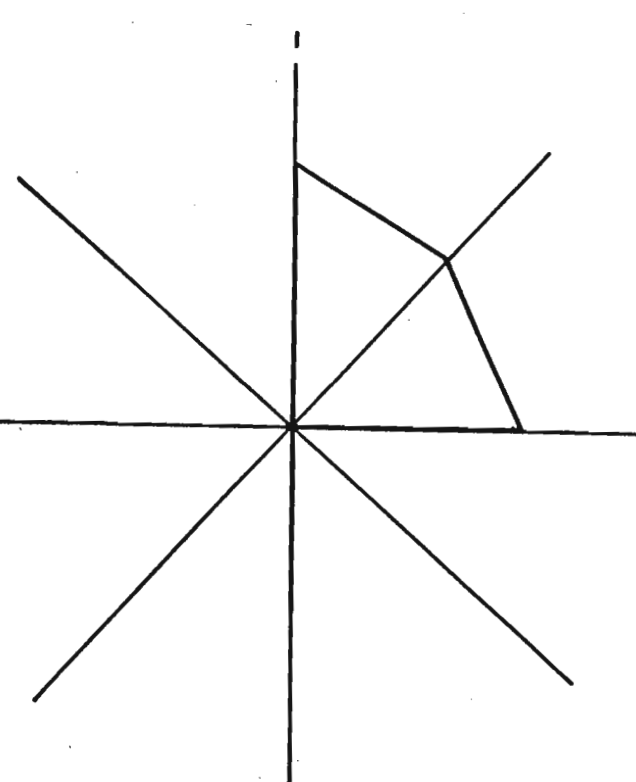
Q. obliquifolia



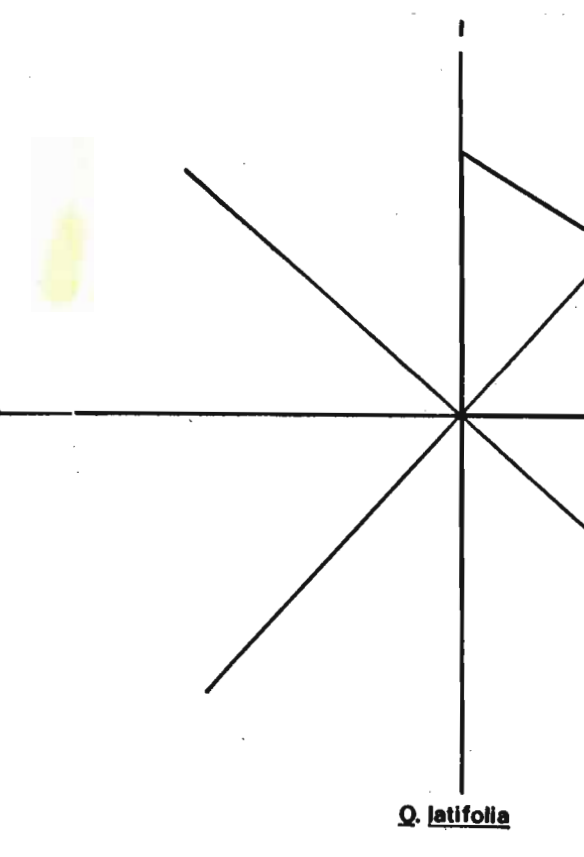
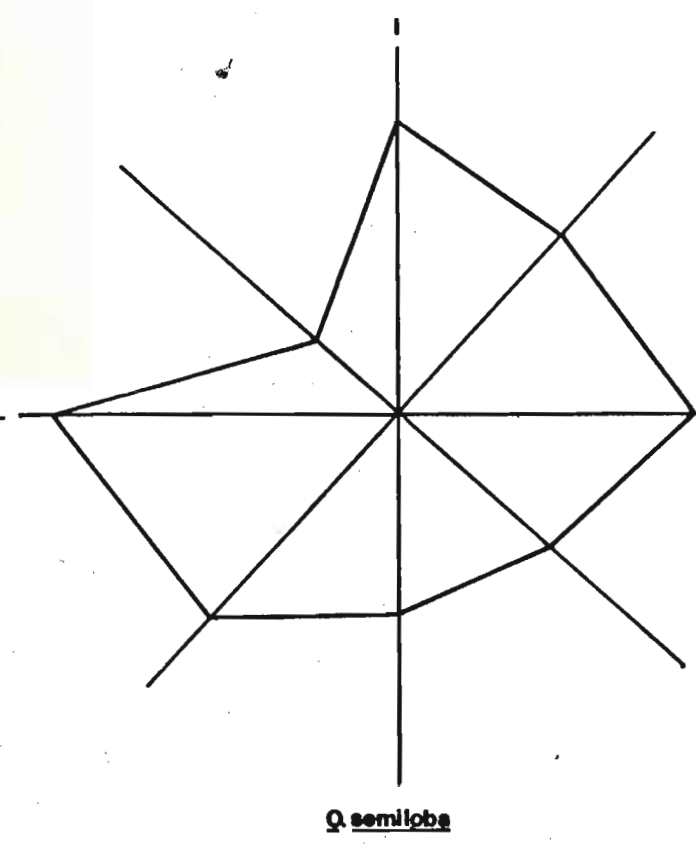
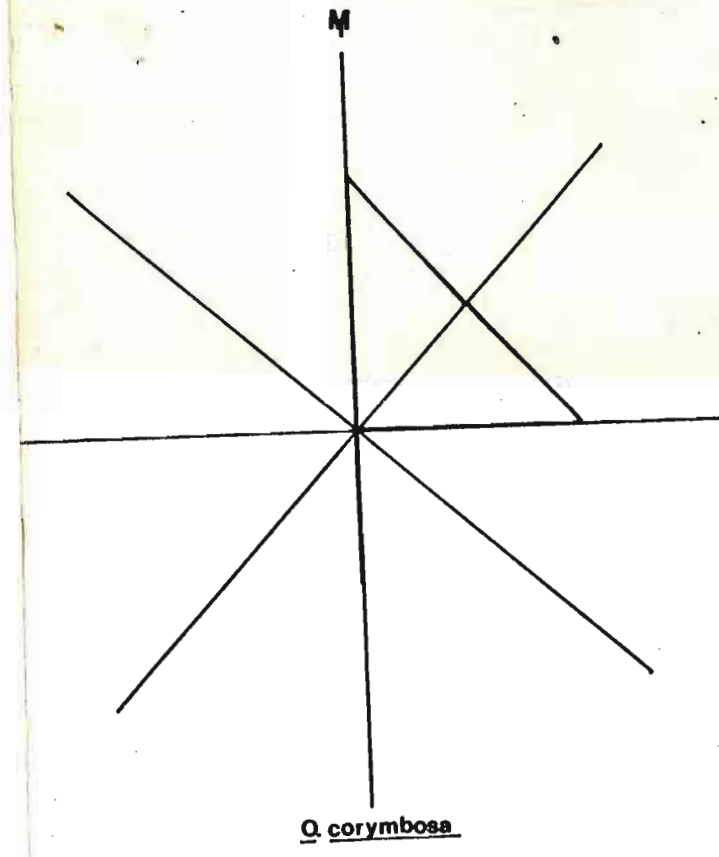
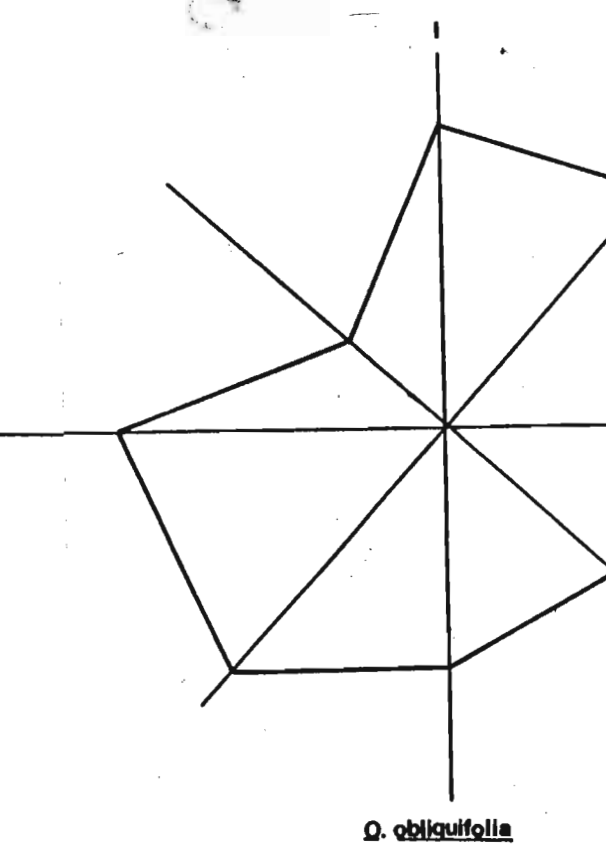
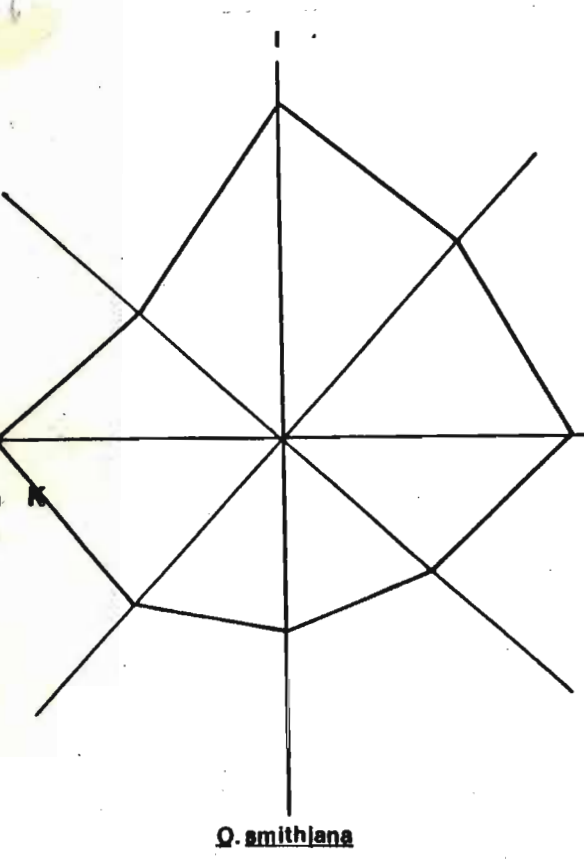
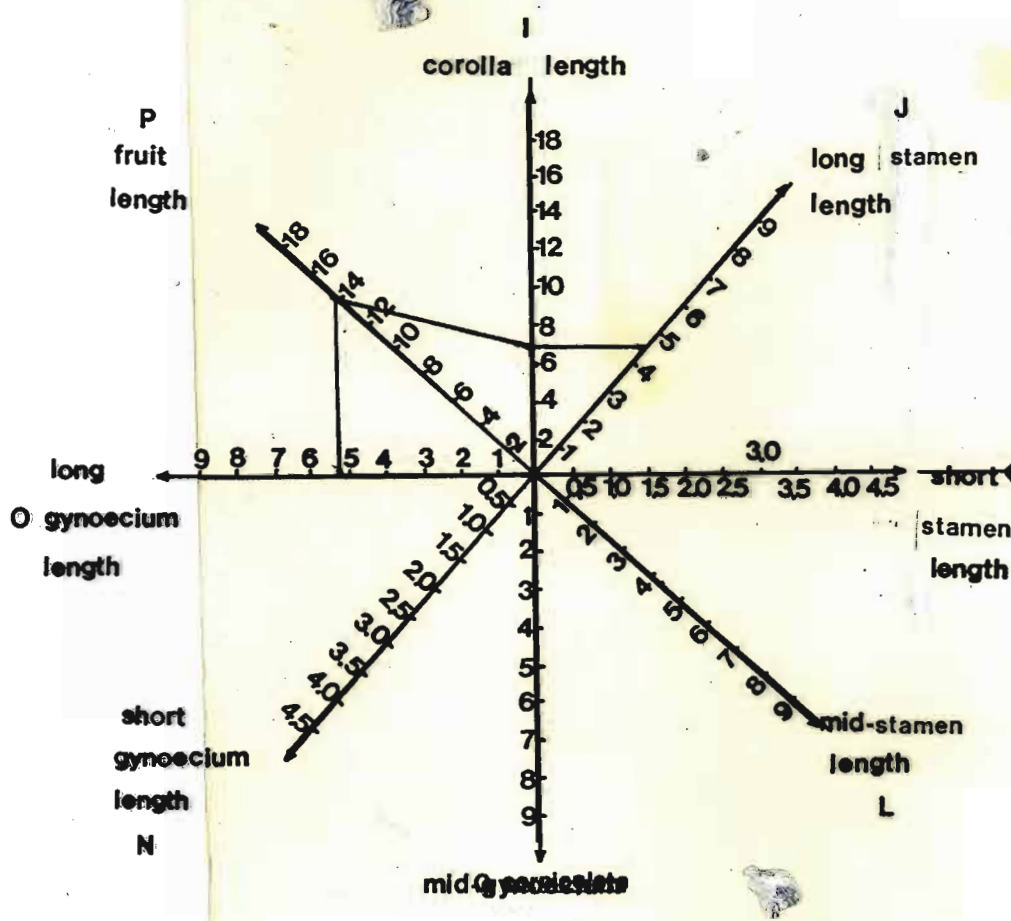
Q. corymbosa

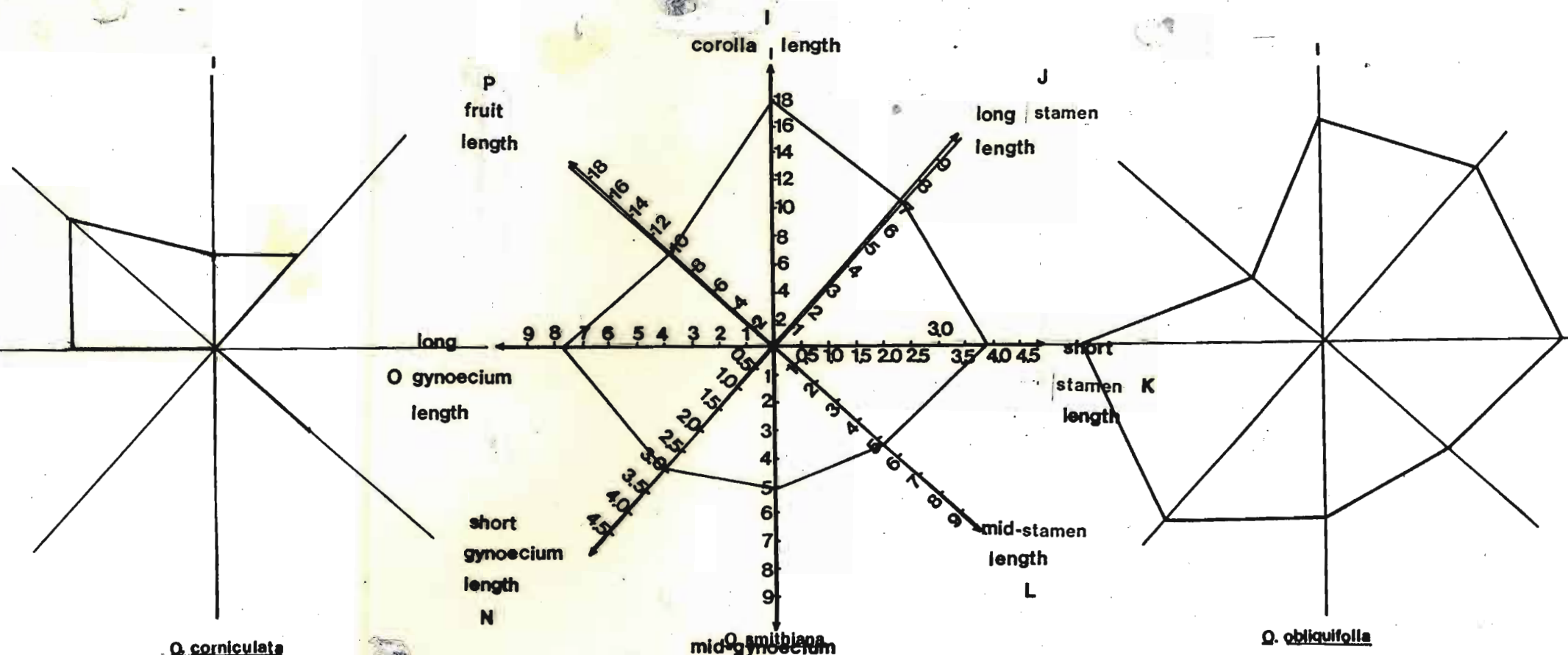


Q. semiloba



Q. latifolia

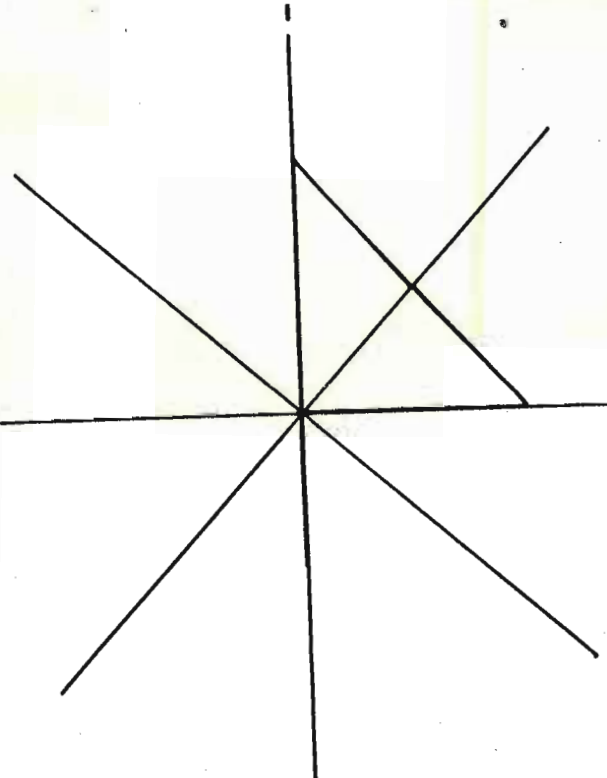




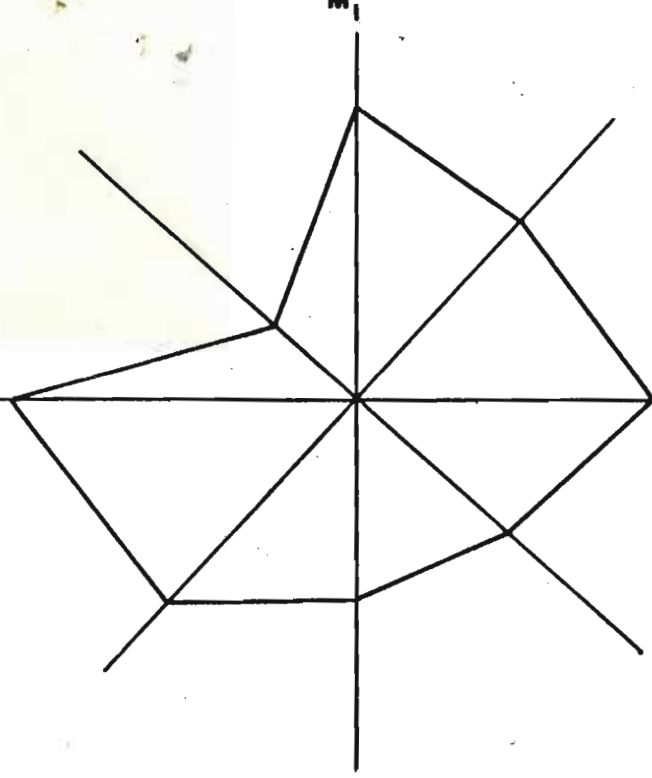
Q. corniculata

Q. ambigua

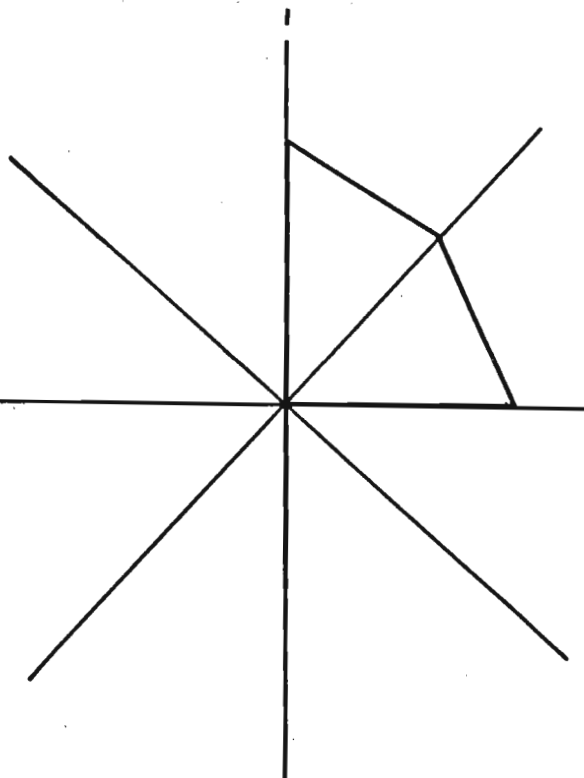
Q. obliquifolia



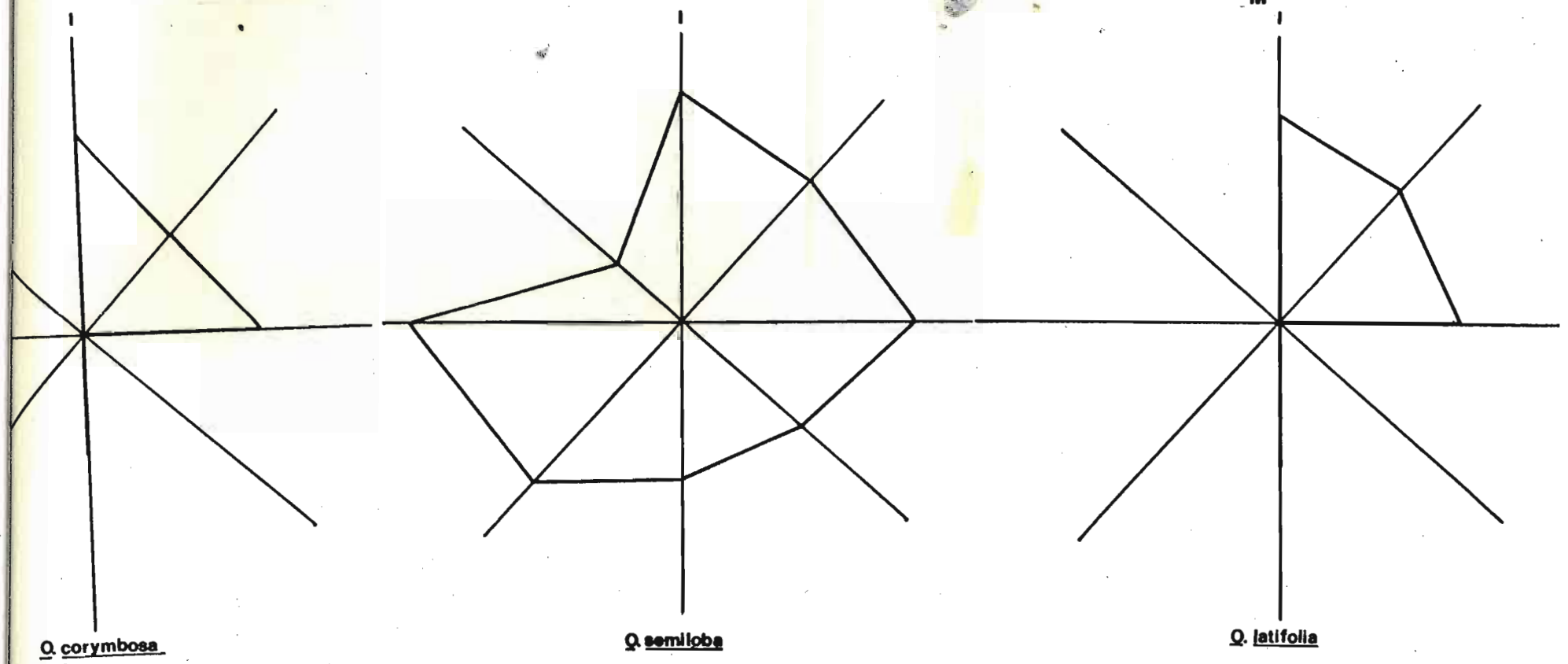
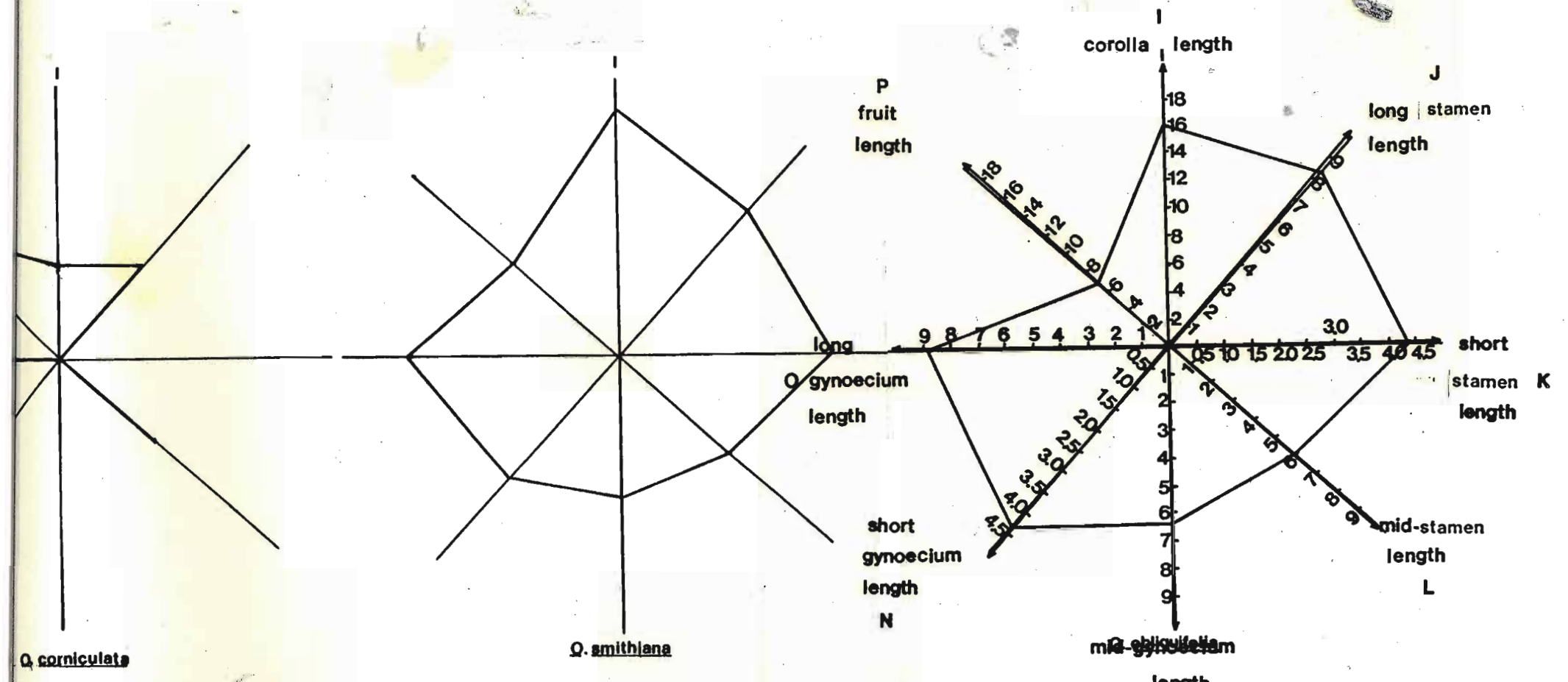
Q. corymbosa

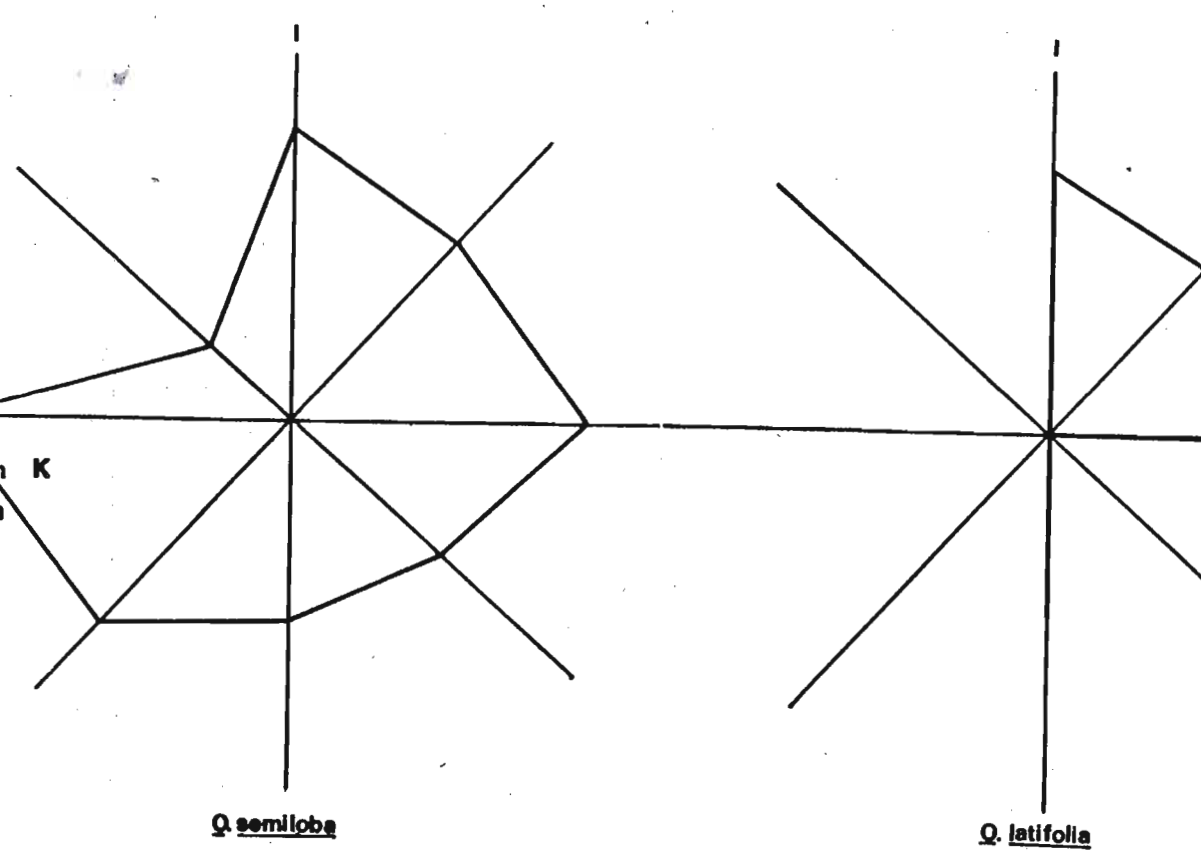
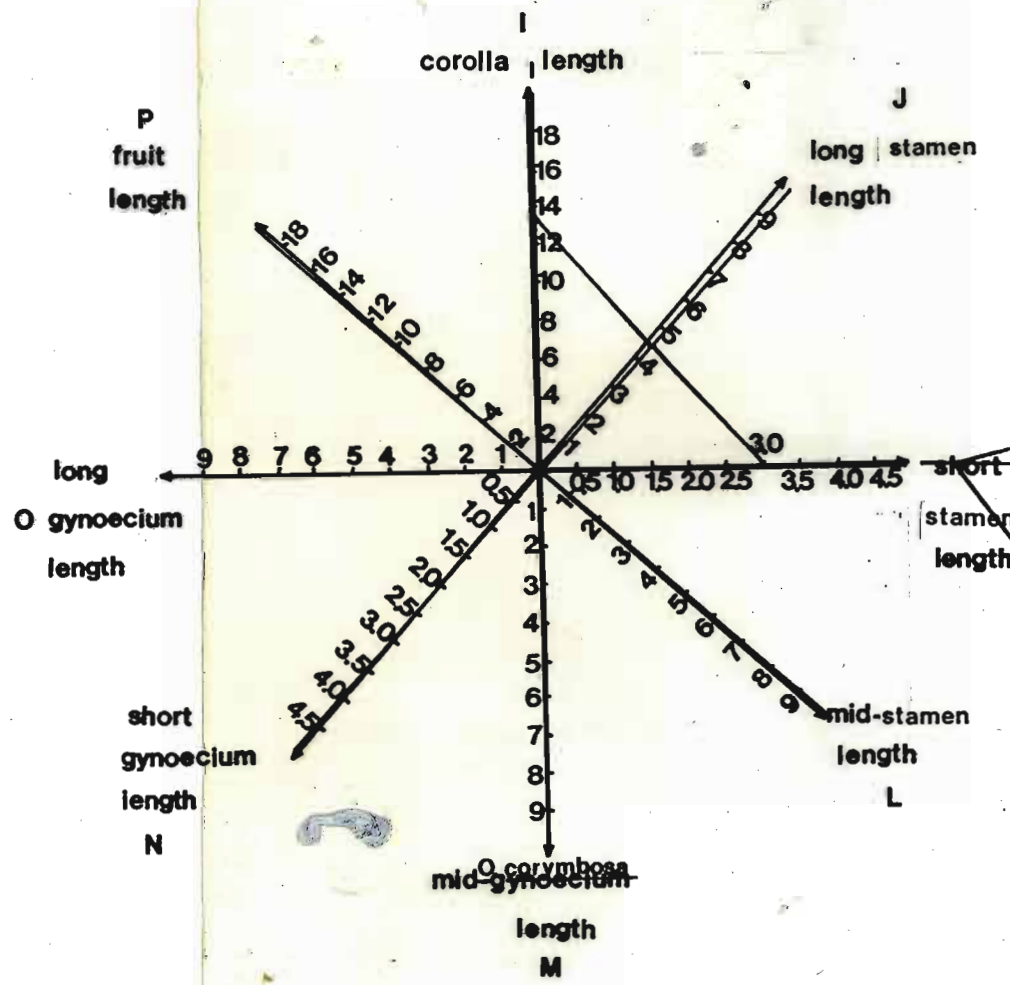
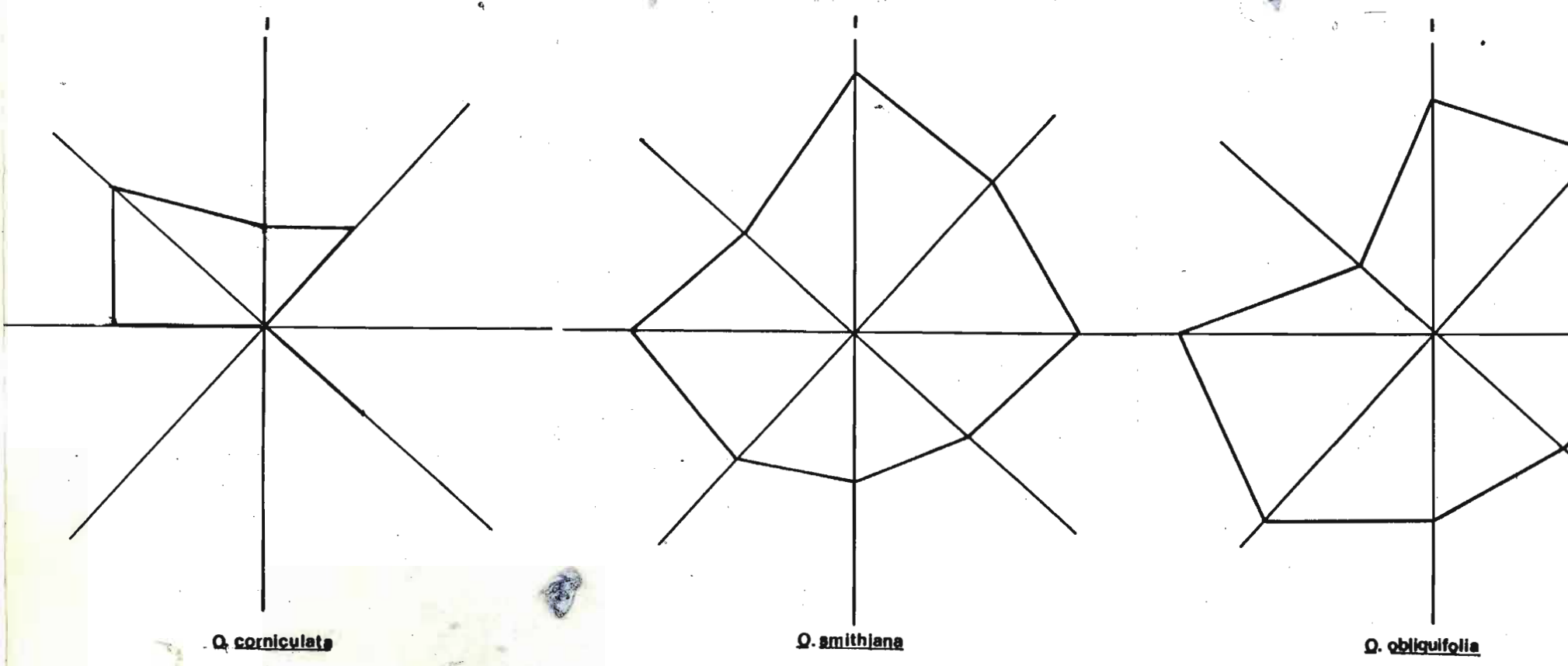


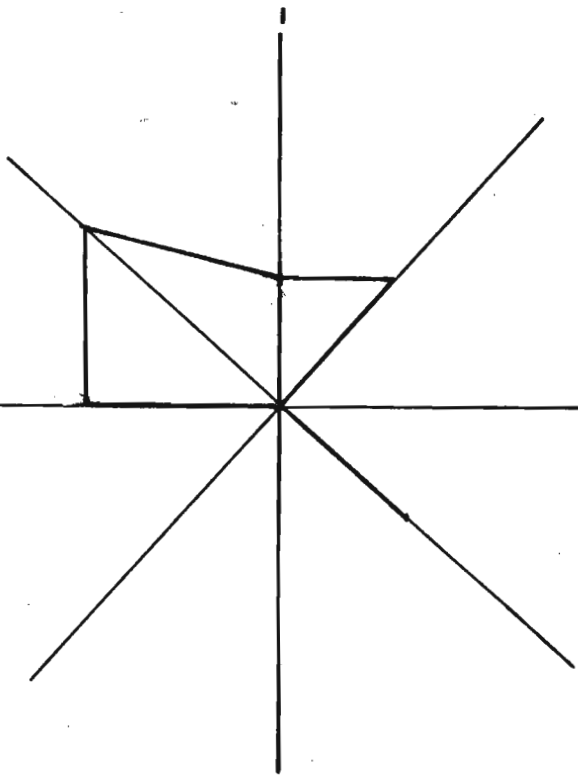
Q. semiloba



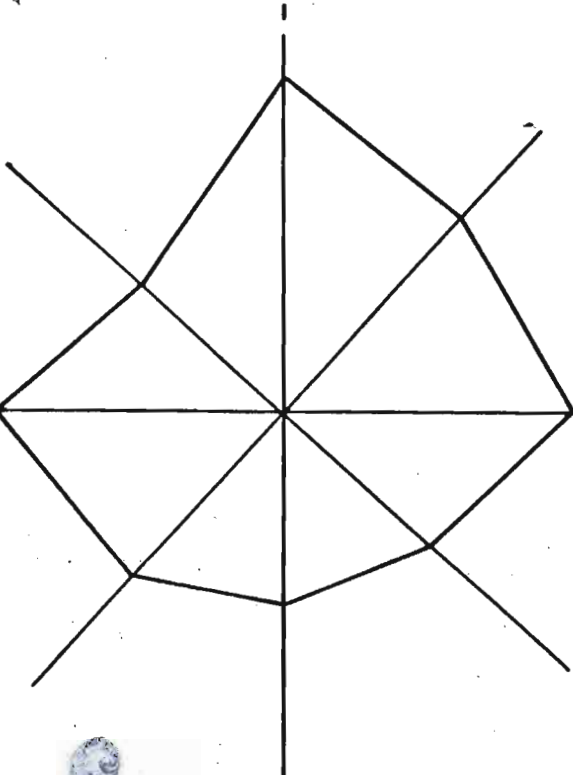
Q. latifolia



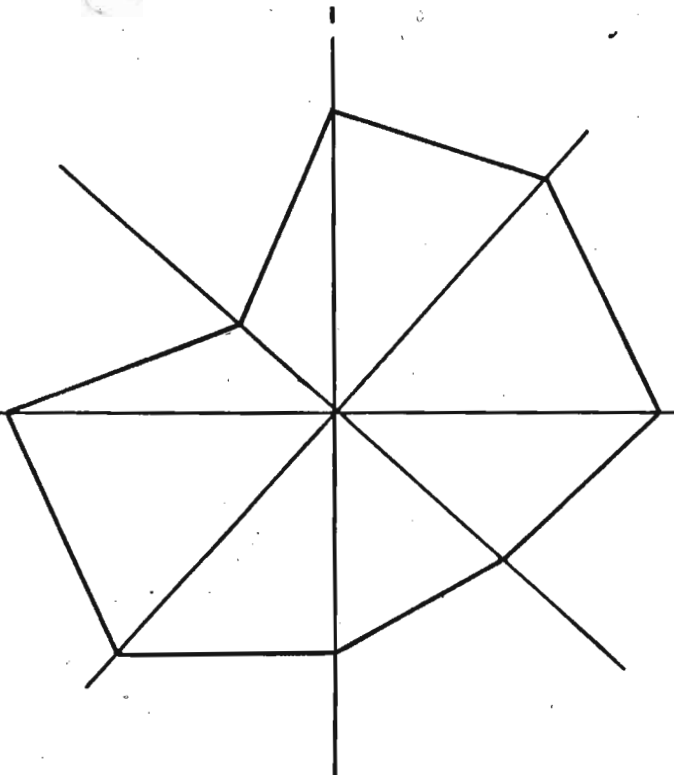




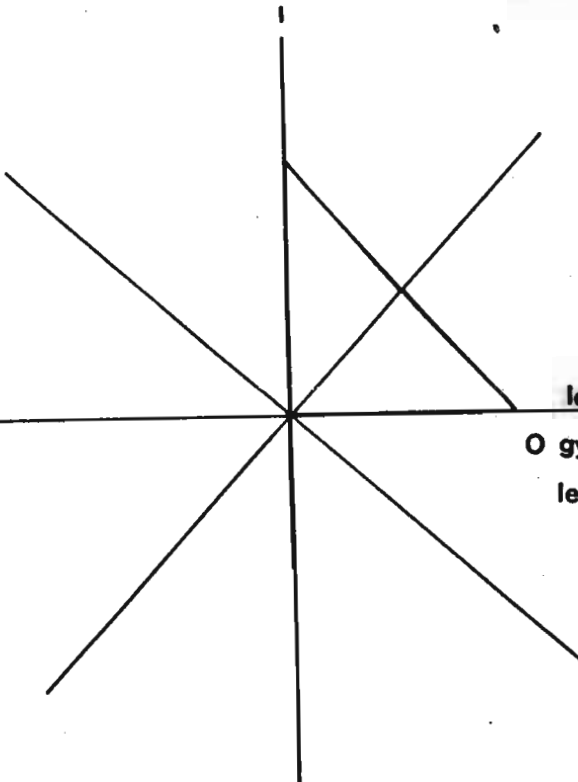
Q. corniculata



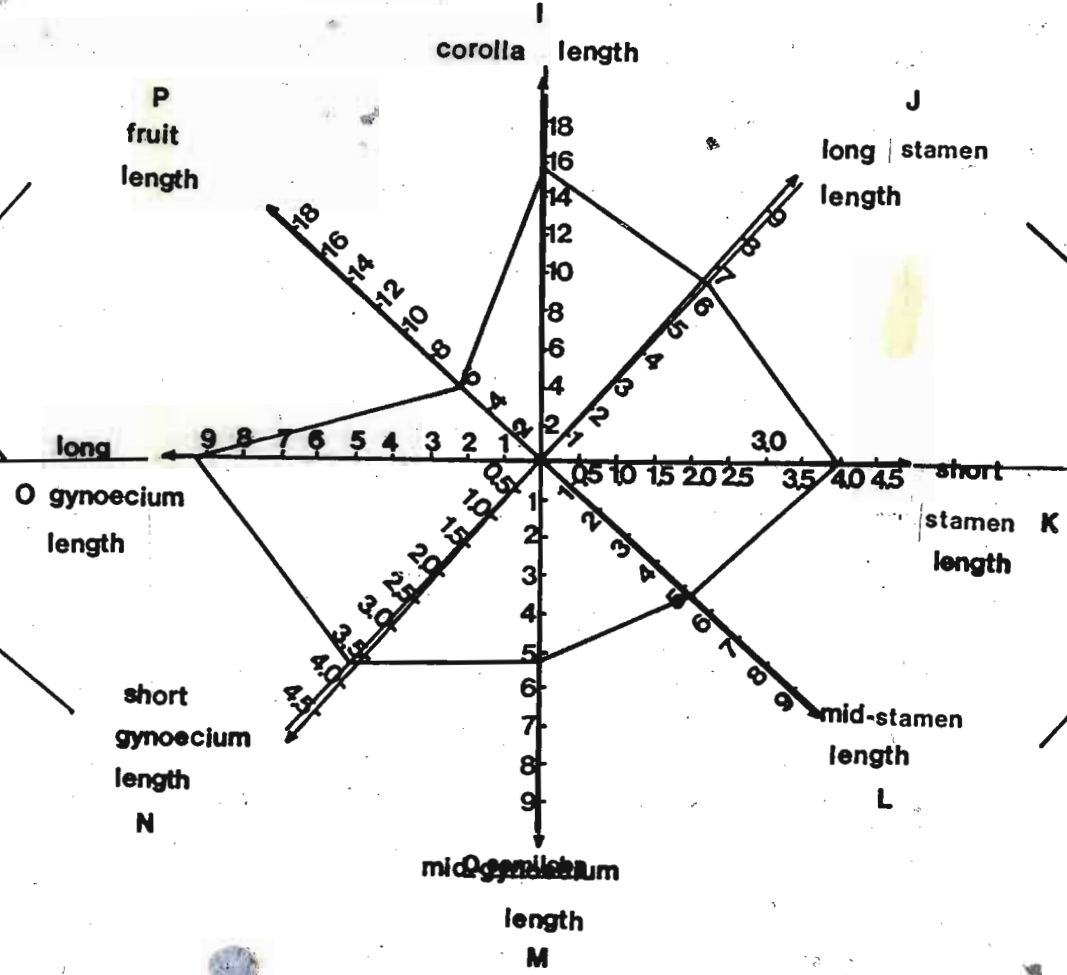
Q. smithiana



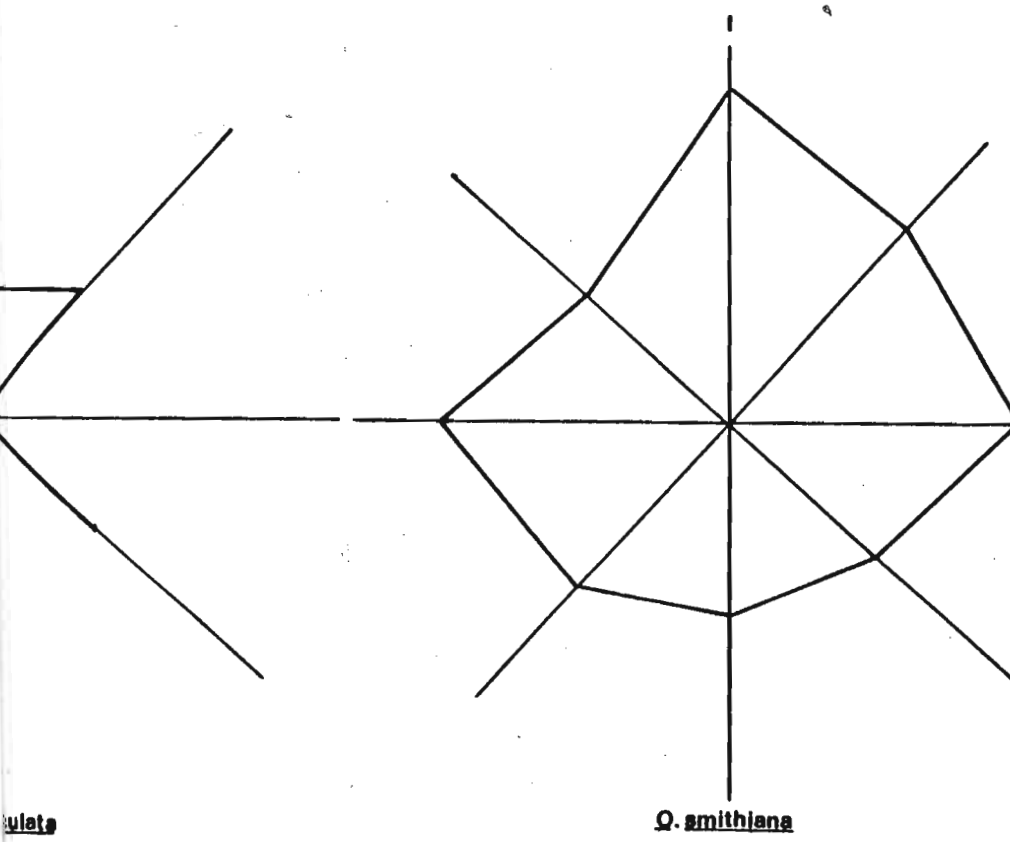
Q. obliquifolia



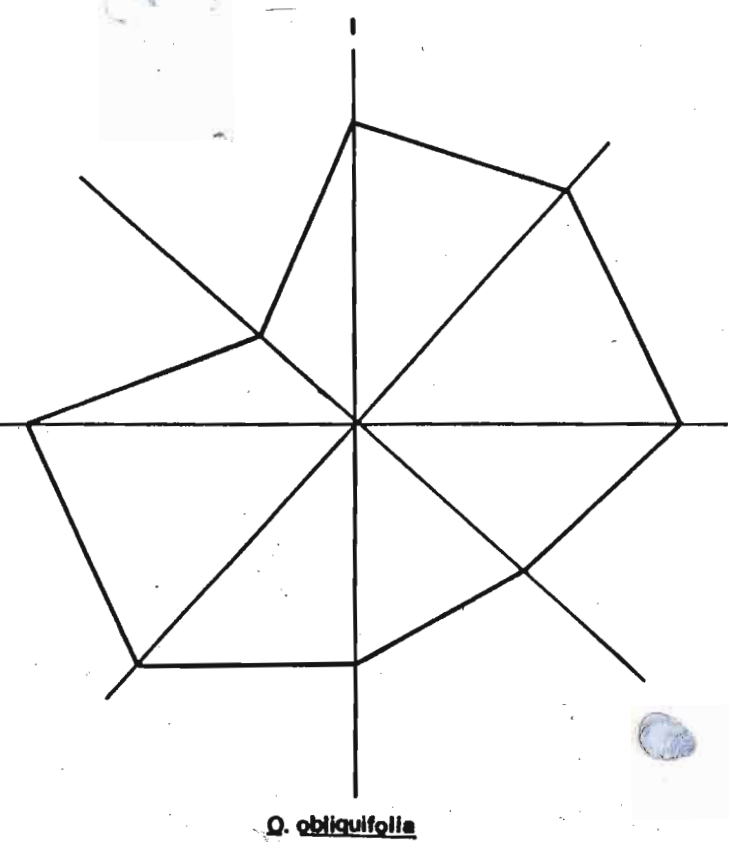
Q. corymbosa



Q. latifolia

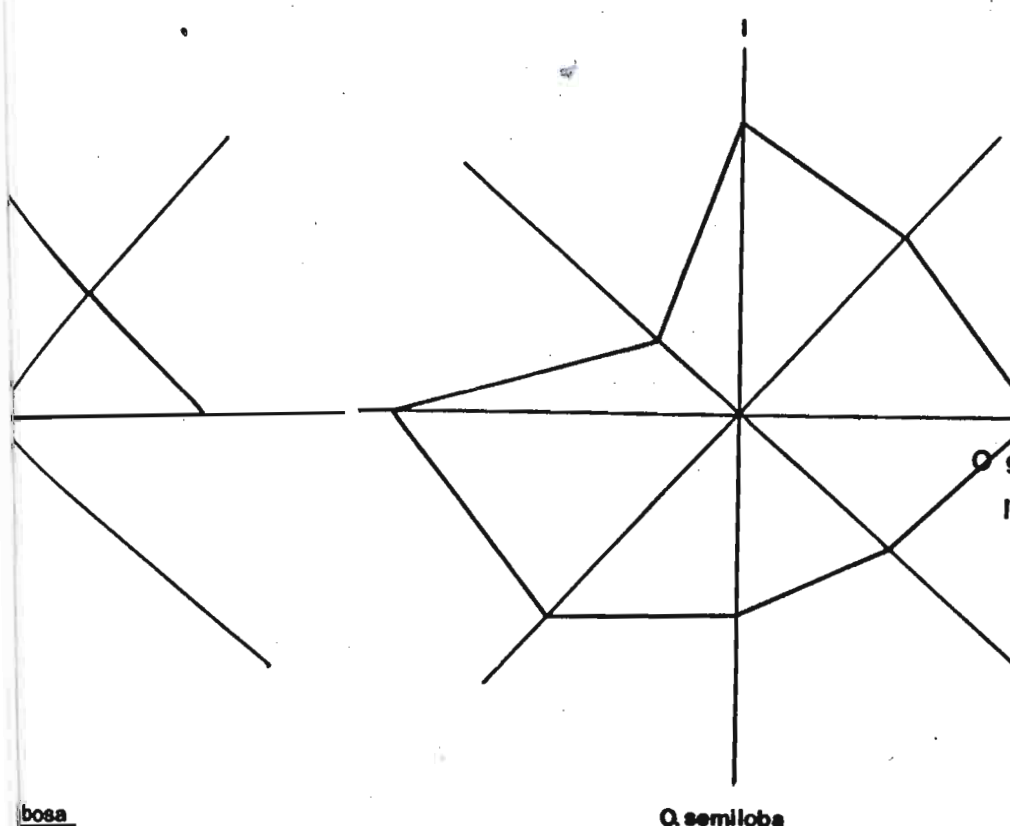


Q. smithiana



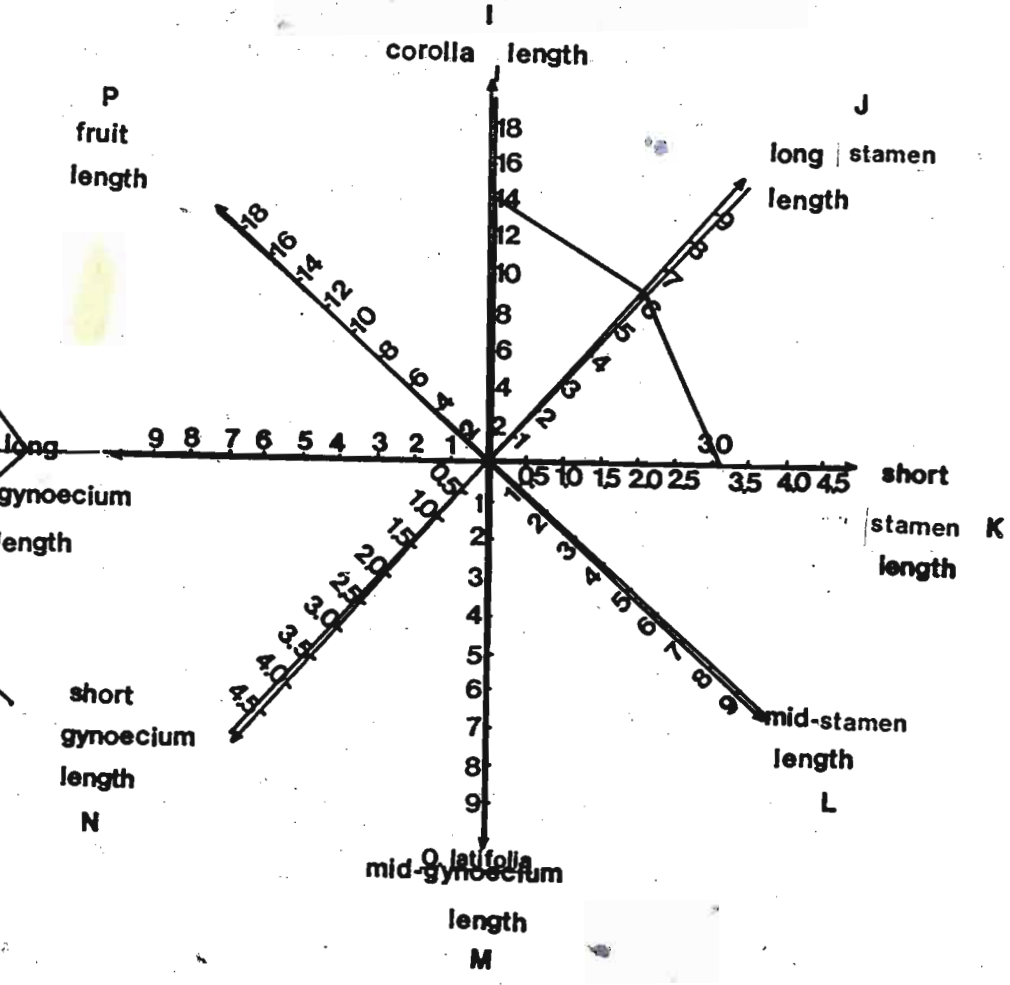
Q. obliquifolia

ulate



Q. semiloba

boea



Q. latifolia

N. Average lengths of short gynoecia

Of all the species of Oxalis in Natal studied by the author, only O. obliquifolia, O. semiloba and O. smithiana possessed the short gynoecial form of flowers. The gynoecial length of O. obliquifolia was 4.4 mm, that of O. semiloba 3.7 mm and that of O. smithiana 3.0 mm.

O. Average lengths of long gynoecia

The author has not found any specimens of O. corymbosa and O. latifolia that possess either the longer or short gynoecial forms. The long gynoecial forms of O. semiloba, O. obliquifolia and O. smithiana, as stated before, are present in Natal. Their lengths varied from 9.1 mm in O. semiloba, 8.7 mm in O. obliquifolia to 7.6 mm in O. smithiana. The average long gynoecial length of O. corniculata was 4.8 mm.

P. Average lengths of fruit

Fruits were absent from all specimens of O. corymbosa and O. latifolia examined. This led to the speculation that these two species are propagated vegetatively, in Natal, by means of bulbils. Fruits were observed, mainly on herbarium specimens, of O. smithiana, O.

obliquifolia, O. semiloba and O. corniculata. Lengths were varied, with O. corniculata having the longest fruit (14.4 mm) and O. semiloba the shortest (5.9 mm). The average lengths of the fruit of O. obliquifolia was 7.0 mm and that of O. smithiana was 10.0 mm.

Figures 19a and 19b

Q. Average widths of bulbs

The overall width of the "bulbs" of O. corymbosa was the widest (24.3 mm). Each bulbil that constitutes the "bulb", however, had an average width of 4.0 mm. O. latifolia had the widest bulb (11.8 mm) apart from O. corymbosa. O. obliquifolia had the narrowest (8.5 mm) whilst the average width of O. pes-caprae, according to Salter (l.c.), was 10.0 mm. Bulbs are absent from O. corniculata.

R. Average widths of leaflets

O. latifolia had the widest leaflets (33.1 mm). O. corymbosa had the second widest leaflets (28.5 mm). the leaflets of O. smithiana were deeply lobed and measurements were taken from the point of maximum divergence. Thus the over-

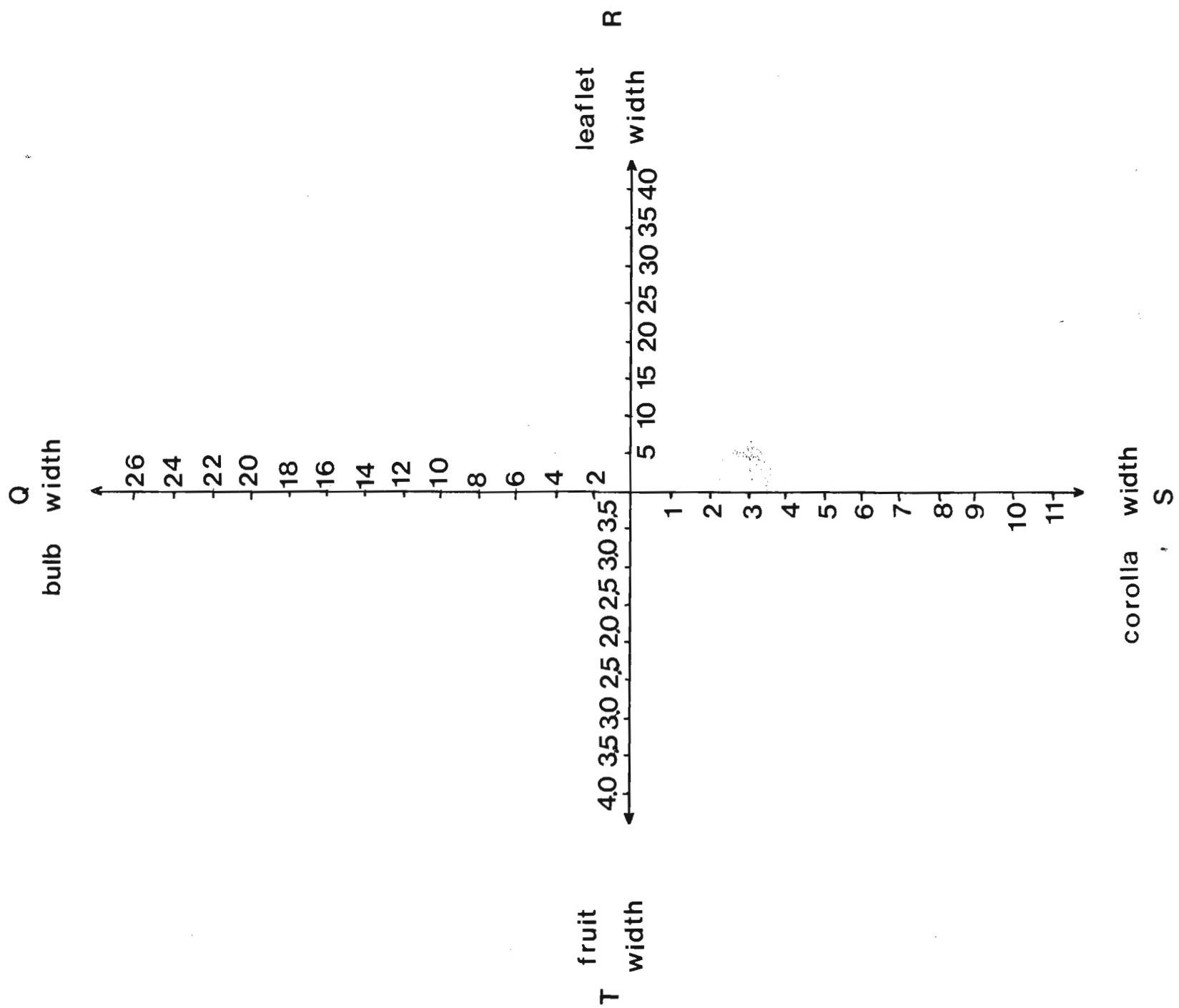


Fig 19a. Polygonal Graph Master Plan (III) (arms Q - T)

all width of the leaflets of O. smithiana was broader (19.8 mm) than that of O. obliquifolia (11.2 mm) whose leaflets were not lobed. The individual lobes of the leaflets of O. smithiana were, however, extremely narrow (3.0-5.0 mm). The leaflet width of O. pes-caprae was fractionally broader than that of O. smithiana. The leaflet widths of O. semiloba and O. corniculata were 21.7 mm and 14.0 mm respectively.

S. Average throat widths of corollas

O. pes-caprae had the widest corolla (10.9 mm) followed by O. obliquifolia (6.4 mm). O. corniculata had the narrowest corolla throat (4.2 mm) while the corolla throat of O. corymbosa was slightly wider (5.5 mm) than that of O. corniculata. The corolla throat widths of O. latifolia and O. semiloba were equal (5.9 mm). The corolla throat width of O. smithiana was 5.8 mm.

T. Average widths of fruit

The widths of the fruit of O. smithiana, O. obliquifolia and O. semiloba were almost the same; being 3.8 mm, 3.5 mm and 3.3 mm respectively. O. corniculata had the narrowest

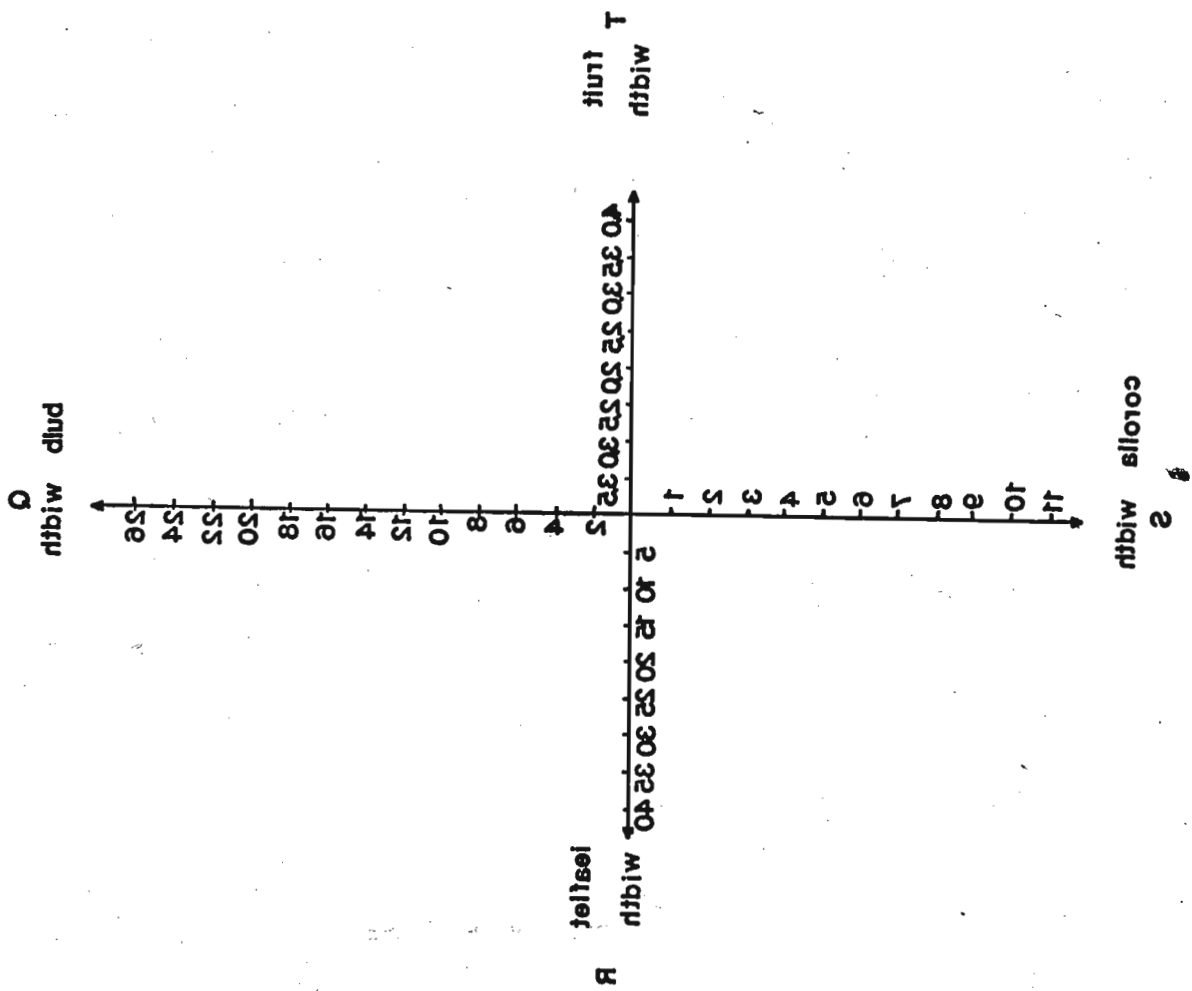
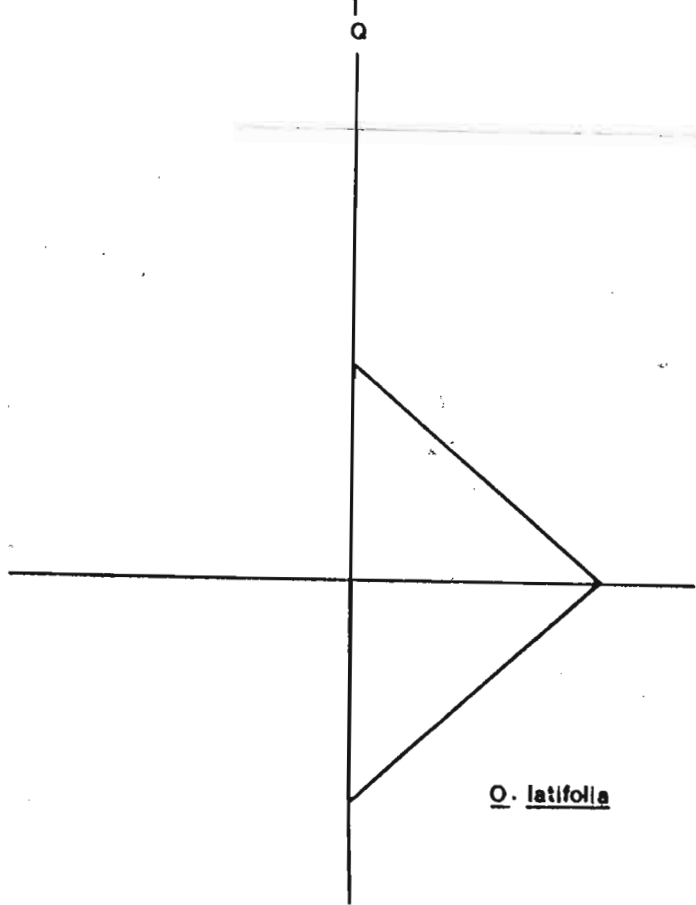
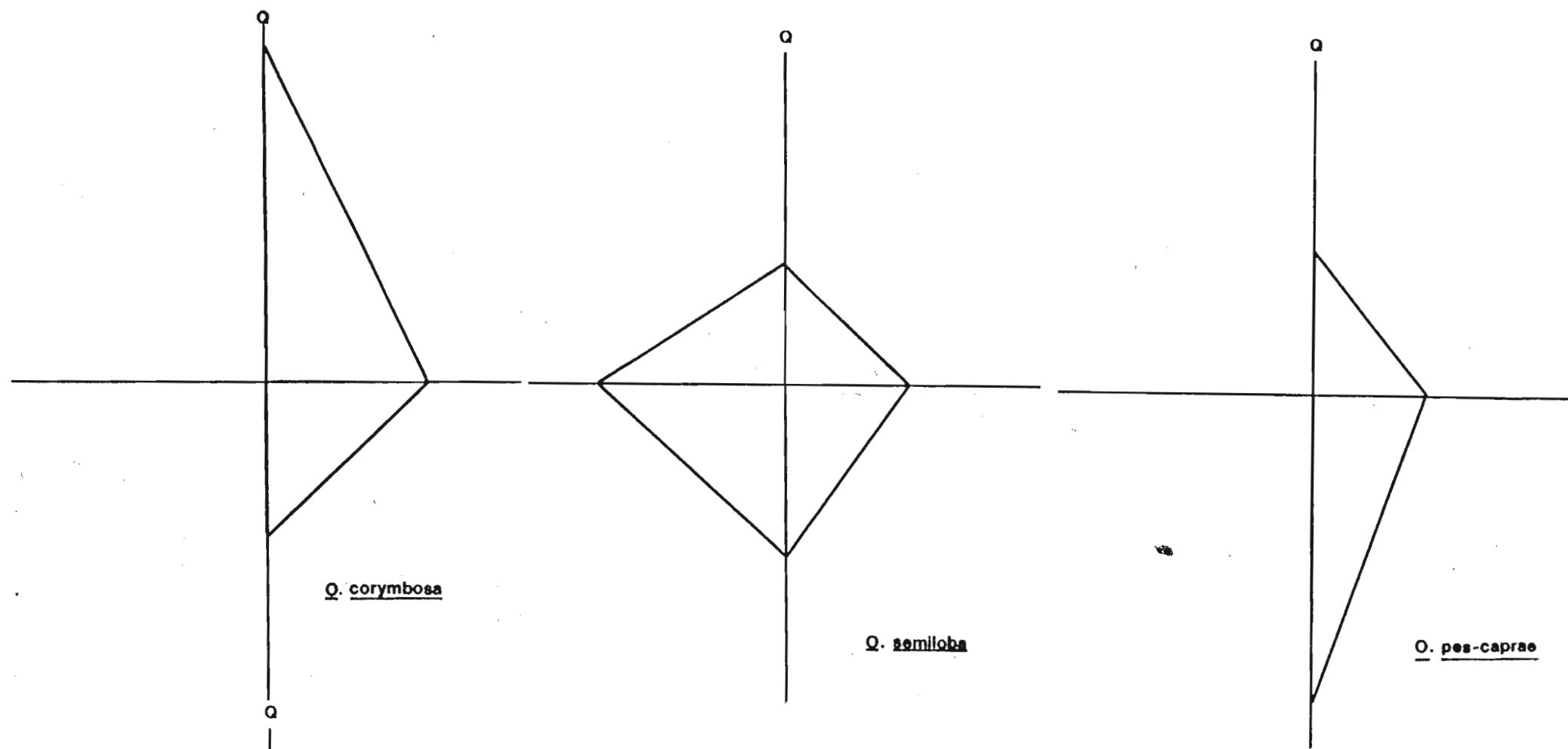
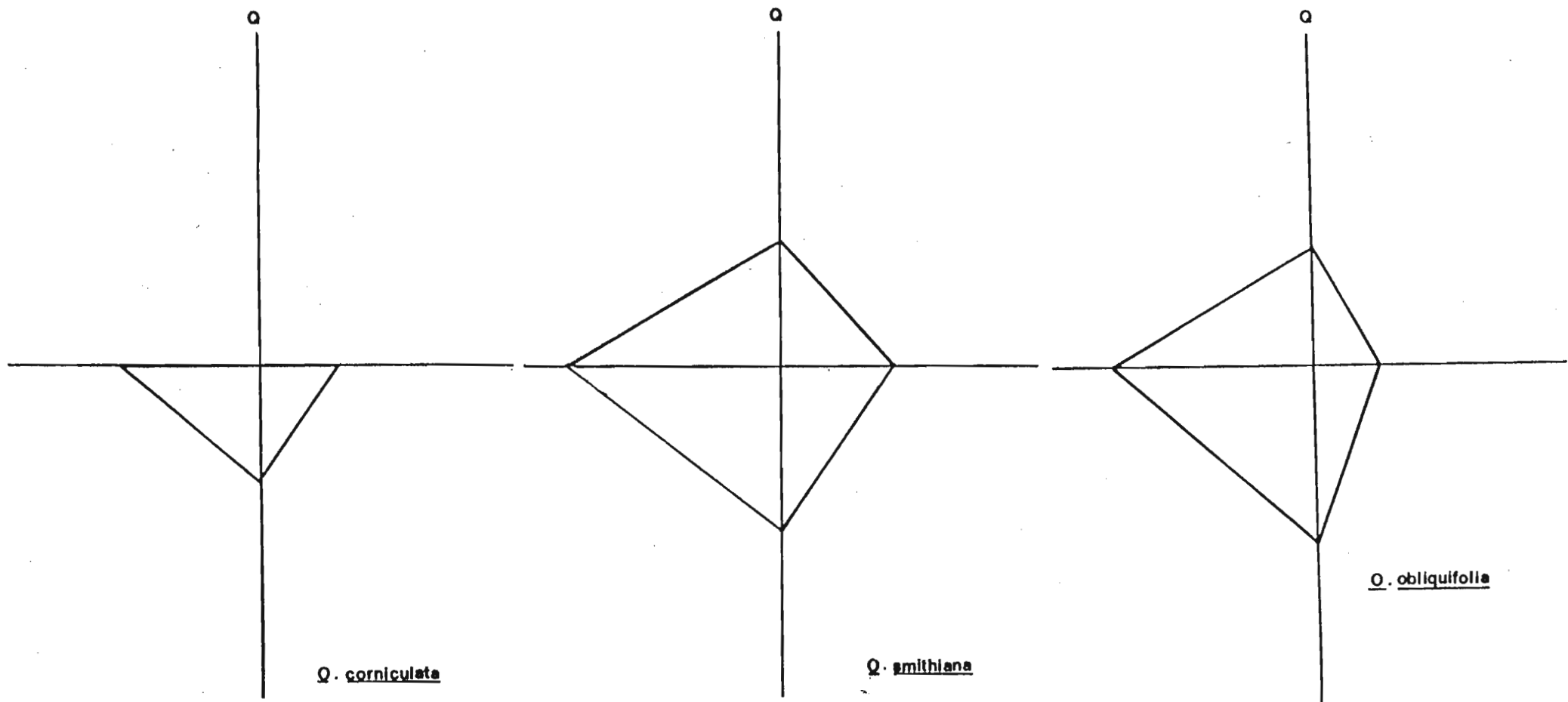
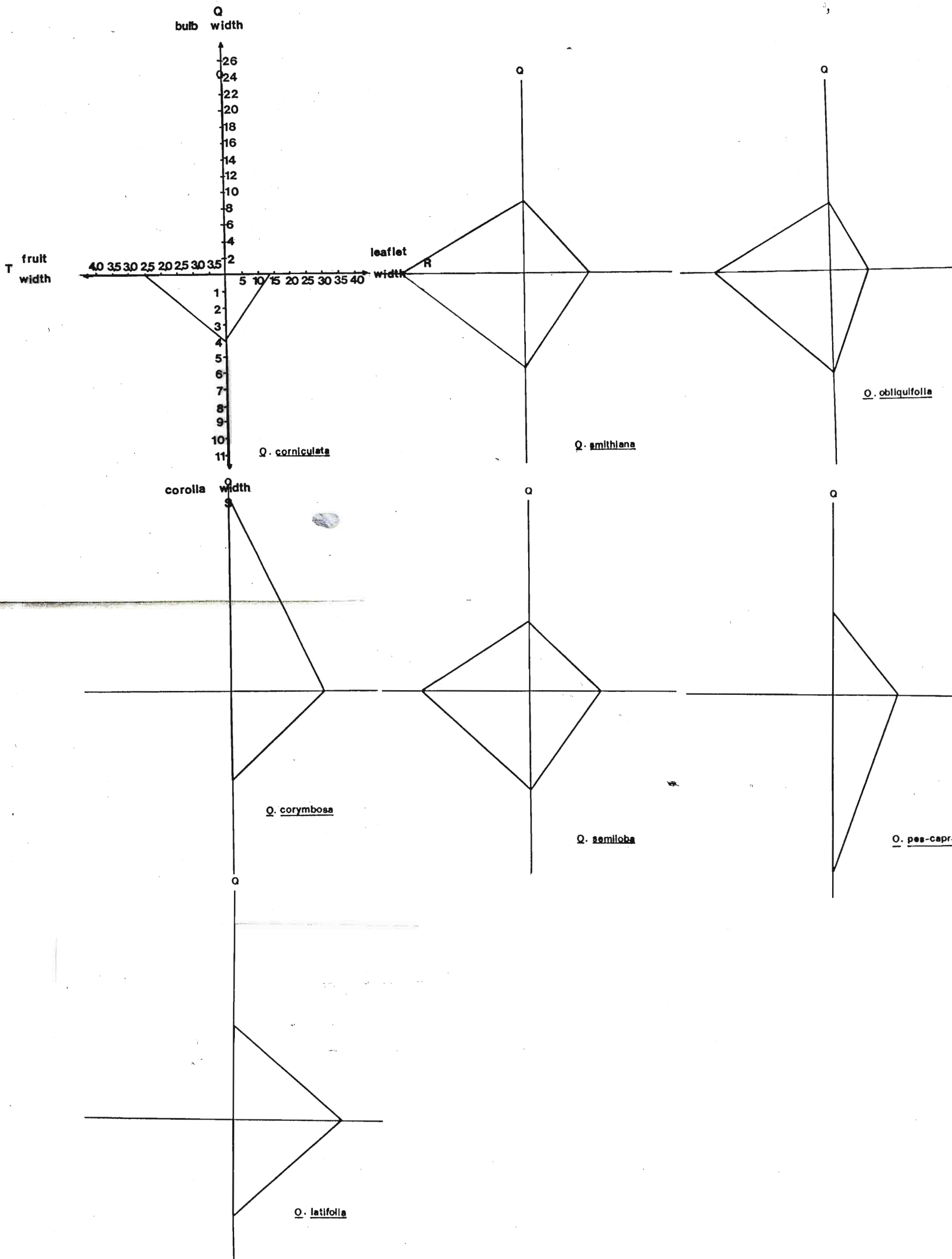
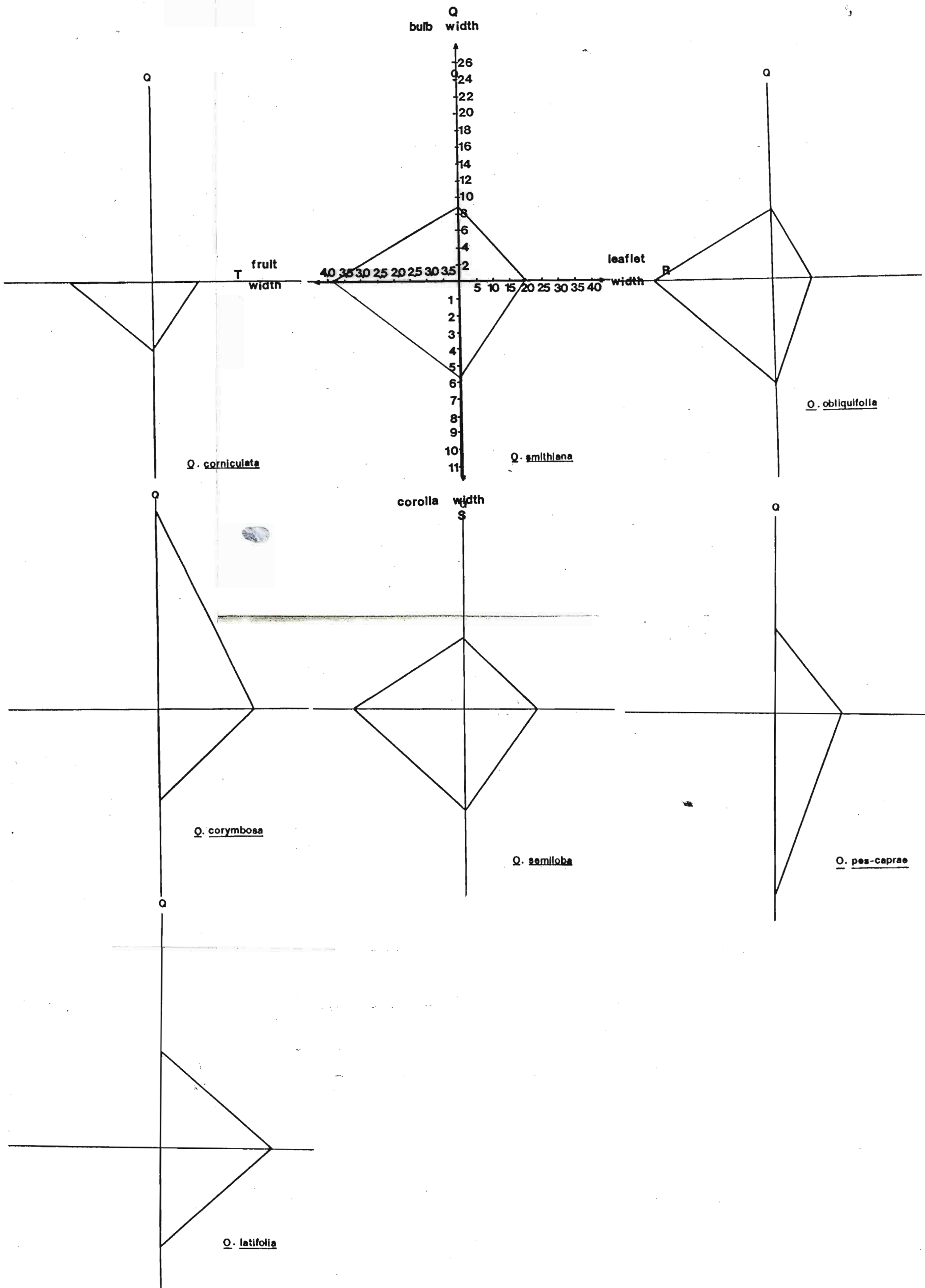
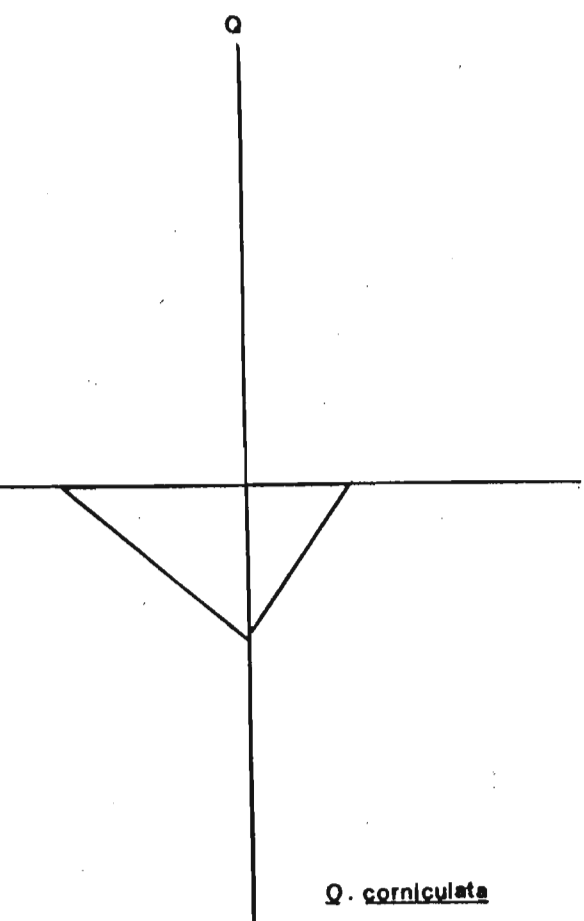


Fig 19b. Polygonal Graphs (III) of Oxalis spp.

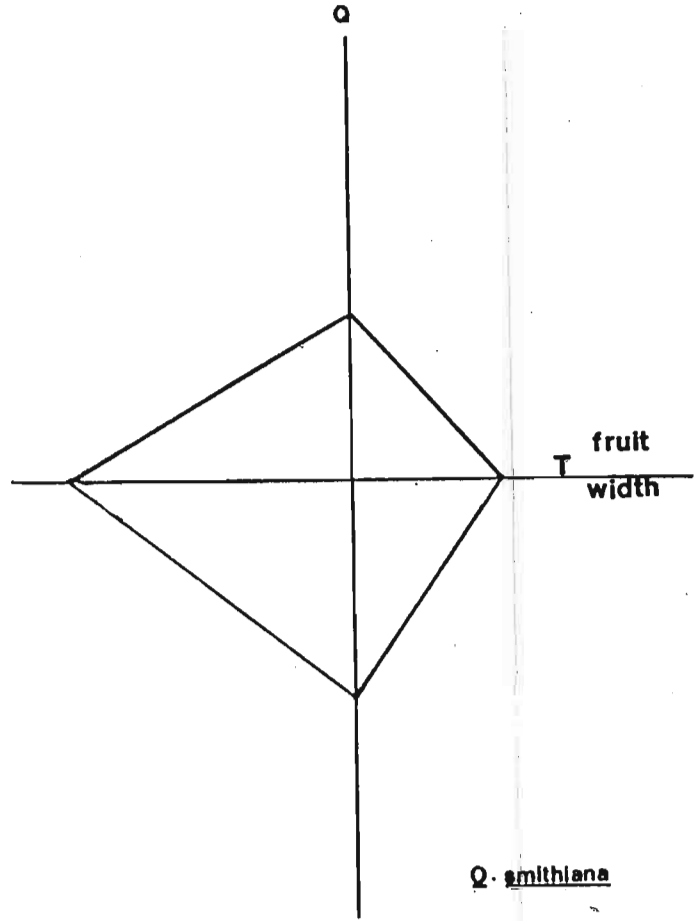




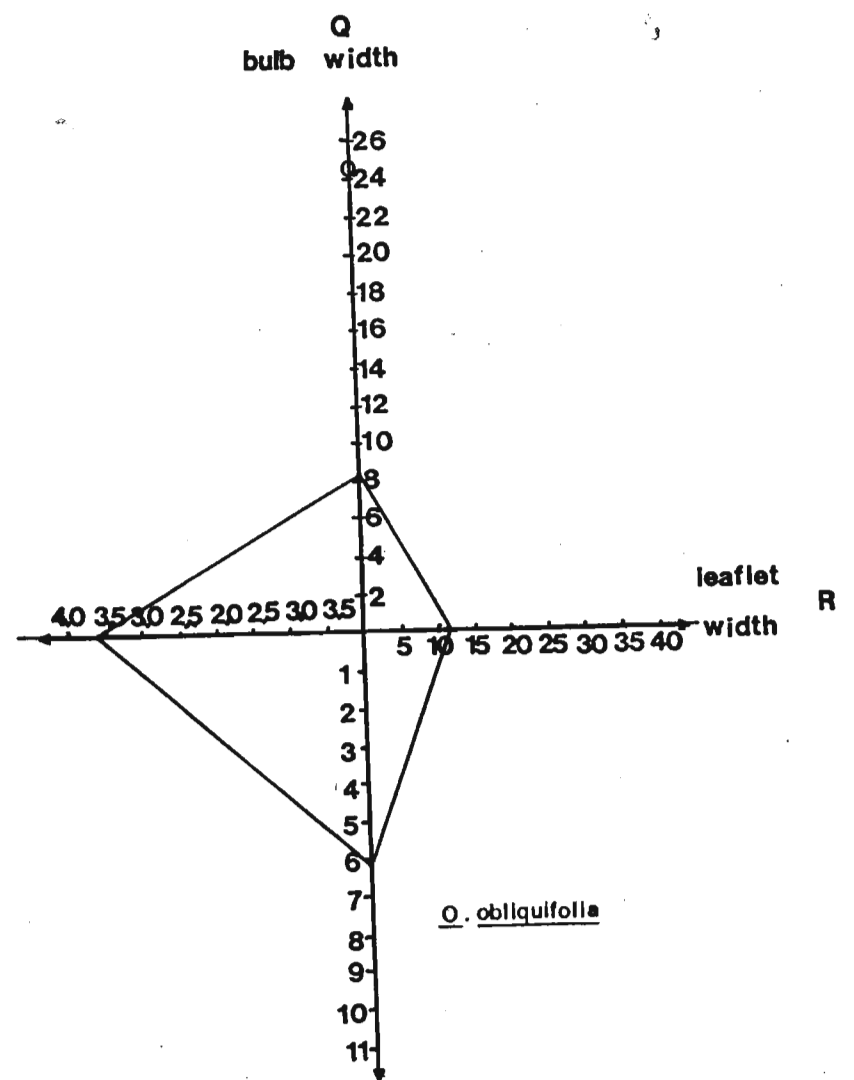




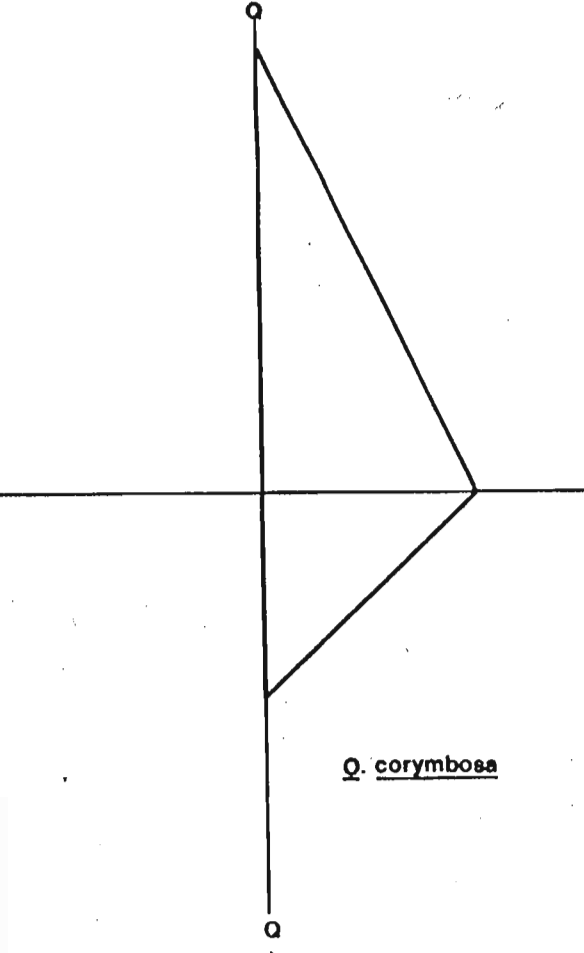
Q. corniculata



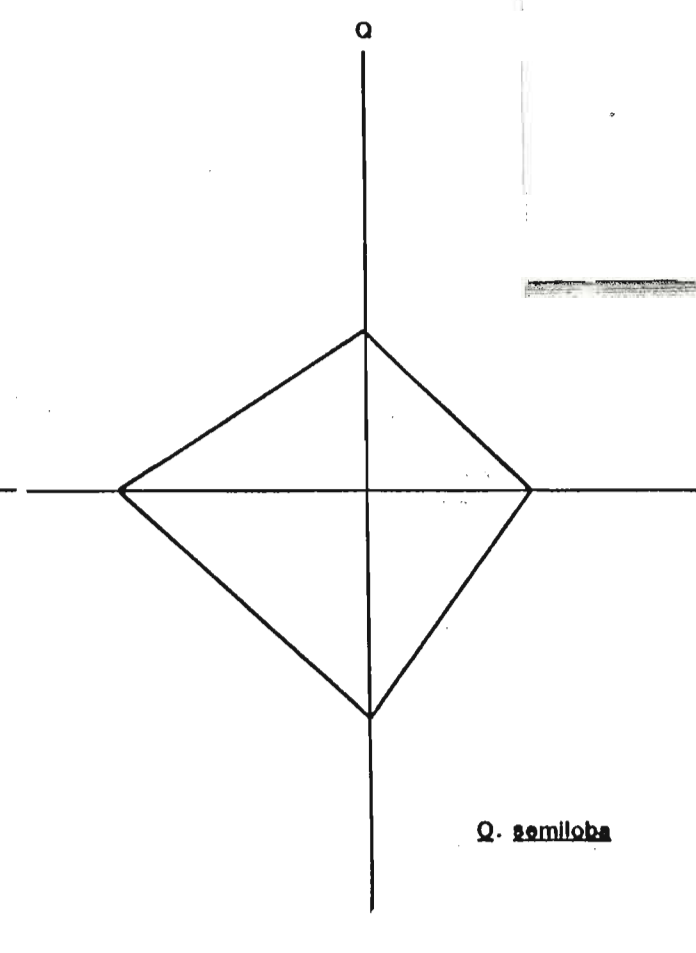
Q. smithiana



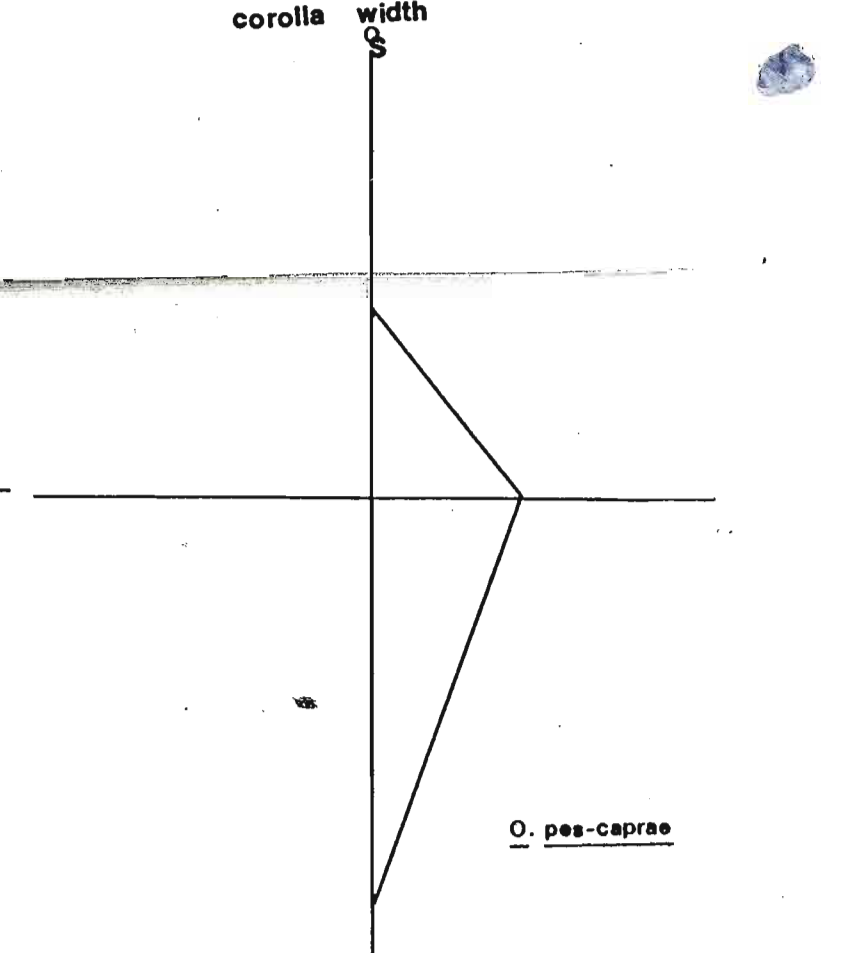
Q. obliquifolia



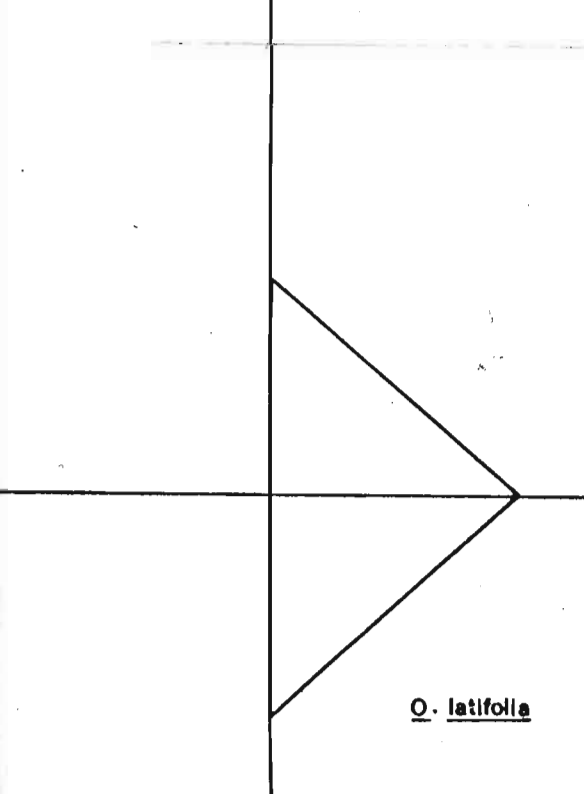
Q. corymbosa



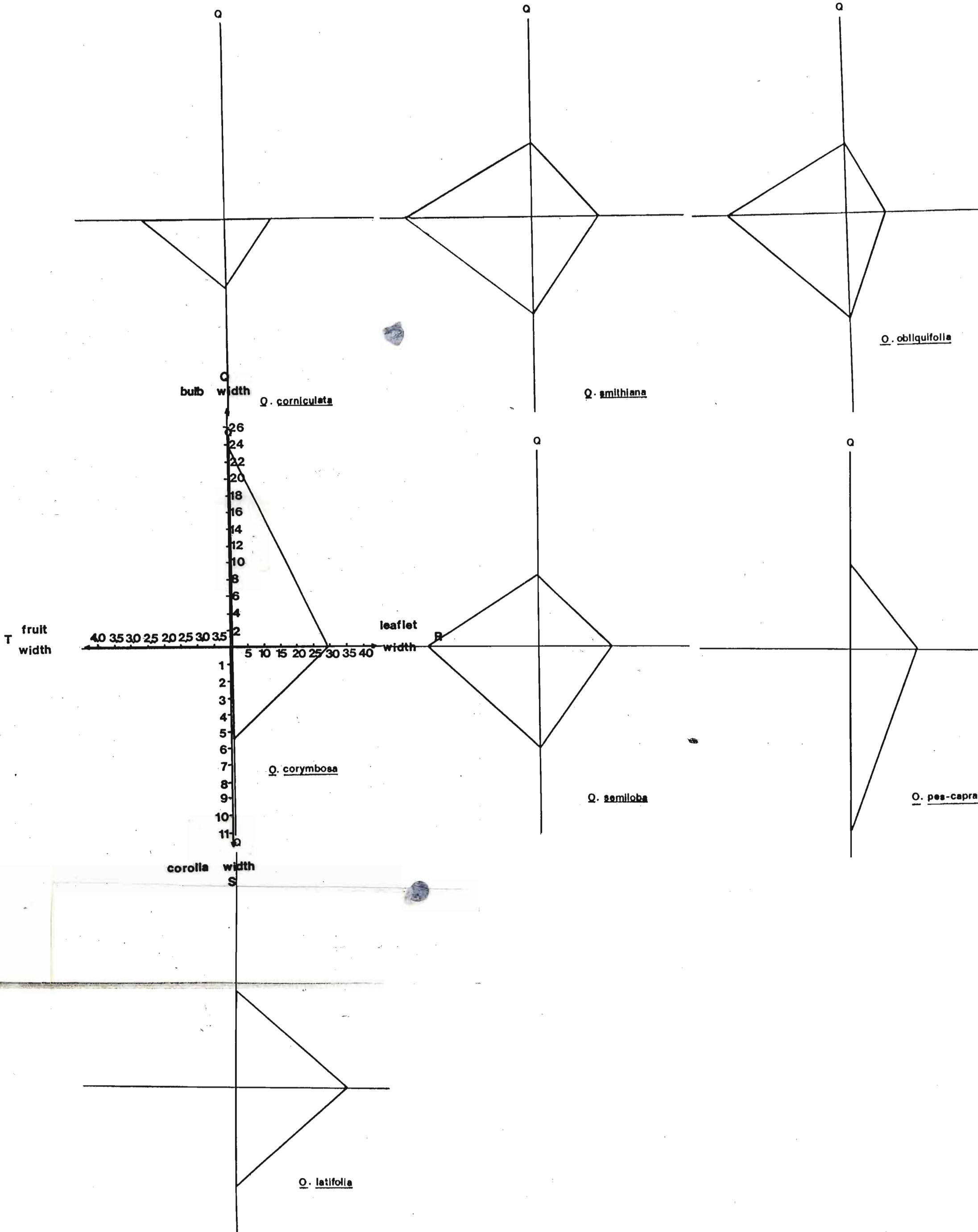
Q. semiloba

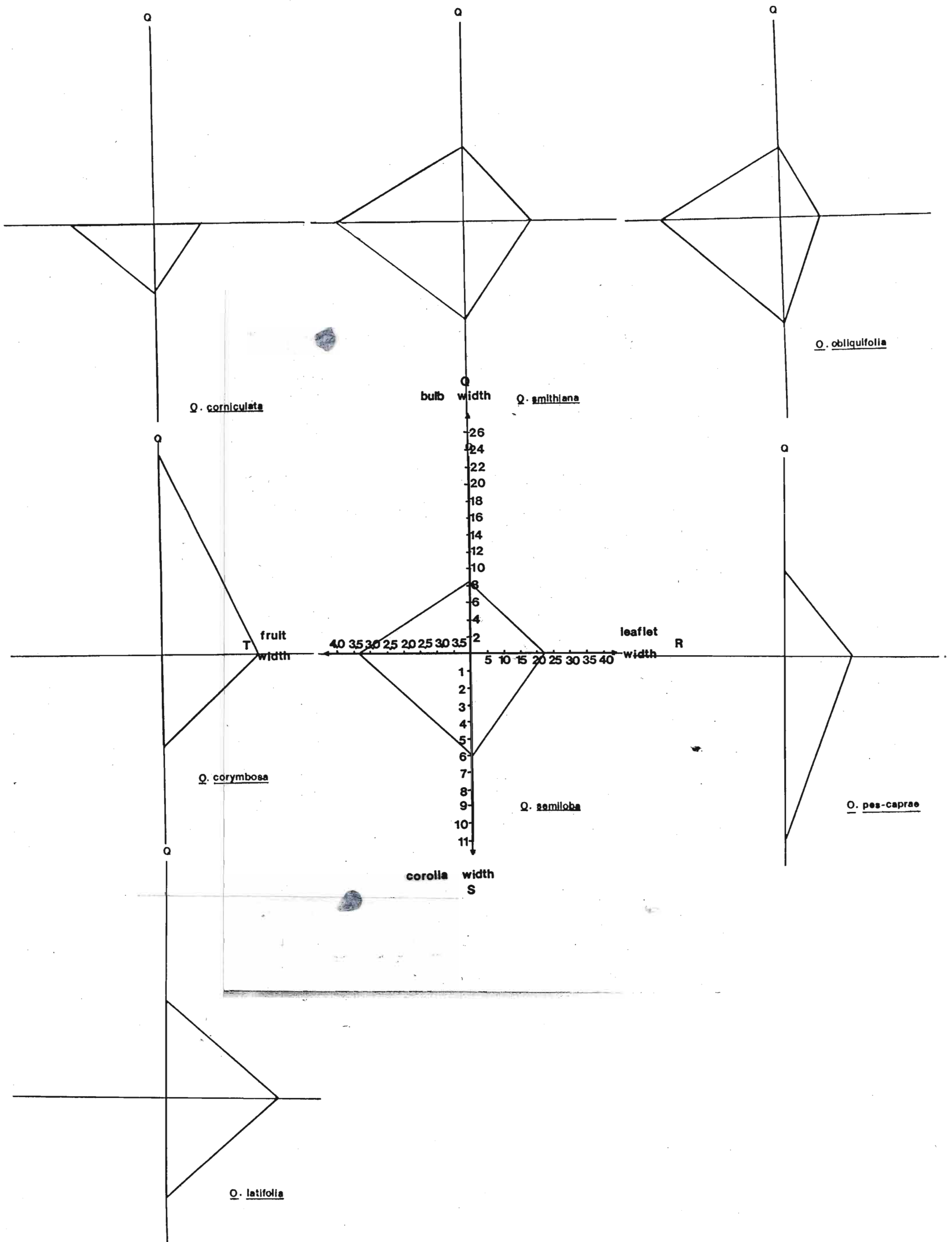


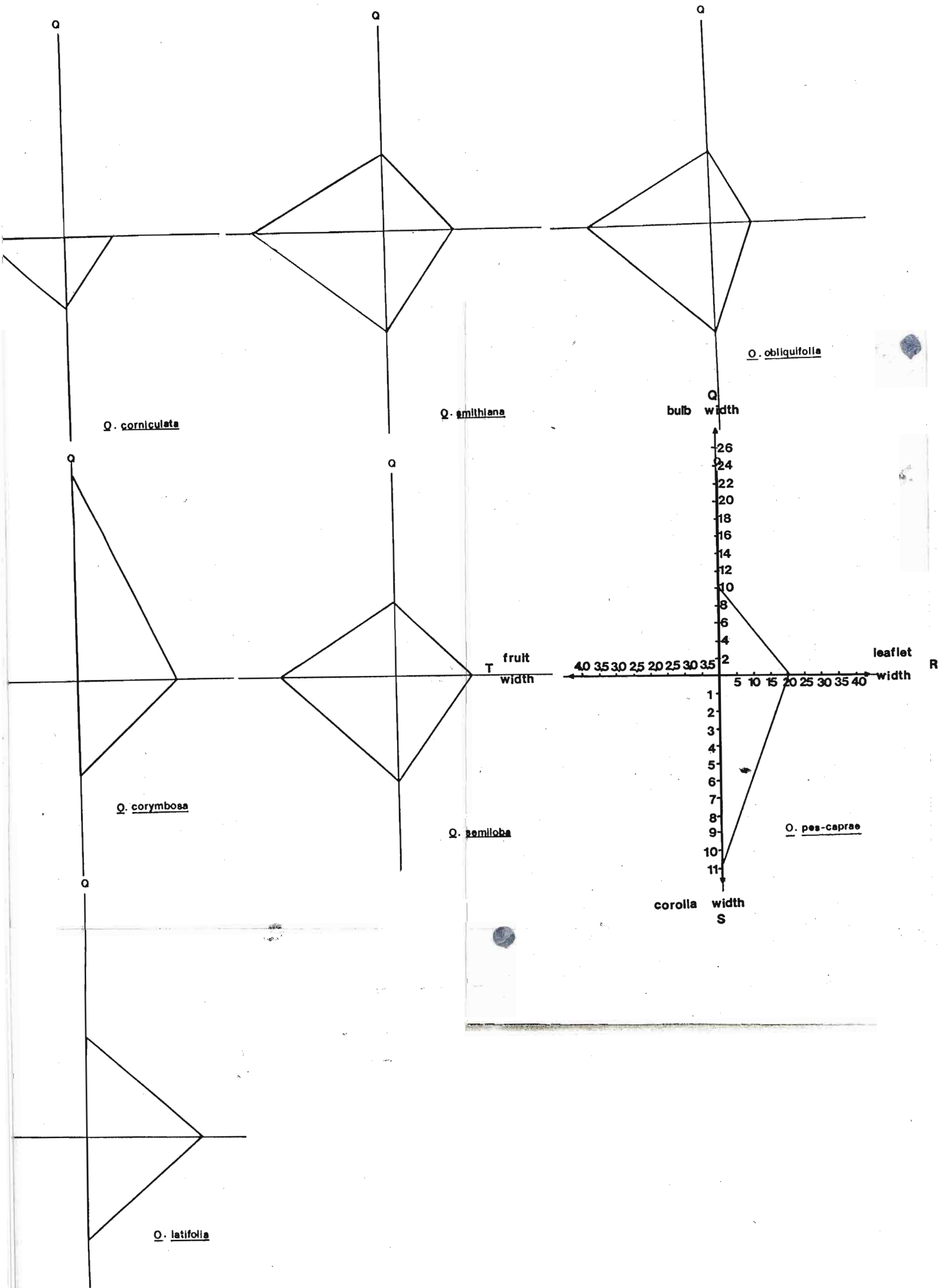
Q. pes-caprae

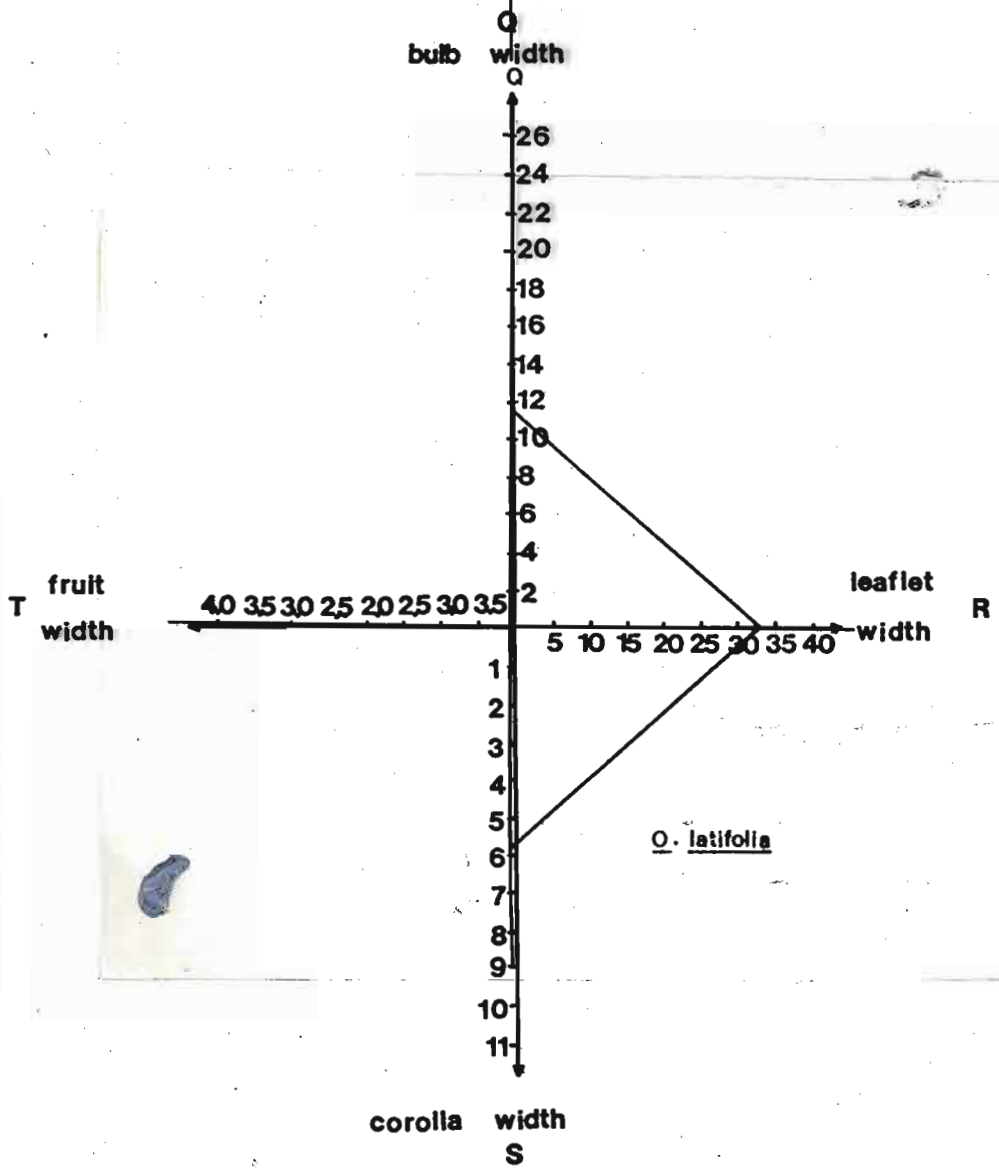
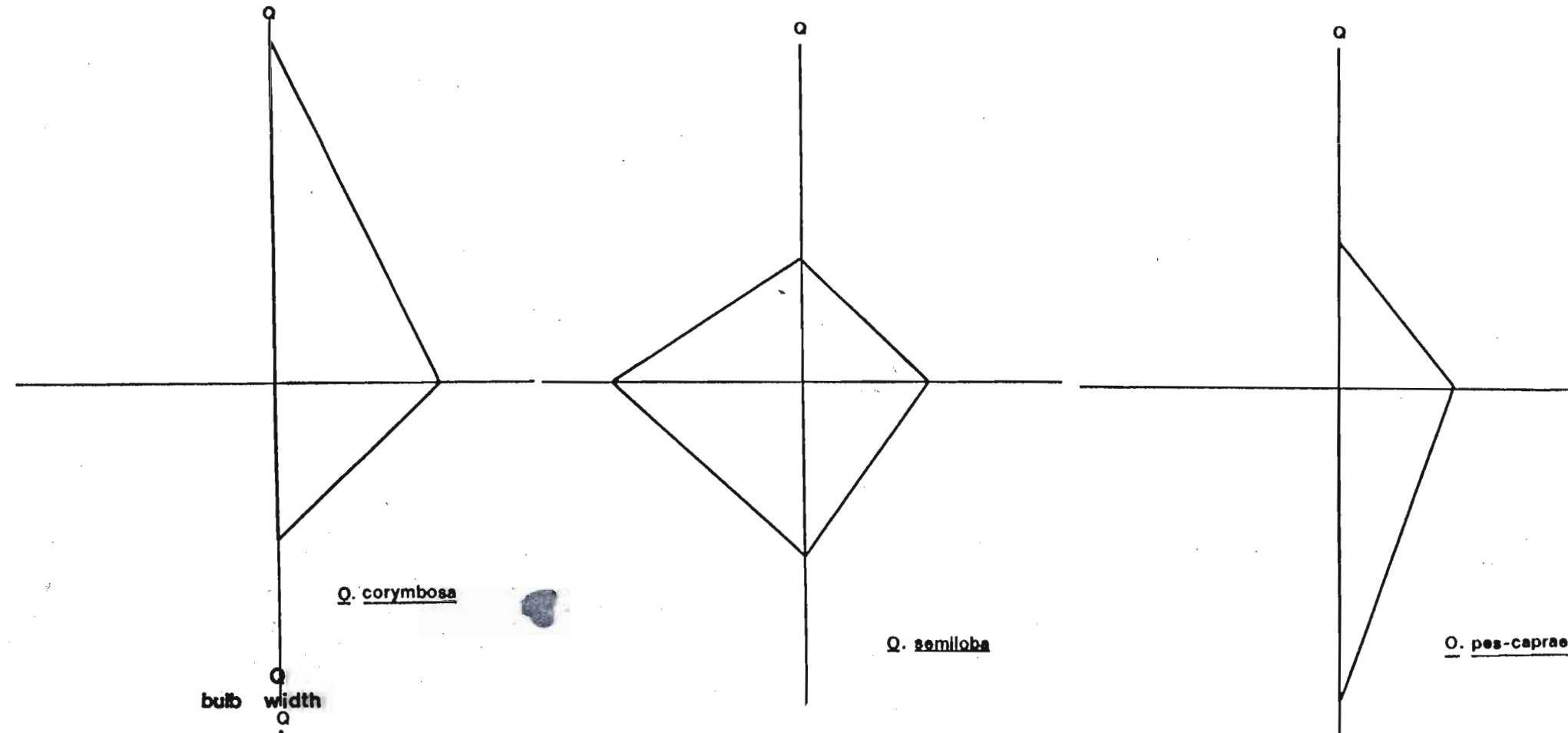
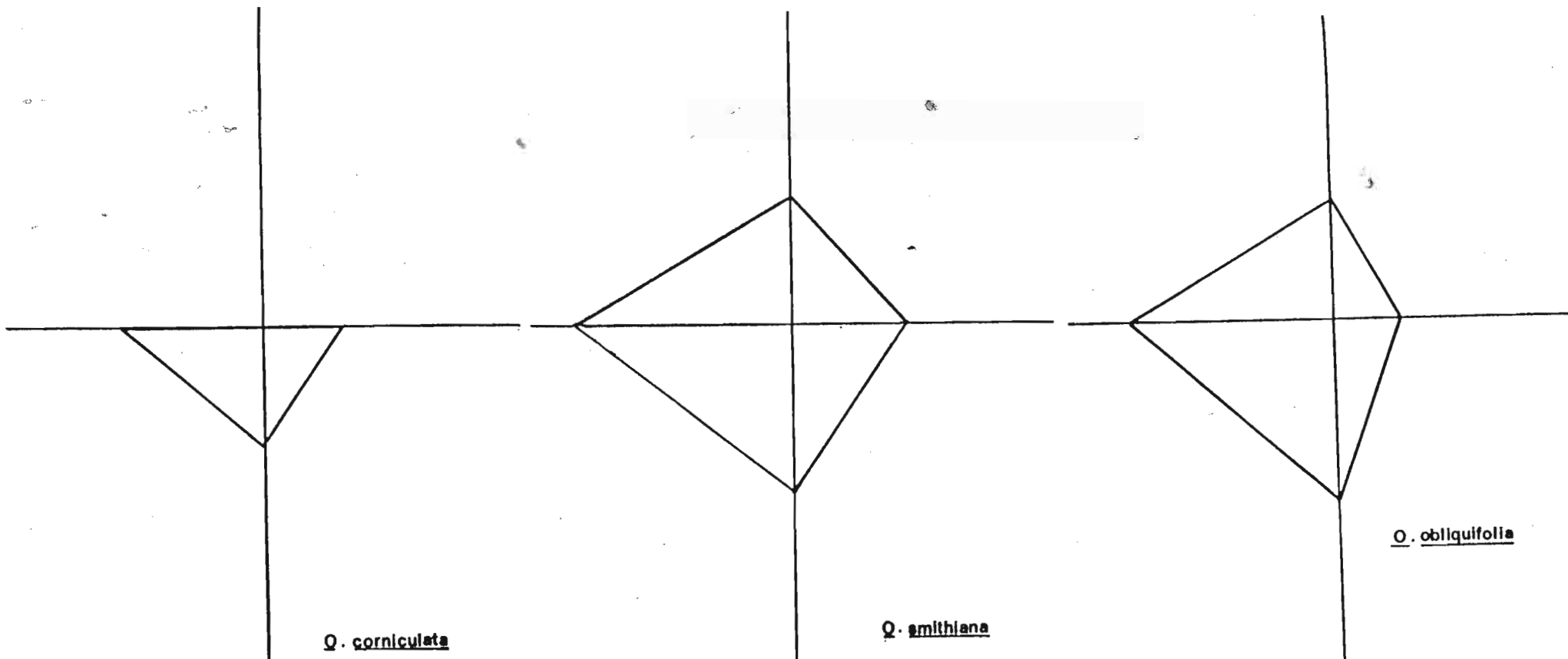


Q. latifolia









fruit (2.5 mm). Fruit were absent from all specimens of O. corymbosa and O. latifolia that were examined. The specimens of O. pes-caprae from Natal did not possess any fruit.

Conclusion

Quantitative differences of morphological characters do exist between the different species of Oxalis in Natal. The differences in the shapes of the polygonal graphs of each species graphically illustrates these differences.

3.4.5 Statistical analysis of morphological characters of Oxalis species

Aim

1. To compare morphological characters of Natal species of Oxalis with those of the same species occurring in the other three provinces to determine whether these morphological characters are fixed and hence taxonomically useful.
2. To determine whether there is a significant difference between the morphological characters of the two varieties of O. smithiana that occur in Natal.

Method

Students t-tests were based upon mean values obtained from Table 5.

Oxalis corniculata and O. pes-caprae were omitted from this study due to an inadequate number of specimens; in the case of O. corniculata only one specimen was received from outside Natal while very few specimens of O. pes-caprae have been collected in Natal. No specimens of O. corymbosa were received from outside Natal.

It must be noted that this study is only a tentative one since large numbers of Natal specimens were compared with only a few specimens from outside Natal. The results give an indication of the area in which the morphological characters must be further investigated.

Table 5. Student's t-values comparing the differences between Natal and non-Natal species as well as comparing the differences between the two varieties of *O. smithiana* occurring in Natal

Character	<i>O. smithiana</i> var.	<i>O. smithiana</i> var.	<i>O. obliquifolia</i>	<i>O. semiloba</i>	<i>O. latifolia</i>	<i>O. smithiana</i> var. vs <i>O. smithiana</i> var.
bulb (l)	-0.6 n.s.	0.7 n.s.	2.2 ^{**}	-1.8 ^{**}	-	-1.8 ^{**}
bulb (w)	-1.2 n.s.	0.2 n.s.	1.4 n.s.	-2.1 ^{**}	-	-1.3 n.s.
rhizome (l)	1.2 n.s.	2.7 ^{**}	1.4 n.s.	0.1 n.s.	-	0.7 n.s.
petiole (l)	1.4 n.s.	-0.4 n.s.	1.0 n.s.	3.0 n.s.	2.8 ^{**}	-0.1 n.s.
leaflet (l)	2.2 ^{**}	0.9 n.s.	1.3 n.s.	-0.7 n.s.	1.4 n.s.	-3.6 ^{**}
leaflet (w)	-0.3 n.s.	-0.1 n.s.	0.3 n.s.	-0.3 n.s.	1.6 n.s.	-1.7 ^{**}
peduncle or scape (l)	1.0 n.s.	0.4 n.s.	0.2 n.s.	0.9 n.s.	2.6 ^{**}	0.9 n.s.
bract (l)	0.4 n.s.	-	0.2 n.s.	-0.4 n.s.	1.7 n.s.	0.6 n.s.
pedicel (l)	-	-	-	-0.2 n.s.	-	-
sepal (lobe) (l)	-3.3 n.s.	-2.3 ^{**}	0.6 n.s.	0.6 n.s.	-0.3 n.s.	-3.0 ^{**}
sepal (lobe) (w)	2.6 n.s.	-3.5 ^{**}	-	-0.7 n.s.	-1.8 n.s.	-
corolla (l)	2.1 ^{**}	0.6 n.s.	0.2 n.s.	-0.1 n.s.	-0.2 n.s.	-0.5 n.s.
corolla throat (w)	3.0 ^{**}	0.7 n.s.	2.5 ^{**}	4.6 ^{**}	2.3 ^{**}	-1.0 n.s.
fruit (l)	0.5 n.s.	-0.4 n.s.	-	-3.0 ^{**}	-	-9.4 ^{**}
fruit (w)	-1.1 n.s.	-0.8 n.s.	-	-2.3 ^{**}	-	0.6 n.s.

n.s. = not significant
^{*} = differences significant at P 0.05
^{**} = differences significant at P 0.01
l = length
w = width

Comparison of Natal specimens of Oxalis with those from the other three provinces of South Africa

O. smithiana

1. var. α (white flowers)

Leaflet and corolla lengths were significantly different at $P < 0.05$. Sepal lengths and corolla widths were significantly different at $P < 0.01$.

Leaflet and corolla lengths and widths, throat width in the case of corollas, of the the Natal specimens were significantly shorter and narrower. The sepal lengths of the Natal specimens, however, were significantly longer.

2. var. β (mauve flower)

Sepal lengths were significantly different at the $P < 0.05$ level whilst widths and rhizomes lengths were significantly different at the $P < 0.01$ level.

Results indicated that the sepal lengths of Natal specimens of O. smithiana var. β were significantly shorter than specimens occurring outside Natal; sepal widths of Natal specimens of O. smithiana var. were, however, significantly wider. The rhizome lengths of the Natal specimens were significantly

shorter.

O. obliquifolia

Bulb lengths were significantly different at $P < 0.05$. This indicated that the bulb lengths of the Natal specimens of O. obliquifolia were significantly longer than those specimens collected outside Natal.

The corolla throat widths were significantly different at $P < 0.01$; thus indicating that the corollas of the Natal specimens were significantly narrower than those from the other three provinces.

O. semiloba

In O. semiloba, as can be seen from Table 5, fruit width as well as bulb length and bulb width were significant at $P < 0.05$. Corolla throat width and fruit length were significantly different at $P < 0.01$.

This meant that the bulb length and width, the fruit length and width as well as the corolla throat width of the Natal species of O. semiloba was significantly larger or wider than those specimens collected outside Natal.

O. latifolia

Corolla throat width and bract and peduncle lengths were found to be significantly different at $P < 0.05$. Petiole lengths, however, was significantly different at $P < 0.01$.

Bract length in the Natal specimens were significantly longer than those from outside Natal. The corolla throat width, and peduncle and petiole length of the Natal specimens, however, were significantly narrower and shorter respectively.

3.3. Conclusions

Bulbs were present in all species of Oxalis, except O. corniculata. The overall morphology of the bulbs appeared to be species specific. The colour of the outer protective scales also varied between species.

The only two bulbous species that did not possess rhizomes were O. corymbosa and O. latifolia (both species indigenous to South America). Nutrients are probably supplied to the developing new parent bulb, in these two species by means of diffusion. In the rhizomatous species, the rhizomes supply the developing parent bulbs with nutrients. In addition, new bulbs develop along the

length of the rhizomes, or on stalks as in the case of O. latifolia. These bulbs, or bulbils as those of O. latifolia are referred to as, break off from the parent plant and form new plants. The process is repeated. In this manner vast areas of suitable habitats can be colonised.

Adventitious contractile roots occur in all bulbous species of Oxalis. Unfortunately no specimens collected of O. pes-caprae possessed contractile roots. The sizes as well as the overall morphology of these contractile roots were very plastic. Contractile roots were occasionally branched. The sizes of the contractile roots depended upon environmental conditions.

The overall leaflet morphology and venation generally differs between species. The epidermal cells of members of this genus was much convexed in order to concentrate light onto the photosynthetic cells. Abaxially the cell walls appeared slightly crenulated to very wavy. Stomata were of the anomocytic type. All species, except O. obliquifolia exhibit sleep movements at night or when stressed.

SEM was used to investigate the floral morphology of the different species. Morphology of the petal throat region, pollen, stigmas and styles as well as seeds was investigated. Infrageneric variation, to some degree, was ob-

served for all parts investigated. With regards to the petal throats; pubescence, and to some extent the shape of the cells, varied. The ornamentation of the pollen grains were similar although the ornamentations on the colpi appeared to be species specific. Pubescence varied on the styles of the different species and the ornamentation on the seed producing species of Oxalis was definitely species specific.

Polygraphs were used to graphically illustrate the quantitative differences between morphological characters of the different species. Statistical comparisons between morphological characters of Natal and non-Natal specimens of the same species, indicated that some of the morphological characters within each species was significantly different. This indicated that the quantitative measures of certain morphological characters are not fixed and are thus not taxonomically useful when studying the genus on a larger scale e.g. within South Africa.

4. ANATOMY

4.1 Introduction

Antomical characters have been employed for systematic purposes for more than 100 years. Caution should, however, be exercised in drawing conclusions from anatomy alone since similarities could perhaps be the result of convergent or parallel evolution. Thus only when anatomy is coupled with evidence from other sources or characters, will a natural classification be obtained (Radford, et al, 1974).

Embryology

According to McLean and Ivimey-Cook (1956), Oxalis possesses the asterad type of embryo i.e. the basal cell contributed towards embryological development. Variations of this type of development occurs in Oxalis and Poa.

Root Development

Renewal buds occur in a specific position within the soil or soil surface. This is mainly due to the pull of special roots termed contractile roots which are common in the bulbous species of Oxalis Fahn, 1974).

Contractile roots, or parts of roots, are distinguishable from a normal root by their wrinkled appearance (Fahn, l.c.). Collapsing cells occur in some transverse zones (Esau, 1960). Metcalf and Chalk (1950) state that the contractile root is bounded, externally by a few layers of cork, whilst the bulk of the root consists of secondary phloem. Secondary phloem is composed of radial rows of parenchyma cells with isolated sieve tubes scattered throughout. The cortex is narrow and parenchymatous whilst the stele is tetrarch when young. According to Esau (1960) the reduction in the root length is thought to result from a reduction in volume rather than a growth phenomenon.

Davey (1946) and Reyneke (1975) described the mechanism of contraction in seedlings. Apparently, the main contraction occurs when the horizontal cells of uniform secondary phloem parenchyma lose their protoplasts and sap and collapse. Alternating with these zones of collapsing cells, are narrow zones of turgid living cells. The vertical walls of the collapsing cells fold so that the horizontal walls are brought together. Each collapsing zone become inclined upwards so that the diameter of the root core becomes reduced and tears away from the periderm and cortex remnants. The phloem strands are contorted but alive. Xylem strands and associated cambium are spirally contorted.

With the collapsing of the central tissue of the stele, the plumule is drawn down through this tube below the soil level where, in the protective pocket of tissues it develops into a bulb (McLean and Ivimey-Cook, 1956).

Metcalf and Chalk (1950) give the following account of the anatomy of the Oxalidaceae:

Vascular structure

The stem and the petiole consist of a circle of collateral bundles often with an external sclerenchymatous ring in the pericycle.

Vessels occur in multiples of four or more cells; perforations are simple and members are medium or short. Parenchyma is vasicentral and scanty, often with numerous diffuse crystalliferous strands. Rays are uniseriate, heterogenous to almost homogenous and the fibres are septate with simple pits. Fibres vary in length from moderate to very short.

The epidermal cells of the stems are variable in size. In O. corniculata some of these cells have tannins within them (Cutler, 1978). The cortex is relatively narrow and composed of large, loosely packed parenchymatous cells with a complete cylinder of cortical fibres.

Vascular bundles are collateral, widely separated and arranged in a ring. In O. corniculata vessels are about 30 um long; solitary or in short radial rows. The perforations on the plates of the vessel elements are simple. The pith consists of large, thin walled parenchyma in O. corniculata. Figure 20 schematically represents the stem anatomy of O. corniculata.

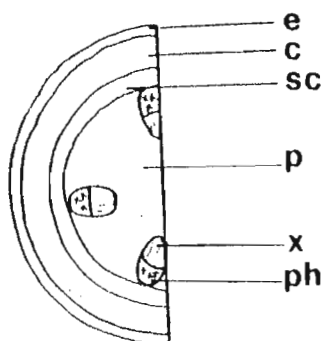


Figure 20. Stem anatomy of O. corniculata.

e = epidermis; c = cortex; sc = sclerenchyma; p = pith; ph = phloem; x = xylem.

Leaf structure

Leaves of Oxalis are dorsiventrally flattened with, when present, unbranched hairs of variable length. Bladder-like hairs, for water-storage occur in some species of Oxalis. Glandular hairs of varying lengths and unicellular heads occur in Biophytum and Oxalis. The epidermis of Oxalis leaves is often very broad in proportion to the

total lamina width, sometimes arching outwards. In some species, tall palisade-like leaf cells, exceeding the remainder of the total leaf thickness occur. The lower epidermis is papillose. Secretory cavities occur in the leaves of some Oxalis species. Within these cavities one finds oxalates in the form of dissolved potassium oxalate and small, solitary cubical calcium oxalate crystals.

Leaf development is characterised by substantial changes in morphology and anatomy. These changes are the product of differential cell or tissue expansion and growth. Such growth in developing tissues implies an enlargement of specific tissues and a separation of cells closely associated in the early development stages. This is the result of the development of large airspaces within the leaf (Fagerberg and Culpepper, 1984).

These changes according to Fagerberg and Culpepper (l.c.) perhaps facilitate the physiological function of the leaf and hence represents an important aspect of leaf function. Leaf structure must be so in order to maximise a diverse set of functions.

Internal leaf morphology of many plant species varies from that characteristic of shade leaves at low light intensities to that of sun leaves when development occurs at illuminations approaching full daylight. Not only do sun leaves tend to have more highly developed palisade and

spongy mesophyll regions than shade leaves, but also have higher photosynthetic rates at light saturation.

Higher assimilation rates are suggested to result from changes in the activity of the enzymes involved in photosynthesis and the variation in the number of chlorophylls per photosynthetic unit. But higher photosynthetic rates are perhaps also the consequence of changes in the internal leaf morphology caused by illumination (Noble et al, 1975).

Leaf plasticity is common in some plant species. Seliskar (1985) studied five species of salt marsh plants in order to determine whether morphological and anatomical differences between plants at the upper and lower distributional limits were fixed or plastic. In other words to investigate whether there were correlations between morphology, anatomy and the environment. After a year's study it was concluded that all five species were morphometrically plastic and that the soil moisture content, which was greatest at the lower elevational site and that this, perhaps accounts for much of the structural changes in the transplants.

Leaf length and leaf volume in many plants, Oxalis spp. included, varies with light intensities. Fagerberg and Culpepper (l.c.) worked on the leaves of Helianthus annuus. Studies revealed that during leaf development, at

low light intensities, there was an 85% increase in leaf length and that leaf volume increased by 64%. The leaves were divided into five compartments namely palisade, spongy, vascular and epidermal tissues and intercellular airspace. It was discovered that shading caused internal reallocation of this compartment space. There was a significant increase in the intercellular space volume in the spongy and palisade parenchyma at all developmental stages. The relationship between cell volume and surface areas, however, did not change.

It was concluded that at low light intensities, the spongy and palisade tissues of the sunflower leaves are very similar in a number of important structural parameters namely, cell surface area exposed to intercellular space and in contact with vascular tissue and the amount of intercellular space.

The petiole in transverse sections has a circle of separate vascular bundles. The phloem groups of the petiole bundles are attached externally to a ring of sclerenchyma in some species, e.g. *O. corinculata*, but not in others.

Secretory cavities, variously interperated as schizogenous or lysigenous in origin, with brown or red, sometimes transparent, and crystalline substances, are present in the pinnae of Oxalis species of America and South Africa. These cavities occur in different positions in different species. Cavities are absent in some species with well developed stems. The cavities are generally situated on th dorsal side of the vascular bundles when occurring on bulb scales; they are often elongated and resemble canals. Crystals are mostly solitary and are sometimes visible as transparent dots in some Oxalis species.

4.2 Discussion of the anatomy of Natal species of Oxalis

Transverse sections of leaflets, petioles and peduncles or scapes were examined in order to determine whether there were any anatomical differences between the different species.

Plan diagrams were made for all the organs investigated.

4.2.1 Tissue types and arrangements in transverse sections of leaflets

Table 6 summarises the differences and similarities of tissue types and their arrangements as well as the number of layers per tissue type. Transverse sections of all the leaflets were composed of the

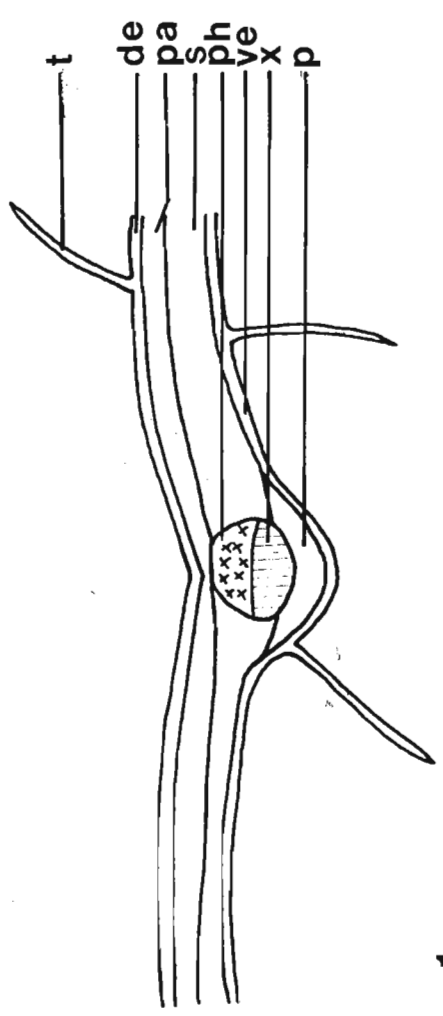
Table 6. Tissue types and the number of layers of some types in transverse sections of the leaflets of *Oxalis* spp. in Natal.

tissue types and No.	upper epidermis		dorsal palisade mesophyll		spongy mesophyll		vascular tissue		parenchyma		mid-rib collenchyma		ventral palisade mesophyll		lower epidermis		trichomes	
		No.		No.		No.	phloem	xylem		No.	chyma		No.		No.	dorsal	ventral	
<i>corniculata</i>	+	1	+	1	+	2	+	+	+	2	-	-	-	+	1	+	+	
<i>smithiana</i>	+	1	+	1	+	2	arrangement differs	+	+	2	-	-	+	+	1	-	-	
<i>obliquifolia</i>	+	1	+	1	+	2	+	+	-	-	-	-	+	+	1	-	+	
<i>corymbosa</i>	+	1	+	1	+	2	+	+	+	2-3	-	-	+	+	1	-	+	
<i>seri-loba</i>	+	1	+	1	+	2	+	+	+	2-3	-	+	+	+	1	-	+	
<i>pes-caprae</i>	+	1	+	1	+	2	arrangement differs	+	+	2-3	-	-	+	+	1	-	+	
<i>latifolia</i>	+	1	+	1	+	1-2	+	+	+	2-3	-	-	+	+	1	-	-	

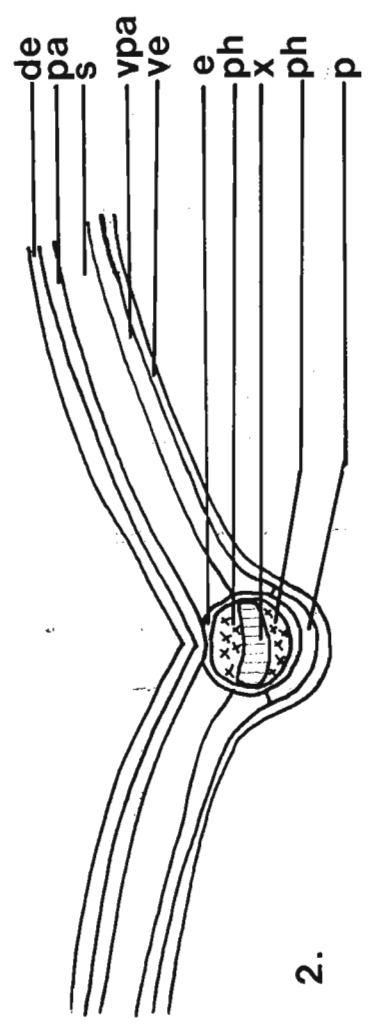
Fig. 21. Plan diagrams of transverse section of leaflets.

- .1. O. corniculata X50
- .2. O. smithiana X50
- .3. O. obliquifolia X60
- .4. O. corymbosa X70
- .5. O. semiloba X75
- .6. O. pes-caprae X60
- .7. O. latifolia X75

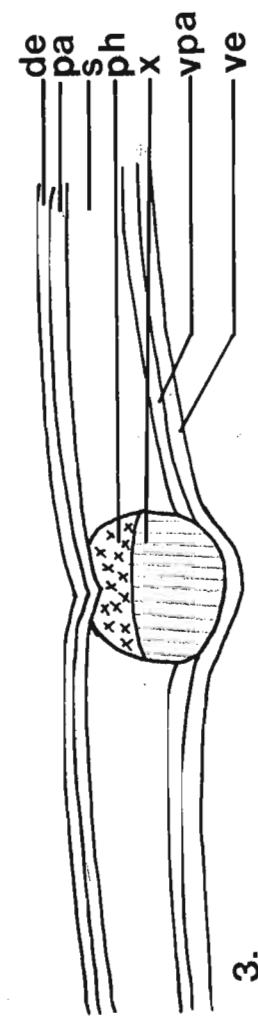
c = collenchyma
 de = dorsal epidermis
 e = endodermis
 p = parenchyma
 pa = palisade mesophyll
 pe = pericycle
 ph = phloem
 s = spongy mesophyll
 t = trichome
 ve = ventral epidermis
 vpa = ventral palisade mesophyll
 x = xylem



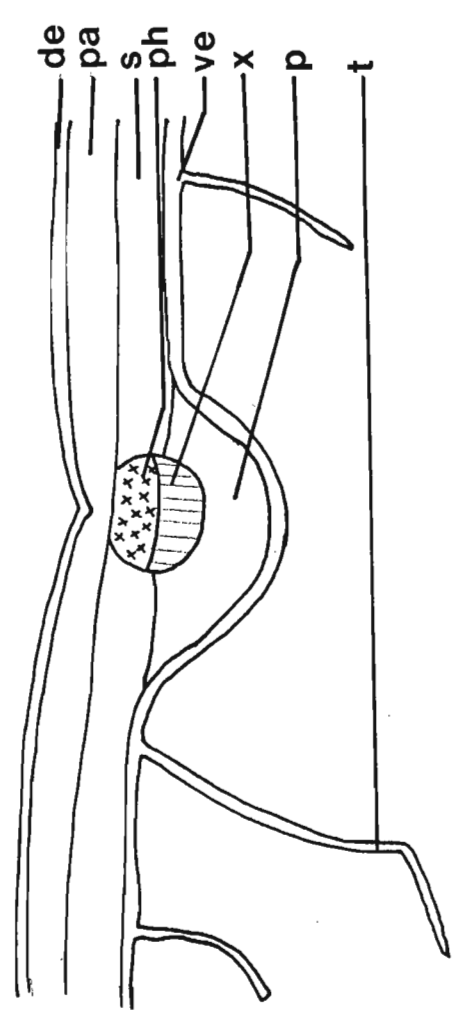
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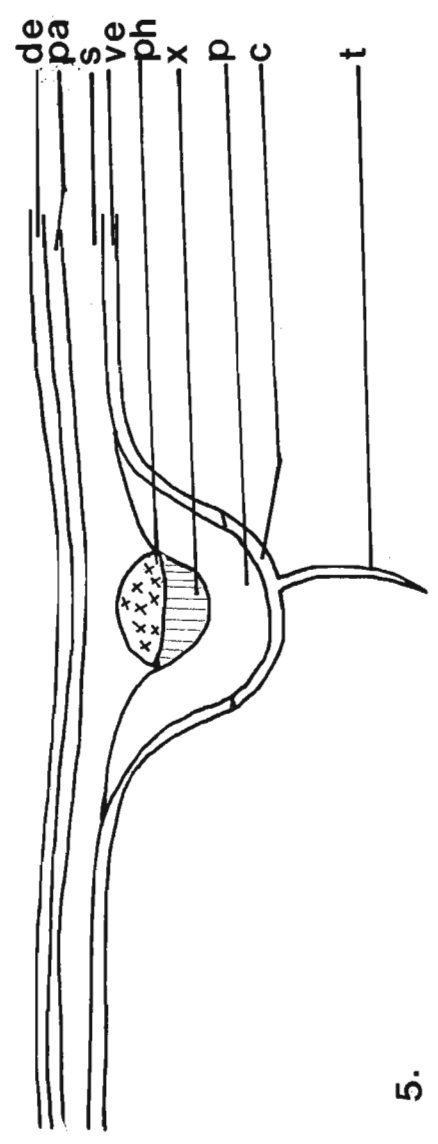
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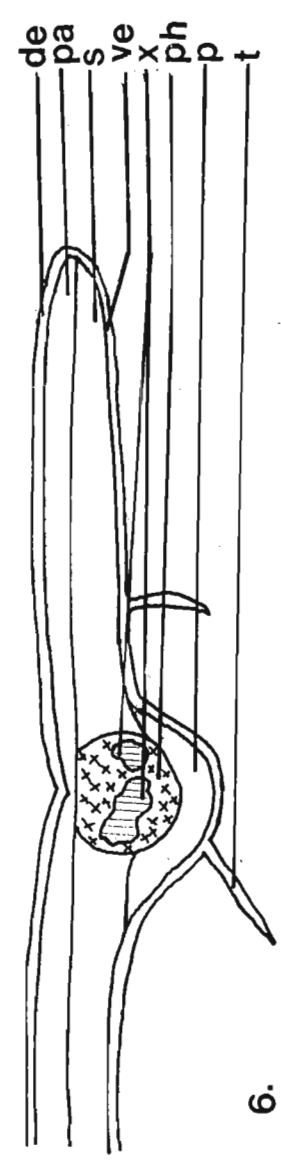
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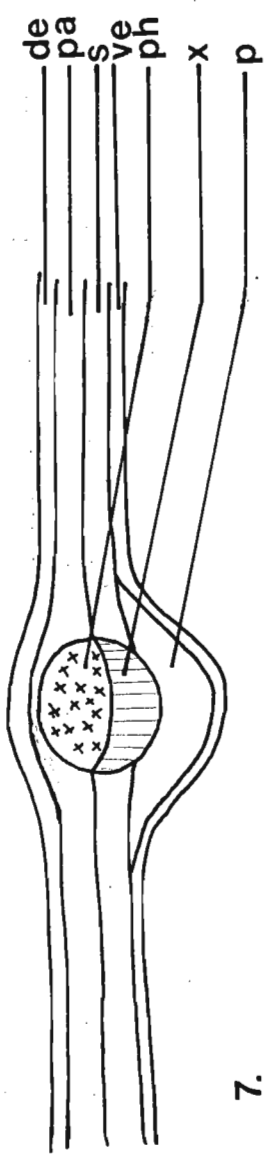
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7.

tissues normally found in leaves; namely upper and lower epidermal tissue covered by cuticles and with or without trichomes; palisade and spongy mesophyll tissue. Mid-ribs were composed of vascular tissue that consisted of xylem and phloem tissue and parenchyma tissue.

The arrangement of vascular tissues of O. pes-caprae and O. smithiana differed from those of the other Oxalis species (Figs. 21.2 and 21.6a). In both O. pes-caprae and O. smithiana a core of xylem tissue was surrounded by phloem tissue. In the case of O. pes-caprae the central xylem tissue was broken up into bundles by columns of phloem tissue.

With the exception of O. obliquifolia (Fig. 21.3), the ventral portion of the mid-ribs consisted of 2-3 layers of parenchyma tissue.

All species possessed upper and lower epidermal tissue that was composed of tall, hyaline cells whose outer surface were greatly convexed. The convexed shape of the outer cell walls served to concentrate light onto the palisade cells below thus enhancing the photosynthetic process. This seemed to be an adaptation to their shady habitats.

Where present, mainly uniseriate, eglandular trichomes occurred on the epidermal surfaces. With the exception of O. corniculata (Fig. 21.1), O. obliquifolia (Fig. 21.3) and O. smithiana (Fig. 21.4) uniseriate trichomes occurred only on the ventral epidermal surfaces. Both surfaces of O. corniculata were pubescent whilst both surfaces of O. obliquifolia and O. smithiana were glabrous.

Another interesting feature of O. obliquifolia and O. smithiana (Figs 21.3, 21.2) was the presence of palisade mesophyll tissue ventrally. This resulted in the spongy mesophyll of these two species being sandwiched between two layers of palisade mesophyll tissue.

The upper and lower epidermes of all species of Oxalis consisted of single layers of cells as did the palisade mesophyll. Spongy mesophyll tissue in all species was composed of 1-2 layers of cells.

4.2.2 Tissue types and arrangements in transverse sections of petioles

Table 7 summarises the tissue types and arrangements in transverse sections of petioles.

Tissue types commonly noted in transverse sections of Oxalis were epidermal tissue (single layer), cortical tissue consisting of an outer photosynthetic zone (1 layer in all species except O. semiloba which had 2 layers) and an inner achlorophyllous zone (2-4 cell layers), endodermal tissue was present in most species; steles were composed of xylem and phloem tissue, parenchyma rays and pith.

Endodermal tissue was not distinguishable in O. corniculata (Fig. 22.1) and O. pes-caprae (Fig. 22.6). In the remaining five species (Figs. 22.2-22.5 and 22.7) an endodermis was readily distinguished. A ring of pericycle tissue was easily distinguishable in O. obliquifolia and O. smithiana (Figs 22.3 and 22.2 respectively).

The most distinctive anatomical features of O. corniculata (Fig. 22.1) was a ring of sclerenchyma tissue (3-4 layers deep) that separated the cortex from the stele.

Table 7. Tissue types and the number of layers of some types in transverse sections of the petioles of *Oxalis* spp. in Natal.

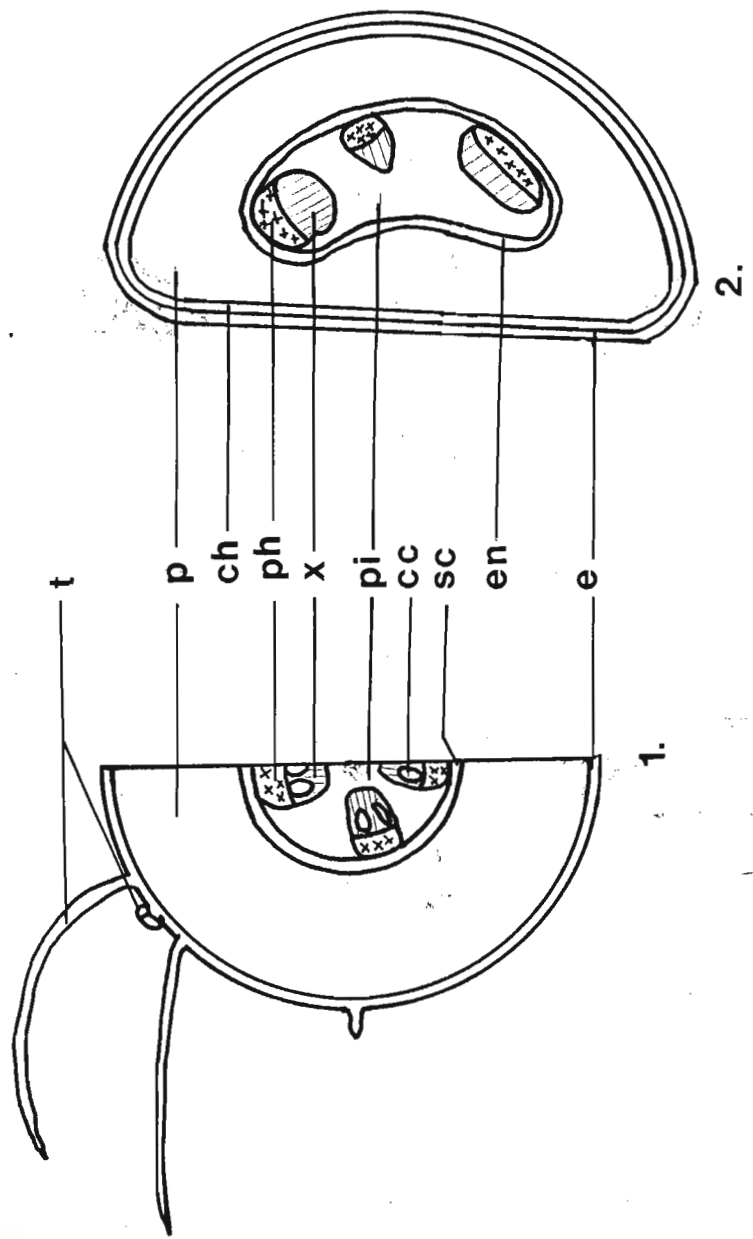
sp.	epidermis		chloro-phyllous		achloro-phyllous		endodermis	peri-cycle	sclerenchyma		vascular bundles		pith	trichomes	
	No.		No.		No.				No.		phloem	xylem		gland.	egla
<i>corniculata</i>	+	1	+	1	+	2-3	-	-	+	2	+	+	+	s	+
<i>smithiana</i>	+	1	+	1	+	2-3	+	+	-	-	shape differs	+	+	-	-
<i>obliquifolia</i>	+	1	+	1	+	2-3	+	+	-	-	+	+	+	-	+
<i>corymbosa</i>	+	1	+	1	+	3-4	+	-	-	-	+	+	+	+	+
<i>semiloba</i>	+	1	+	2	+	2-3	+	+	-	-	+	+	+	-	+
<i>pes-caprae</i>	+	1	+	1	+	6-7	+	-	-	-	+	+	+	-	+
<i>latifolia</i>	+	1	+	1	+	2	+	-	-	-	+	+	+	-	+

c.c. = carinal canals
 egland = eglandular trichomes
 gland = glandular trichomes
 s = sessile
 † = 3 with starch

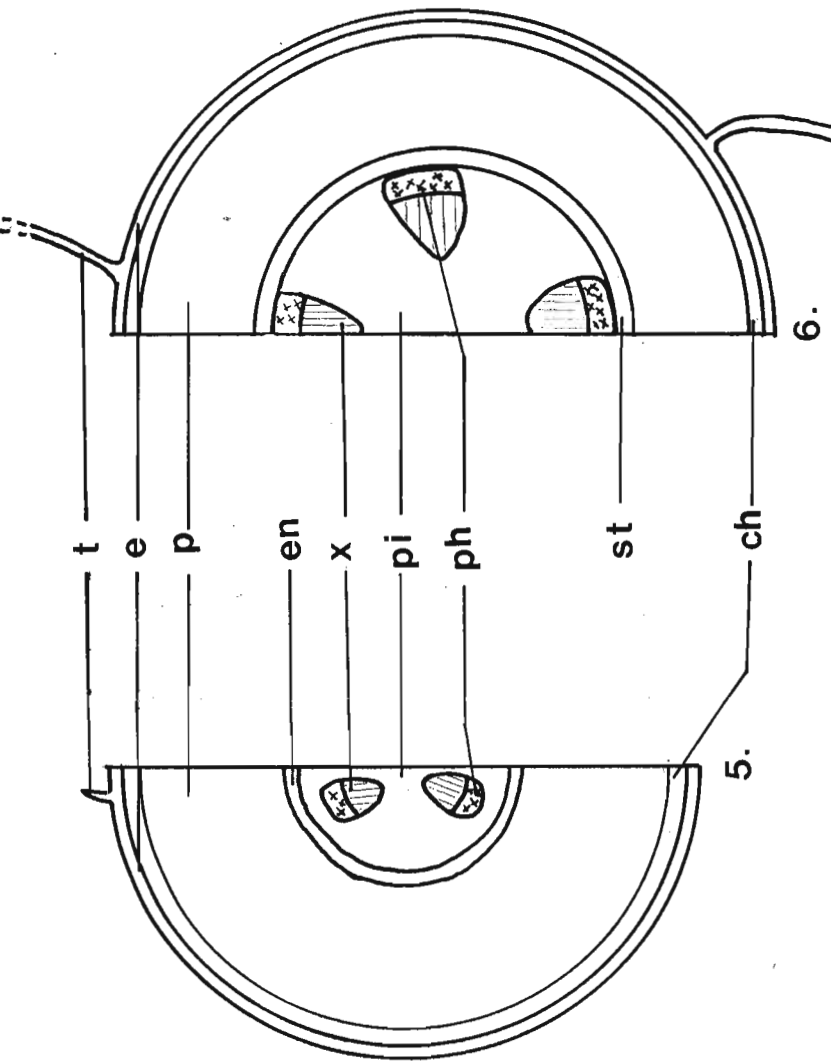
Fig. 22. Plan diagrams of transverse sections of petioles.

- .1. O. corniculata X50
- .2. O. smithiana X70
- .3. O. obliquifolia X60
- .4. O. corymbosa X70
- .5. O. semiloba X40
- .6. O. pes-caprae X55
- .7. O. latifolia X30

cc = carinal canal
 ch = chlorophyllous layer
 e = epidermis
 en = endodermis
 p = parenchymatous cortex
 pe = pericycle
 ph = phloem
 pi = pith
 sc = sclerenchyma
 st = starch layer
 t = trichomes
 x = xylem

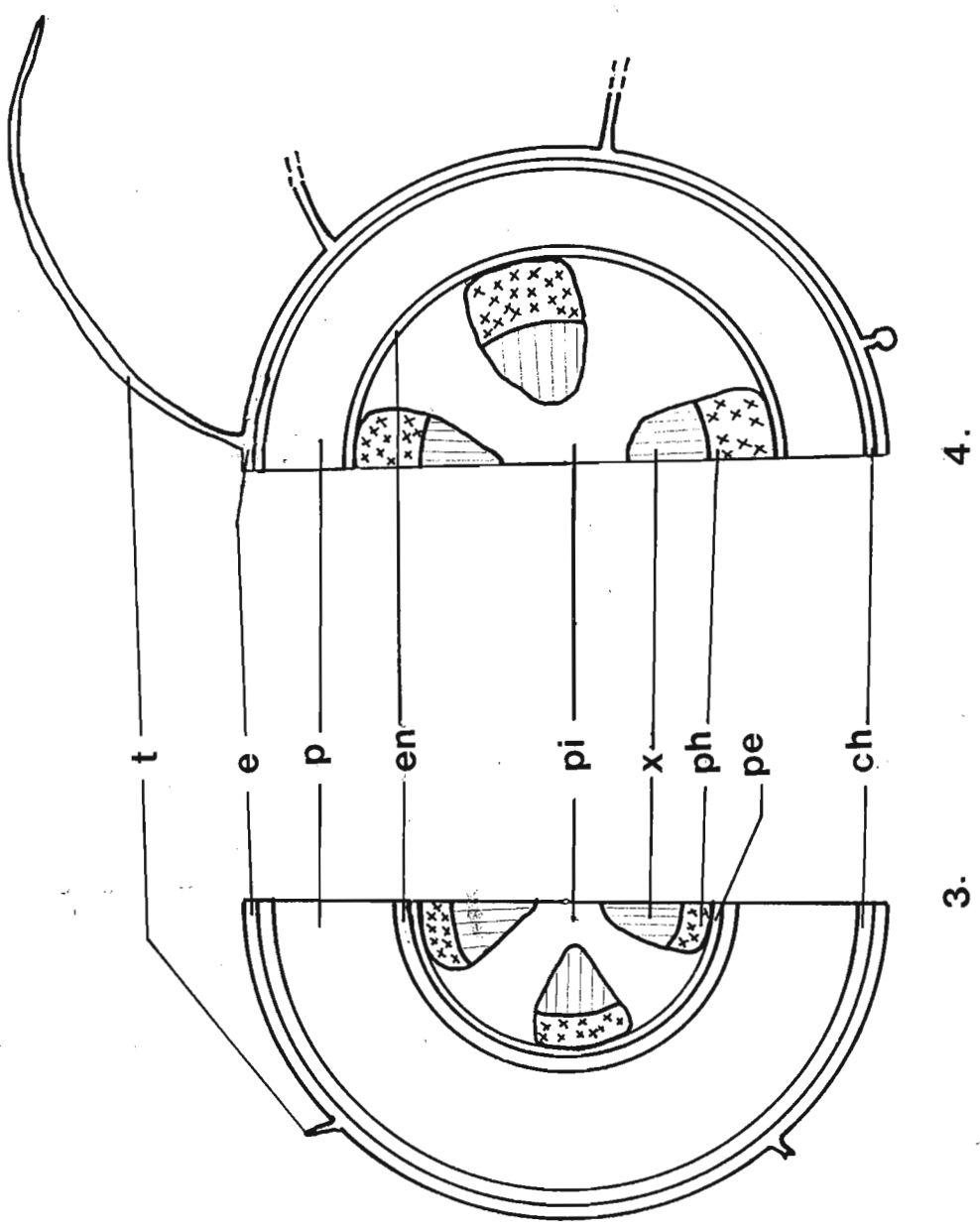


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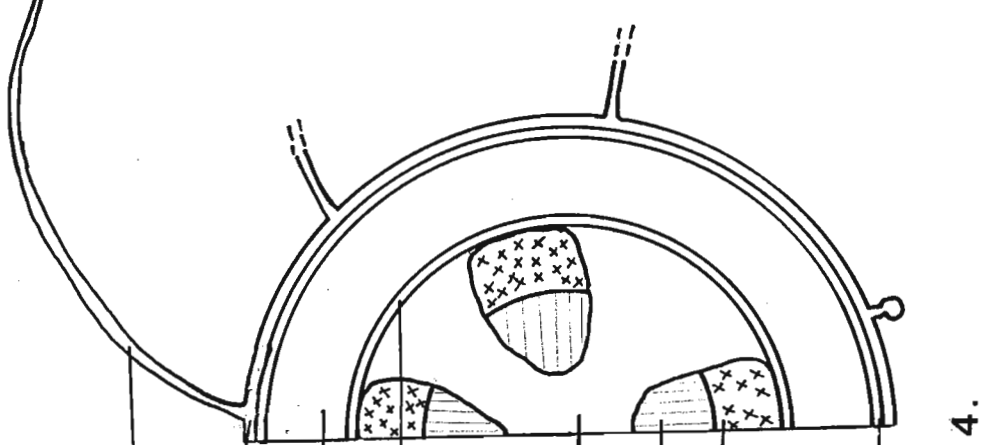


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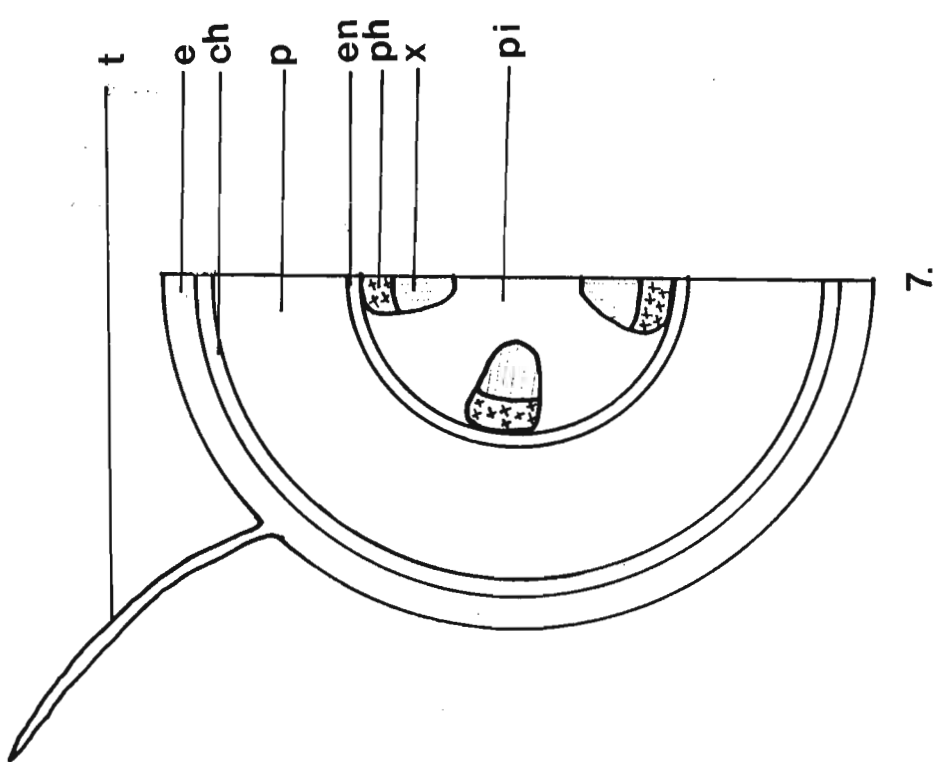
6.



3.



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In O. pes-caprae (Fig. 22.6) 1-2 cell layers of cortical parenchyma tissue closest to the stele, were filled with starch grains.

All species possessed up to five bundles of vascular tissue each separated by parenchymatous rays. The shape of the vascular bundles and the number of vascular bundles (3) of O. smithiana (Fig. 22.2) differed from the other species.

Xylem development in all species was endarch.

Carinal canals were visible only in O. corniculata (Fig. 22.1).

In all species the pith consisted of parenchymatous tissue.

Only the petiole of O. smithiana (Fig. 22.2) was glabrous. All the other species possessed uniseriate, eglandular trichomes. O. corniculata (Fig. 22.1) and O. corymbosa (Fig. 22.4) were the only two species that possessed a few glandular trichomes. Those of O. corniculata were sessile whilst those of O. corymbosa were stalked.

All species, except O. smithiana possessed terete petioles. The petioles of O. smithiana was semi-terete (Fig. 22.2).

4.2.3 Tissue types and arrangements in transverse sections of peduncles/scapes

Table 8 shows the different tissue types and arrangements in transverse sections of peduncles/scapes.

Tissue types that occurred in sections of specimens examined were: epidermal tissue (1 cell layer thick); cortical parenchymatous tissue which consisted of an outer photosynthetic zone (usually 1-2 cell layer thick, except O. corniculata which was 2-3 cell layers deep) and an inner achlorophyllous zone (absent in O. corniculata (Fig. 23.1), 2-3 layers deep in O. smithiana and O. obliquifolia (Figs. 23.2, 23.3) and 3-4 layers deep in the other species. The cortex of O. corniculata (Fig. 23.1) consisted only of photosynthetic tissue. Xylem and phloem tissue were present in all specimens examined.

O. semiloba (Fig. 23.5) was the only species of Oxalis in Natal that possessed a ring of collenchyma (2 cell layers thick). This collenchyma tissue was found to lie immediately below the epidermis.

O. corniculata (Fig. 23.1) and O. latifolia (Fig. 23.7) did not appear to possess epidermes. A ring of sclerenchyma tissue (2 cell layers deep) separated the cortex and stele of O. corniculata (Fig. 23.1)

Table 8. Tissue types and the number of layers of some types in transverse sections of the peduncles or scapes of *Oxalis* spp. in Natal.

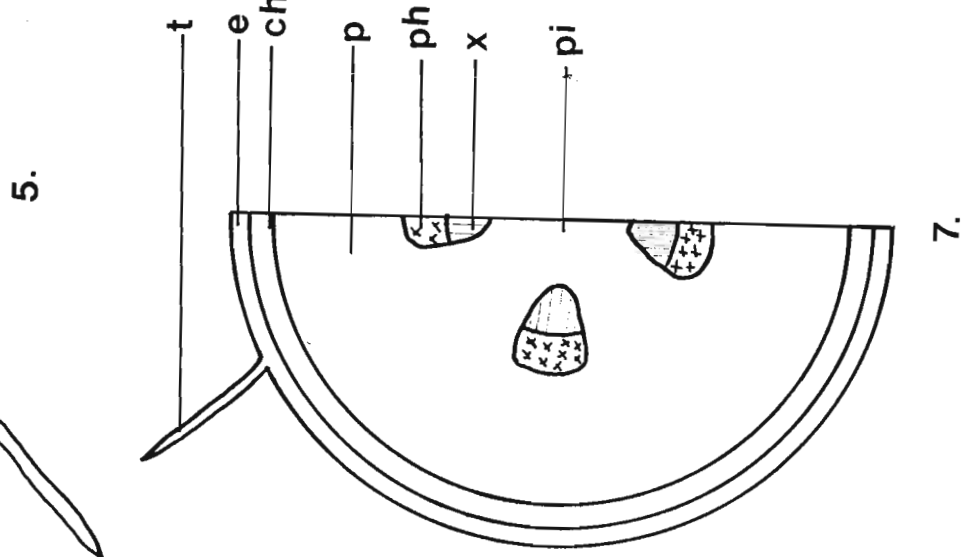
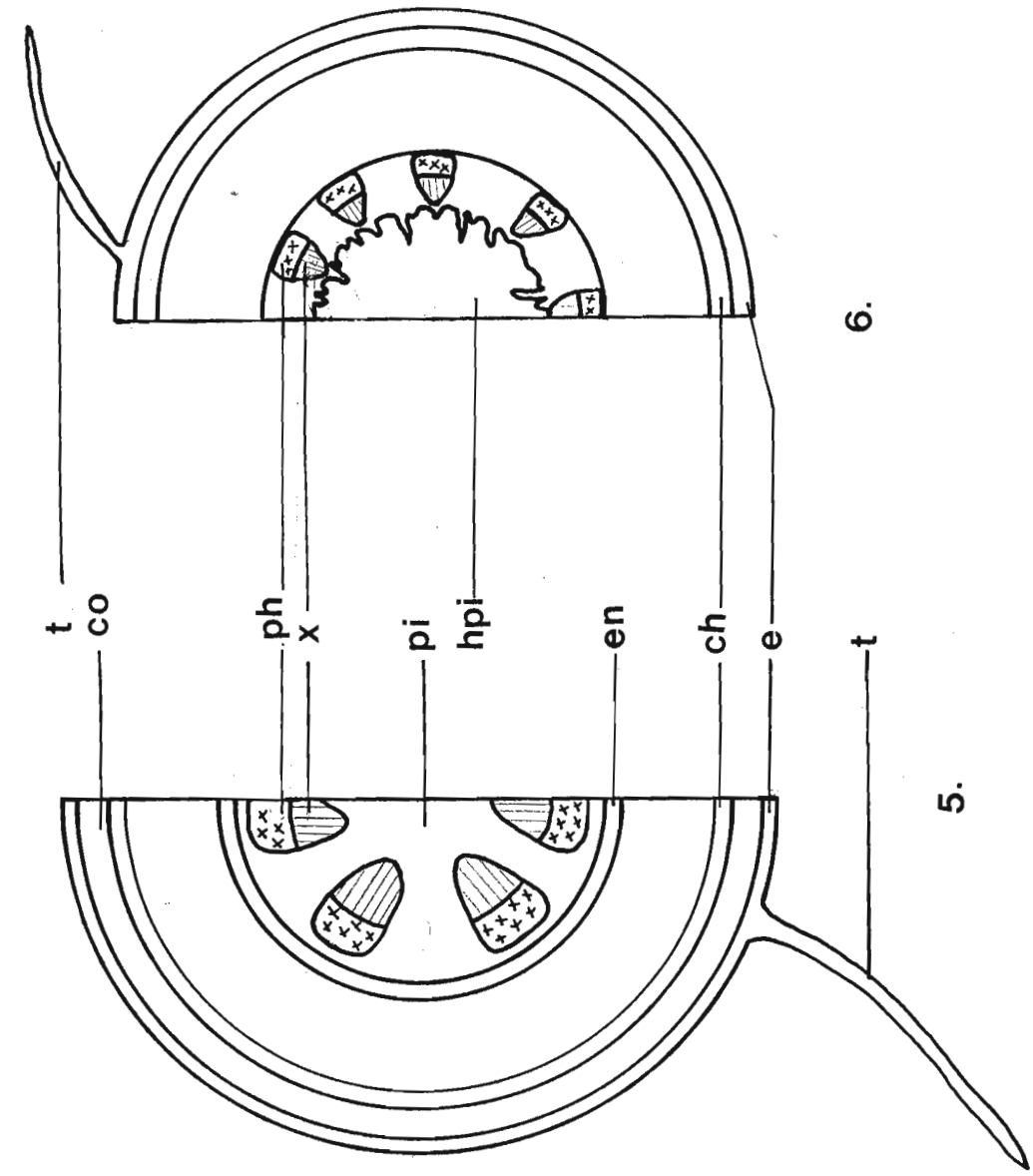
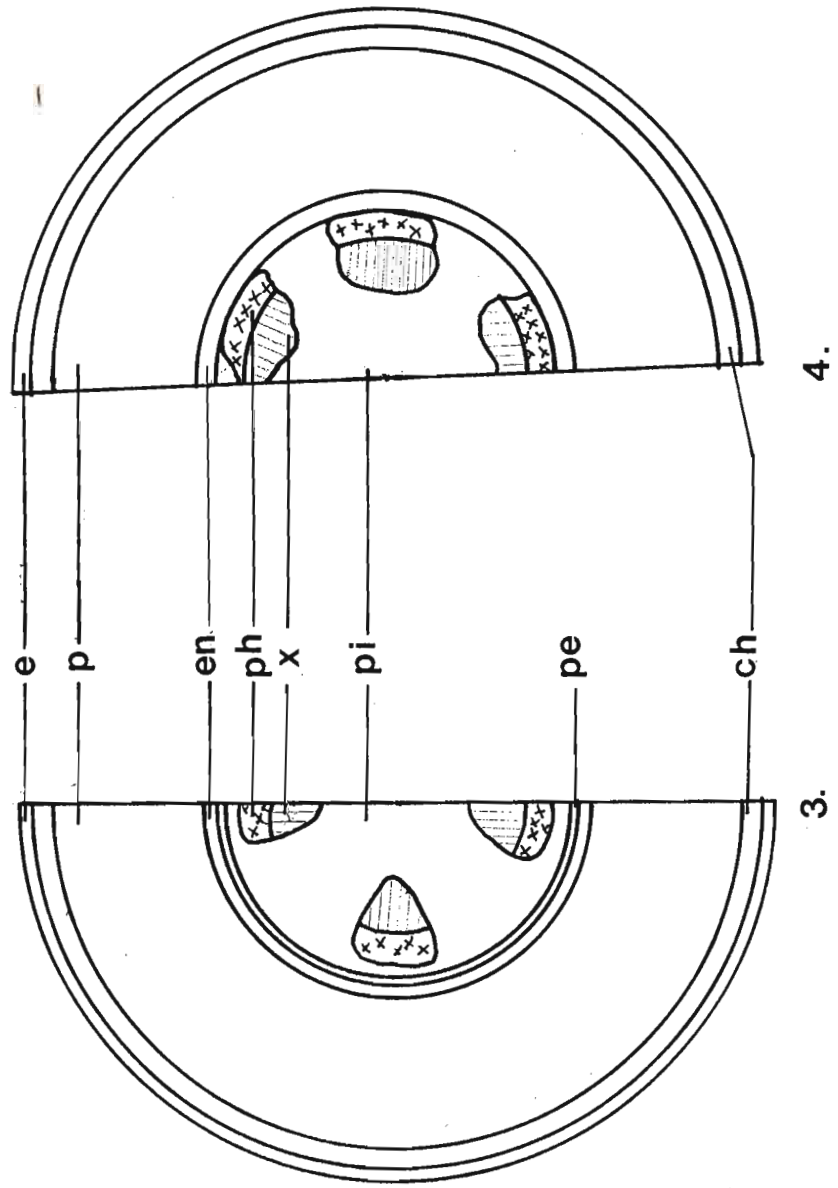
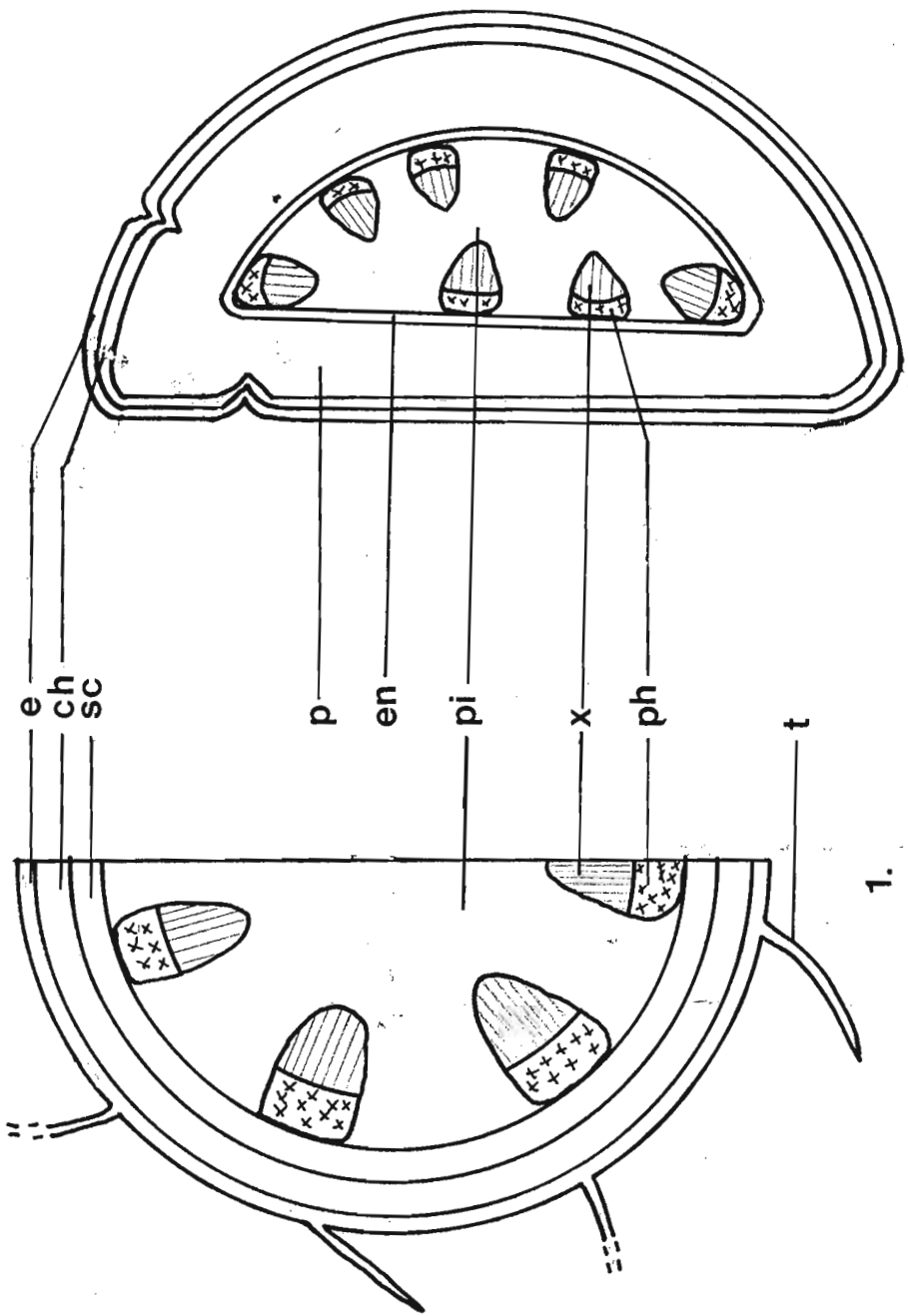
Tissue Type and No.	Epidermis		collen- chyma		chloro- phyllous		scleren- chyma		achloro- phyllous		endode- mis		peri- cycle		vascular bundles		pith		tricho- uniser- iate
	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	phloem	xylem	parench.	hollow					
<i>corniculata</i>	+	1	-	-	+	2-3	+	2	-	-	-	-	-	-	+	+	-	-	+
<i>smithiana</i>	+	1	-	-	+	1	-	-	+	2-3	+	+	-	-	+	+	-	-	-
<i>obliquifolia</i>	+	1	-	-	+	1	-	-	+	2-3	+	+	+	-	+	+	-	-	-
<i>corymbosa</i>	+	1	-	-	+	1-2	-	-	+	3-4	+	+	-	-	+	+	-	-	-
<i>semiloba</i>	+	1	+	2	+	1	-	-	+	3-4	+	+	-	-	+	+	-	-	+
<i>ves-caprae</i>	+	1	-	-	+	1	-	-	+	3-4	+	+	-	-	+	-	+	+	+
<i>latifolia</i>	+	1	-	-	+	1-2	-	-	+	3-4	+	+	-	-	+	+	-	-	+

parench. = parenchyma

Fig. 23. Plan diagrams of transverse sections of
peduncles/scapes

- .1. Peduncle of O. corniculata X70
- .2. Scape of O. smithiana X70
- .3. Scape of O. obliquifolia 70
- .4. Peduncle of O. corymbosa X70
- .5. Peduncle of O. semiloba X60
- .6. Peduncle of O. pes-caprae X40
- .7. Peduncle of O. latifolia X60

ch	=	chlorophyllous layer of cortex
co	=	collenchyma
e	=	epidermis
en	=	endodermis
hpi	=	hollow pith
p	=	parenchymatous layer of cortex
pe	=	pericycle
ph	=	phloem
pi	=	parenchymatous pith
sc	=	sclerenchyma layer
st	=	parenchymatous layer with starch grains
t	=	trichomes
x	=	xylem



2.

4.

5.

whilst the vascular bundles of O. latifolia (Fig. 23.7) appeared to be scattered in the ground tissue. The number of vascular bundles in all species of Oxalis in Natal ranged from 5-10; with O. pes-caprae having the greatest number (Fig. 23.6). O. obliquifolia was the only species of Oxalis examined that had a clearly visible pericycle layer (Fig. 23.3.).

O. pes-caprae (Fig. 23.6) was the only species examined that possessed a hollow pith. The piths of all other species (Fig. 23.1-23.5 and 23.7) was composed of parenchyma tissue.

The peduncle of O. corymbosa (Fig. 23.4) and the scapes of O. obliquifolia and O. smithiana were glabrous. All the other Oxalis species possessed uniseriate, eglandular trichomes. The peduncles of O. corniculata (Fig. 23.1) were densely pubescent whilst those of O. latifolia (Fig. 23.7), O. pes-caprae (Fig. 23.6) and O. obliquifolia (Fig. 23.4) were sparsely pubescent.

4.3 CONCLUSIONS

The distinguishing anatomical features of the petioles of the six species of Oxalis examined were:

1. O. corniculata - a ring of sclerenchyma in the cortex.
2. O. latifolia - no clear distinction between cortex and stele.
3. O. corymbosa - trichomes and pericycle absent, shape of vascular bundles differ from other species.
4. O. pes-caprae - hollow pith.
5. O. obliquifolia - clearly distinguishable pericycle, scape glabrous.
6. O. semiloba - a ring of collenchyma immediately below the epidermis.
7. O. smithiana - the semi-terete shapes of the petiole and scape; petioles and scapes glabrous.

There are clearly distinguished anatomical differences between the species of Oxalis of Natal. On a broader scale however, no significant conclusions can be drawn until the anatomy of all species of Oxalis in South Africa have been investigated.

5. PLANT BREEDING SYSTEMS

5.1 Introduction

Plant taxonomists traditionally place heavy reliance on assessing relationships and in arriving at taxonomic conclusions. From the standpoint of reproductive biology, differences in number, shape, and position of floral parts, in perianth-colour patterns and in various phenological traits, are all features that represent adaptations to various modes of pollination. Such an awareness can aid taxonomists in making intelligent taxonomic assessments. Floral and other characteristics associated with allogamy or xenogamy (heterostyly, dioecism, monoecism, etc.) can serve as a source of taxonomic confusion, because of the striking and discrete morphological differences between the floral forms of the same species, but they can be used as traits in providing a syndrome of characters to separate closely related taxa at various taxonomic levels.

Breeding systems are taxonomically important since the extent of interbreeding largely defines the pattern of variation and hence the delimitation of taxa. It is suggested, therefore, that taxonomists should make an attempt to understand the reproductive methods of the plants with which they work, since such an understanding will strengthen the foundation upon which taxonomic judgements are made (Hsu, 1986).

5.1.1 Heterostyly

Heterostyly was morphologically known for centuries, but it was only during the mid nineteenth century that Darwin, in Britain, and Hildebrand, in Germany, began to understand its biological significance (Ornduff, 1974).

The term heterostyly was first used by Hildebrand in 1867 to describe the breeding mechanism of plants of the same species which had two or three different ratios of style length : stamen length present in flowers. He also indicated that these plants were self-incompatible (although he did not use this term). He stated that the different lengths of floral parts was a mechanism for insect pollination (Vuilleumier, 1967).

Darwin in "The different forms of flowers on plants of the same species" (1877) adopted Hildebrand's terminology.

He, like Hildebrand, limited heterostyly to cases in which "one form is fully fertile only when it is fertilised with another form". He also believed that heterostyly facilitated insect pollination. Darwin also introduced several new terms. Darwin was the first to distinguish between (1) legitimate crosses i.e. between unlike forms (LxS styled plants) and (2) illegitimate crosses i.e. between like forms (LxL or SxS styled plants) (Ornduff, 1964; Vuilleumier, l.c.).

He gave the name "pin" to flowers with long styles and short stamens and "thrum" to those with short styles and long stamens. Darwin also noted dimorphisms in pollen size and shape, stigma surface etc. of these plants. His crosses showed that legitimate crosses resulted in more viable seeds than illegitimate ones although, he could not explain why this was so. It was later discovered that it was physiological incompatibility reactions, a property of heterostylous species, that caused Darwin's unexplained failure of illegitimate crosses (Vuilleumier, 1967).

Botanists later used the term heterostyly more loosely. For example Mulcahy (1964) defines heterostyly as being "one of several cases where a single species may contain two or more forms of flowers. Forms differ in relative lengths of styles and stamens as well as the size of the stigmatic papillae, ornamentation, size and colour of pollen and incompatibility reactions".

According to Vuilleumier (l.c.) only 22 families include heteromorphic flowers. This means that heterostyly is a rare phenomenon amongst the angiosperms as a whole (Yeo, 1975).

5.1.2 Tristyly

Tristyly is even more rare occurring only in three Angiosperm families. These are the monocotyledonous family Pontederiaceae and dicotyledonous families Lythraceae and Oxalidaceae (Ornduff, 1974; Yeo, l.c.; Richards, 1986). These are all families with stamens arranged in two whorls. Yeo (l.c.) states that it is highly probable that this arrangement is a necessary precondition for the evolution of stamens of two distinctly different lengths in the same flower.

The fact that tristyly and hence heterostyly occurs in three unrelated families indicates, as Vuilleumier (l.c.) points out, that heterostyly is of polyphyletic origin with parallel evolution occurring in the different families.

In tristyly three types of flowers occur: (1) long-styled flowers with two sets of anthers below the stigma or stigmas, (2) mid-styled flowers with one set of anthers above the stigma or stigmas and the other below and (3) short-styled flowers with two sets of anthers above the stigma or stigmas. Figure 24 diagrammatically represents the crossing pattern and the floral morphology of a tristyly, self incompatible system.

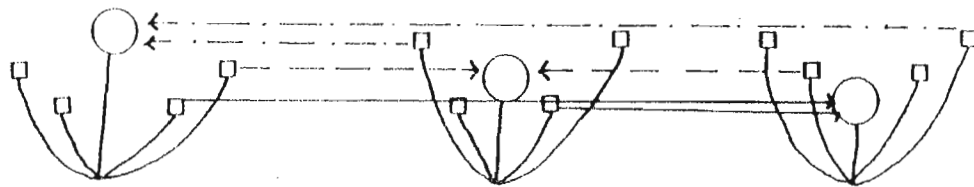


Figure 24. Diagrammatic representation of the crossing pattern and floral morphology of a tristylous species with an incompatibility system. Arrows from anthers () to stigmas. (o) indicate pollinations resulting in the most productive seeds. All other possible crosses are comparatively unproductive (Ornduff, 1964).

About half the world's species of Oxalis are endemic to South Africa and most of these are localised in the Cape Province. Jacquin, in 1794, was perhaps the first botanist to describe heterostyly in the South African species of Oxalis. However, he misinterpreted floral trimorphism to represent specific differences and described them as such. Thus O. macrogyna Jacq. (long-styled), O. fallax Jacq. (mid-styled) and O. luteola Jacq. (short-styled) = O. luteola (Ornduff, 1964; 1974).

Later, Hildebrand, in 1867, reported heterostyly in several South African species and pointed out Jacquin's error. Salter (1944) stated that all species native to South Africa were "probably" tristylous although in some rare species not all stylar forms have yet been observed. Marloth in 1925 had, however, stated unequivocally that "all indigenous species are trimorphic" (Ornduff, l.c.).

Ornduff (l.c.) agrees that probably all South African species are morphologically tristylous and that it seems probable that homostyly has not evolved in South African species of Oxalis. However, he adds that this morphological heteromorphism is not always associated with outcrossing or self-incompatibility.

In several tristylous species of Oxalis and numerous distylous species, morphological arrangement favouring cross pollination is strongly reinforced by a physiological incompatibility system preventing fertilization after illegitimate pollinations. Such heteromorphic incompatibility can arise only as a result of strong selective pressures exerted over a long period of time. There is evidence that when selective pressures regulating the maintenance of these systems are relaxed or altered in direction, the integrated syndrome of morphological and physiological traits characteristic of heteromorphic incompatibility may rapidly break down, usually in the direction of increased inbreeding. There are several

routes which the breakdown of heteromorphic incompatibility may follow. The diverse breeding systems of the American representatives of Oxalis section Corniculatae are most probably derived from an ancestral trimorphically incompatible system (Mulcahy, 1964; Ornduff, 1972).

5.1.3 Functional dimorphism

Oxalis suksdorfii is morphologically tristylous. Experimental studies carried out by Ornduff (1964) indicated that plants with long styled flowers are weakly self-compatible and show little differentiation in size or compatibility relationships of pollen from the two sets of stamens. The mid-styled flowers have strongly differentiated pollen but produce few capsules or seeds when artificially or naturally pollinated. The short styled flowers are self-incompatible and show slight pollen differentiation. Ornduff (l.c.) states that the data gathered indicates that O. suksdorfii approaches functional dimorphism since the mid-styled flowers contribute little pollen and few seeds in sexual reproduction. He postulated that perhaps the species is in a process of completely losing its mid-styled forms. However, an abundance of this form in the wild, according to Ornduff (l.c.), indicates that this form is retained because it contributes to the general fitness or because the genetic control of heterostyly in this species prevents its elimination.

5.1.4 Autogamy and Cleistogamy

Ornduff (1969) stated that the evolutionary shift from xenogamy (outbreeding) to autogamy (selfing) has been mediated through decreased flower size and alterations in floral morphology which reduces the energetic cost per flower and facilitates self pollination respectively.

Once increased inbreeding, as a result of autogamy, became superimposed on ecological characteristics the result was:

1. assurance of seed set without the necessity of a pollinator,
2. reduced generation times; since fertilization occurs prior to anthesis and
3. the ability to reproduce large quantities of essentially uniform, highly adapted genotypes as a consequence of (1).

This enabled autogamous and or self-compatible members to become characteristic colonisers and occupants of permanently disturbed habitats (Eiten, 1963; Cruden, 1977).

The degree of outcrossing associated with the trimorphic incompatibility system is apparently disadvantageous to members of Oxalis section Corniculatae. This section, incidentally, occurs mainly in North and South America and the Greater Antilles. The apparent disadvantages of the trimorphic incompatibility system to members of this

section has led to the adoption of nearly every evolutionary strategy leading to the breakdown of this trimorphic incompatibility:

1. the first change is the reduction and eventual loss of self-incompatibility,
2. the disappearance of secondary morphological characteristics (e.g. pollen size heteromorphism) associated with trimorphism although trimorphic styles and stamens are retained by some taxa and
3. in some phyletic lines leading to quasi-homostyly;

the morphological apparatus of heterostyly is retained because of the highly reduced flower size and certain changes in anther phenology (e.g. anther dehiscence prior to anthesis) (Eiten, 1963).

Nearly all changes in this section result in inbreeding but factors leading to these changes are unclear (Eiten, l.c.).

5.1.5 Semi- and Quasi-homostyly in the Section *Corniculatae*

In some races of *O. corniculata*, the lower set of anthers are sterile. *O. corniculata* is mostly semi-homostylous with styles equal in length to the longer set of stamens. Quasi-homostyly of some races of *O. corniculata* and *O. dillenii* and some South American species is one in which

positional relationships of anthers and stigmas is basically a heterostylous one (Eiten, l.c.).

Eiten (l.c.) concludes by stating that the diverse floral structure and the associated varying degrees of autogamy within certain taxa of this section means that the reproductive system within the group is continuing to respond to strong selective pressures in the direction of inbreeding.

5.1.6 Cleistogamy

In Oxalis, cleistogamous flowers develop perfectly but are extremely reduced in size. Tristyly occurs in cleistogamous and chasmogamous flowers. Although self-pollinating, chasmogamous flowers are generally almost totally sterile, the habitual self-pollination of cleistogamous flowers yields fully fertile seeds (McLean and Ivimey-Cook, 1956).

In O. acetosella, there is a corresponding balance between the formation of normal, open (chasmogamous) flowers and the very reduced, bud-like (cleistogamous) ones in the same plant. The cleistogamous flowers occur generally in summer when other vegetation has overgrown the plant. Pollen of the cleistogamous flowers of O. acetosella germinates within the anther cells thus the pollen tubes have

a short distance to traverse before reaching the stigma (Proctor and Yeo, 1973; Von Denffe et al, 1976).

According to Ornduff (1964) knowledge of the breeding system of Oxalis has not advanced much beyond the stage at which it was left by the researches of Darwin and Hildebrand in the nineteenth century.

5.1.7 Pollen and Papilla Morphology

In Lythrum junceum (Lythraceae) the three floral forms are distinguished by:

1. style length,
2. stamen length,
3. size of pollen grains and
4. size of stigmatic papillae

Pollen measurements of this genus, according to Ornduff (1975) is heteromorphic although the mid- and short- anther pollen grains differed only slightly. Similar conclusions were reached for the length of the stigmatic papillae.

5.1.8 Pollen grain morphology

Erdtman (1966) described the pollen grains of the family Oxalidaceae as being 3-colpate or 3-colporoidate, sometimes 4-colpate, 4-rupate or more or less irregular, prolate (33 x 21 μm - Biophytum abyssinicum), longest axis: 23-63 μm , sexine as thick as nexine or thicker, reticulate e.g. in O. acetosella: Grains 3-colpate (occasionally 4-rupate), sub-prolate (53-44 μm). According to Heslop-Harrison and Shivanna (1977) the pollen of Oxalis is binucleate.

5.1.9 Papilla morphology

In addition to the parameters outlined by Ornduff (1975) for L. junceum, papillae morphology of certain species is also important. Heslop-Harrison and Shivanna (1977) state, with caution that the type of stigma could indicate whether self-incompatibility is gametic or sporophytic.

A dry papillate stigma, normally associated with trinucleate pollen is an indication of a sporophytic self-incompatibility system whilst a wet papillate stigma is an indication of a gametic self-incompatibility system (Heslop-Harrison and Shivanna, l.c.).

According to an artificial classification of stigma types drawn up by Heslop-Harrison and Shivanna (l.c.) the

papillae of the stigmas of Oxalis spp. have the classification IIB(ii) i.e. dry, multicellular and multi-seriate.

The function of these stigmatic papillae is to increase the pollen capturing area as well as to reduce the opportunity for interaction by ensuring that the pollen surface materials cannot be disturbed too freely on the stigma surface from individual grains or small clumps (Heslop-Harrison and Shivanna, l.c.).

5.1.10 Pollinators

The highly evolved trimorphic self-incompatibility system of the three tristyllic families indicates that flowers of these families are pollinated by fairly specialised pollinators. The delicacy of these flowers as well as their colouration hints at insects being the main pollinators of these families.

Yeo (1974) draws attention to the fact that in two of the three tristyllic families; namely the Pontederiaceae and the Lythraceae, the flowers stand nearly horizontally, all the sex organs or at least the longer ones are exserted, turned up at the tips and serve as an alighting place for pollinating insects.

According to Yeo (l.c.), these flowers are thus functionally zygomorphic and pollination is sternotribic. He advances the hypothesis that the insects' proboscides are too short to provide three separate places for pollen transport, unless the anthers and stigmas are especially small as in Oxalis, and so tristyllic species of these two families use the body as well.

According to Perry (1972) tristyllic flowers produce nectar and thus are visited by insects. It would appear that mainly bee-flies, honeybees and butterflies are the visitors of Oxalis spp. Proctor and Yeo (1973) report that the insect visitors of O. rubra are the bee-flies (Bombylius spp.). According to Ward (1980) O. corniculata and O. latifolia offer nectar as a reward to visitors. Ward (l.c.) observed honey-bees (Apis spp.) on O. corniculata and butterflies of the Family Pieridae as well as the Monarch butterfly (Danaus chrysippus) visiting the flowers of O. latifolia. Honey-bees, reports Ward (l.c.), also visit flowers of O. latifolia.

5.1.11 Seed Dispersal

Autochory is the dispersal of seeds by the plant itself. This is especially frequent amongst plants of arid regions. Oxalis spp. are known to be active ballists, since a release in tension of dead tissue causes the seeds to be expelled. The seeds of Oxalis and Biophytum have

a turgid outer testa (the aril) that splits and ejects the seeds over a distance of two metres (Gill and Vear, 1966; van der Pijl, 1969).

In the desert species of Oxalis dispersal of seeds is by fixation. The nude embryo is expelled explosively and soon after wetting by dew is enveloped in mucilage from the radicle which soon afterwards dries and glues the embryo to the soil (van der Pijl, l.c.).

The seeds of O. corniculata are mechanically dispersed from an explosive capsule. When ripe, according to Ridley (1930) the seeds of O. corniculata are surrounded by an aril. This layer contracts, splits and rolls up rapidly upon drying. The seed is shot out. Seeds of O. corniculata fly over distances of about one metre. Ridley (l.c.) reports that Moggridge, in the south of France, observed that the seeds of O. corniculata were dispersed by ants.

The cosmopolitan dispersal of O. corniculata, however, is mainly due to the human agent. According to Ridley (l.c.) O. corniculata is a native of Southern Europe. Clusius in 1594 first reported the occurrence of this species in southern Europe. It is suggested that the species is also a native of the northern temperate zone of the Old World being especially common in India. It is possible that the explosively expelled seed gets into pots or occurs

among the soil attached to plants that are to be exported. O. corniculata is thus generally absent from islands not cultivated by man. It is, however, interesting to note that O. corniculata, which is abundant in the Polynesian Islands, was well established there prior to the advent of Europeans (Ridley, l.c.).

5.1.12 Vegetative dispersal

It is not always possible that all three stylar forms of Oxalis are introduced into a country. This means that seed set is impossible if the plant does not adapt to an autogamous breeding system. Most of these plants opt, at least initially, for vegetative propagation.

The genus Oxalis often produces small underground bulbs. O. cernua, a pest in the Mediterranean regions, occurs as a sterile allopolyploid hybrid; in addition only the short styled form had been introduced. Thus bulbs are responsible for the widespread distribution of this species (van der Pijl, 1969).

According to Galil (1968) the extraordinary capacity of the Oxalis plants to reach the soil surface from great depth and the rapid regeneration of shoots when cut or damaged are highly significant. Due to the self-migration of these bulbs, newly invaded sites soon become covered with a thick carpet of plants.

Because of the elongated shape and strong outer coats, few bulbs are crushed by a plough. Dispersal is thus greatly increased by ploughing and tillage. Bulbs are also widely distributed in the soils of transplanted saplings (Galil, 1968). Galil (l.c.) suggested that the contractile roots of O. cernua play a role in vegetative dispersal rather than in depth adjustments. He likens their function to that of the contractile roots of Allium neapolitanum and Brodiaea lactea.

It is common knowledge that seeds are cached by mammals, but few realize that bulbs, tubers and corms have also been found in caches. Long range dispersal of the bulbs of O. cernua is via the mole rats (Spalax) that construct underground "granaries". The bulbs of O. cernua are cached by the mole-rat Spalax ehrenbergi. The rat makes two types of cache; one associated with the nesting chamber and others as stores. The female crops the young shoots as they appear from the bulbs in the nesting place but bulbs in the stores may remain uneaten. Thus the plants establish themselves readily and spread vigorously from these caches (Fig. 25) (Galil, 1968; van der Pijl, 1969; Harper, 1977).

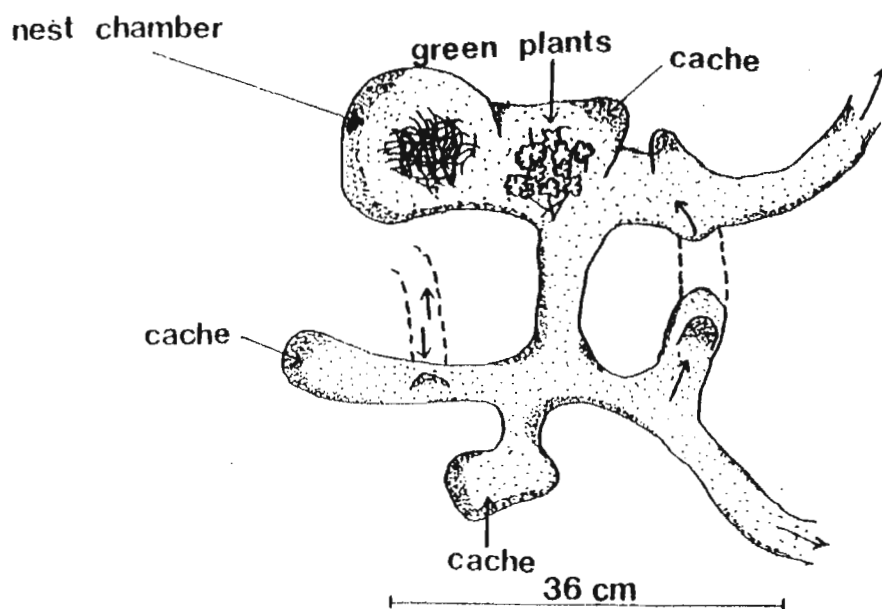


Fig. 25. The arrangement of tunnels and larders of the mole rat (*Spalax ehrenbergi*) which collects and stores bulbs of *Oxalis* as well as a variety of seeds, tubers and corms (From Galil, 1967 in Harper 1977).

Ridley (l.c.) reports that Pistone had observed birds e.g. *Passer hispaniolensis* aiding in the distribution of the bulbs of *O. cernua*.

Local populations of O. corniculata are "grazed" by birds which eat the seeds. Some seeds stick to the feathers around their beaks. This could possibly be a method of seed dispersal (Hennessy, 1987 pers. comm.). The creeping habit of O. corniculata has also aided in the dispersal of this species.

5.2 Discussion

5.2.1 Flowering and fruiting trends of Oxalis spp.
O. corniculata, which is homostylous, flowers throughout the year. Whether or not a colony or plant flowers depends upon the environmental conditions of its habitat. It appears as though a lack of moisture inhibits flowering as well as the spread of the colony. Colonies growing in very moist shady conditions spread mainly vegetatively by means of stolons. Fruit formation, like flowering, occurs throughout the year.

All other species of Oxalis in Natal flowers only during certain periods. The introduced species flower earlier than the indigenous species. O. pes-caprae (indigenous to the Cape winter rainfall regions) flowered from April to September.

O. corymbosa (indigenous to South America) flowered from June to November. These two species had the shortest flowering periods. Although the flowering period of O. corymbosa spans six months, the occurrence of flowering material during this period was few and far between. O. latifolia (the other species introduced from South America) had a fairly long flowering period from June to February. Under optimum environmental conditions colonies of O. latifolia flower profusely, O. pes-caprae, O. corymbosa and O. latifolia are all homostylous in Natal and thus do not produce any fruit. This indicated that the self-incompatibility system is still strong within these species.

Of the three Oxalis species indigenous to Natal, O. smithiana flowered the earliest. The flowering period of O. smithiana was between August and March. O. obliquifolia and O. smithiana had similar habitat requirements and were frequently found growing alongside each other. These two species differed, however in their periods of flowering. O. obliquifolia and O. semiloba both begin to flower in September and finished flowering in June. Although the flowering periods of these two species were the same, they were separated by different habitat requirements. O. semiloba preferred moist, occasionally disturbed urban habitats whilst

O. obliquifolia preferred moist veld or forest type habitats that were seldom disturbed. O. semiloba had a very short fruiting period from April to May. O. smithiana also had a very short fruiting period of three months from October to December. O. obliquifolia formed fruit over a period of seven months from December to June.

Flowering and fruiting trends are summarized in Table 9. O. pes-caprae was the only species of Oxalis in Natal whose bulb required a resting period. This resting period occurred during summer.

Conclusion

With the exception of O. corniculata, which formed flowers throughout the year, and whose flowering period thus overlapped with all other species, all the species had definite restricted flowering periods. Only the flowering periods of O. obliquifolia and O. semiloba overlapped, but these two species are spatially separated.

O. corniculata, which is homostylous, produced seeds throughout the year.

O. pes-caprae, O. corymbosa and O. latifolia, which are homostylous in Natal, do not form any fruit. The

Table 9. Flowering and fruiting trends in *Oxalis* spp. in Natal.

Spp. Month	<i>O. corniculata</i>		<i>O. smithiana</i>		<i>O. obliquifolia</i>		<i>O. corymbosa</i>		<i>O. semiloba</i>		<i>O. pes-caprae</i>		<i>O. latifolia</i>	
	Flr.	Fru.	Flr.	Fru.	Flr.	Fru.	Flr.	Fru.	Flr.	Fru.	Flr.	Fru.	Flr.	Fru.
January	X	X	X		X				X				X	
February	X	X	X		X				X				X	
March	X	X	X		X				X	X				
April	X	X			X				X	X	X			
May	X	X			X				X	X				
June	X	X			X		X		X				X	
July	X	X			X		X		X				X	
August	X	X					X		X				X	
September	X	X					X		X				X	
October	X	X		X			X		X				X	
November	X	X		X			X		X				X	
December	X	X		X					X				X	

Flr. = Flowering

Fru. = Fruiting

three species of Oxalis indigenous to Natal all produced fruit and seeds.

5.2.2 Autogamy and xenogamy

Stage 1 flowers of O. semiloba, O. obliquifolia and O. corniculata were covered in order to determine whether or not fruit formed if insects were prevented from aiding in the pollination process. Floods (September 1987) destroyed the experiment conducted upon O. obliquifolia and subsequently no flowering specimens could be easily located.

No fruit formed when the buds of O. semiloba were covered. This indicated that the self-incompatibility system was strong within this species. In the case of O. corniculata fruit formed after the buds were covered and left for seven days. This meant that successful self pollination occurred implying that the self-incompatibility system had broken down in O. corniculata and that pollen from a flower was compatible with the stigmas of the same flower.

No experiments were conducted on the flowers of O. latifolia, O. corymbosa and O. pes-caprae. These three species are homostylous in Natal and although insects were observed visiting them, no fruit was

ever found on any of these species. This would indicate that the self-incompatibility system was still strong in these species.

Conclusion

It would appear as though O. corniculata is facultatively xenogamous whilst all the other species of Oxalis investigated or observed are strongly xenogamous.

5.2.3 Food reserve in pollen grains

All species of Oxalis that occurred in Natal were investigated in order to determine the type of food reserves in the pollen grains. In all species the food reserve of the pollen grains appeared to be starch.

In the case of O. corymbosa only about 2% of the grains appeared to contain starch. 98% of the grains remained clear thus indicating that these grains did not contain any starch and were thus inviable.

5.2.4 Pollen viability and stigma receptivity

Pollen viability

Table 10 shows the percentage pollen viability of all species investigated at different stages of floral development as well as the receptiveness of the stigmas at the different stages of floral development. The stages of floral development are shown in Fig. 26.

In both O. latifolia and O. corymbosa (species indigenous to South America) pollen grains only became viable from stage 3 (Fig. 26). In all the other species of Oxalis investigated except O. smithiana pollen from the anthers of at least one stamen length per flower became viable from stage 1. In O. smithiana pollen became viable from stage 2.

In O. corniculata, a greater percentage of pollen from anthers of the short stamens was viable from stages 1-3 than from the anthers of the mid-stamen lengths. In O. corniculata, at stage 4, all pollen grains were viable.

O. corymbosa possessed the fewest viable pollen grains. At stage 4 only 38% of the pollen from the long stamens was viable and 14.7% of the pollen of

Table 10. Stigma receptivity and percentage pollen viability of *Oxalis* spp. in Natal.

Floral Development Stages	<i>O. coriunculata</i>		<i>O. smithiana</i>		<i>O. obliquifolia</i>		<i>O. corymbosa</i>		<i>O. semiloba</i>		<i>O. pes-caprae</i>		<i>O. latifolia</i>	
	SR +	0	SR -	0	SR -	0	SR	0	SR -	0	SR	0	SR	0
1	l		-	0	-	0	-	0	-	0	-	0	-	0
	m			0		20.0		0		26.0		0		0
	s			0		20.2		0		56.0		0		0
2	l	+		+	38.4	+	0	+	0	69.3		50.7		0
	m			+	54.3	+	0	+	0	34.0		65.8	+	0
	s			+	51.1	+	0	+	0	34.0		0		0
3	l	+		+	50.7	+	12.0	+	0	78.0		77.8		99.0
	m			+	58.7	+	0	+	0	57.0		66.0	+	0
	s			+	63.0	+	0	+	8.0	37.0		0		96.0
4	l	++		++	62.6	++	38.0	++	100	100		100		100
	m			++	62.2	++	0	++	0	72.0		100	++	0
	s			++	76.4	++	14.7	++	67.7		0	++		100

SR = stigma receptivity
l = long stamens/gynoecium
m = mid stamens/gynoecium
s = short stamens/gynoecium
+ = receptive
++ = very receptive

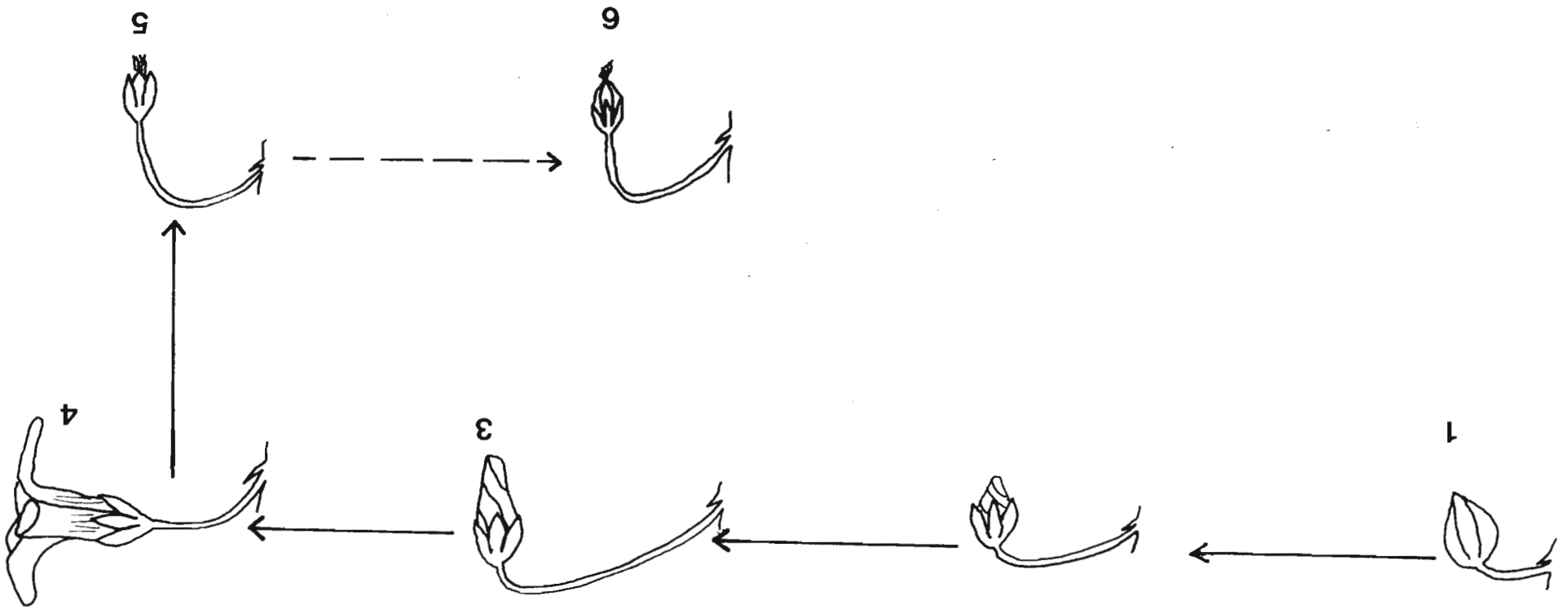


Fig. 26. Diagrammatic representation of the floral development of *Oxalis* spp.

----- in some species only

the short stamens.

In the case of O. latifolia, more pollen of the anthers of the long stamens, at stage 3, was viable than from the anthers of the short stamens. At stage 4 however, all the pollen grains of stamens of both lengths were viable.

Pollen grains of O. semiloba were viable from stage 1. At stage 1, more grains from the short stamens were viable than from the mid-stamens. At stage 2 stamens of both lengths had the same percentage of grains viable. At stages 3 and 4 however, more pollen of the mid length stamens was viable. At all stages most pollen from the anthers of the long stamens was viable.

Pollen of O. obliquifolia became viable from as early as stage 1. At stage 1 the percentage of viable pollen from the short stamens was fractionally more than from the mid- stamens. At stages 2 and 3 more pollen from the short stamens was viable. At stage 4 however, more pollen grains from the anthers of the mid-stamens were viable than from the short stamens. At all stages of floral development, pollen from the long stamens was the most viable.

Only the long and mid-stamen lengths of O. pes-caprae occur in Natal. At stage 1, 21.7% of the pollen of the long stamens was viable. All the pollen grains of the mid-stamens were inviable at this stage. The cytoplasm of the pollen grains were viable whilst the exine stained green. Pollen grains of both stamens lengths became viable from stage 2.

The mean percentage viability of the pollen of the different stamen lengths of the species of Oxalis investigated indicated that:

1. amongst those species that possessed long stamens, the pollen of O. obliquifolia was the most viable (63.1%) and the pollen of O. corymbosa was least (25%),
2. amongst those species that possessed mid length stamens, pollen of O. corniculata was the most viable (90.3%) and that of O. smithiana (43.8%) the least, and
3. amongst those species that possessed short length stamens, pollen of O. corniculata (94.8%) was the most viable and that of O. corymbosa (11.4%) the least.

Of all the species of Oxalis investigated the pollen viability of O. corniculata was the greatest. This is perhaps in keeping with their weedy habit. The pollen of O. corymbosa was the least viable.

Stigma receptivity

The stigma of all three style lengths of O. smithiana, O. semiloba and O. obliquifolia became receptive, although only slightly, at stage 2. At stage 4, all stigmas, of all three styler lengths of all these species, were very receptive.

Only the short styled form of flowers of O. pes-caprae were found in Natal. Stigmas became receptive only at stage 3 and were very receptive at stage 4.

Only the long styled forms of flowers of O. corniculata were found in Natal. The stigmas of these flowers became receptive from as early as stage 1.

Only the mid-styled form of flowers of O. latifolia and O. corymbosa were found. Both these species have been introduced from South America. The stigmas of both these species became receptive from stage 3 of the floral development.

Conclusion

In O. corniculata both the male and female reproductive parts are viable from stage 1 of floral development. In O. latifolia and O. corymbosa (both exotic species) the female parts become viable before the male parts. Of the species of Oxalis indigenous to South Africa, the male reproductive parts of O. obliquifolia, O. semiloba and O. pes-caprae became viable before the female parts; the male and female reproductive parts of O. smithiana, however, became receptive at stage 2. In all instances, however, the anthers only dehisced at stage 4 of floral development. This could therefore be a mechanism to prevent self-pollination.

5.2.5 Pollinators

The floral architecture of the flowers of Oxalis (Fig. 27) allowed for different types of insects to work them. The throat, which is moderately long, catered for the probosci of butterflies and in addition to this, it was wide enough for small bees to enter and exit. The mouths of the flowers of all species provided a fairly sturdy platform on which the visitors could land.

Fig. 27. Half-flower diagram of a mid-styled flower of *O. semiloba*

1. whole corolla lobe
2. 1/2 long anther
3. 1/2 long filament
4. 1/2 mid stigma
5. 1/2 mid style
6. 1/2 calyx lobe
7. whole short stamen
8. cut surface of corolla tube
9. 1/2 staminal tooth
10. locule
11. 1/2 ovary
12. 1/2 receptacle
13. 1/2 pedicel
14. cut surface of calyx tube
15. septum
16. whole calyx lobe
17. whole ovary
18. whole mid style
19. whole staminal tooth
20. 1/2 short filament
21. 1/2 short anther
22. diffuse calli
23. whole stigma
24. whole long stamen
25. whole corolla lobe

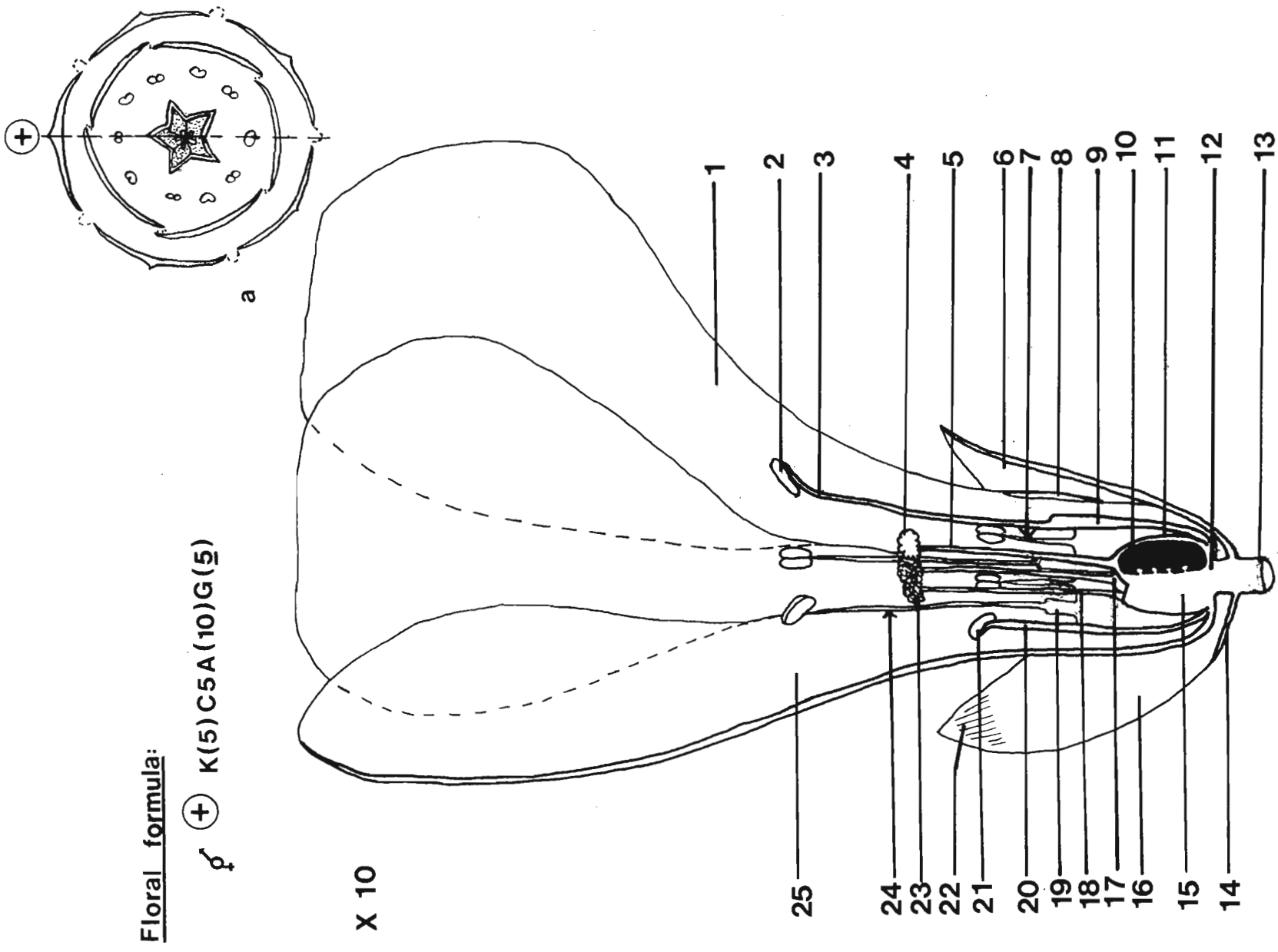


Fig. 27a. Floral Diagram of *O. semiloba*

Bees of the super-family Apoidea commonly visited the Oxalis species. Most bees are hairy (Fig. 29) and when they visit flowers, some of the pollen accidentally sticks to these hairs. This pollen is periodically combed off and placed into "pollen baskets" that usually occur on the hind legs (Fig. 28) in the case of social bees. In the case of the solitary bees or bees with primitive social hierarchies, the "pollen baskets" occur beneath the abdomen. Pollen together with the nectar taken from these flowers is used to make "bee bread" which is used to feed the young (Imms, 1971; Borror, et al., 1976; Whalley, 1979).

Bees were observed to visit the flowers of O. corniculata, O. latifolia, O. semiloba and O. pes-caprae. The bees entered the flowers and spent 30-60 seconds within them. Some of these bees were captured in order to determine whether they visited the flowers for nectar only or whether they collected pollen as well. Another reason for collecting these bees was to determine where exactly on the body the pollen was deposited.

An investigation of the bees caught indicated that they belong to the sub-families 1) Halictidae (sweat/miner bees) and 2) Xylocopinae (carpenter bees). Members of these two sub-families

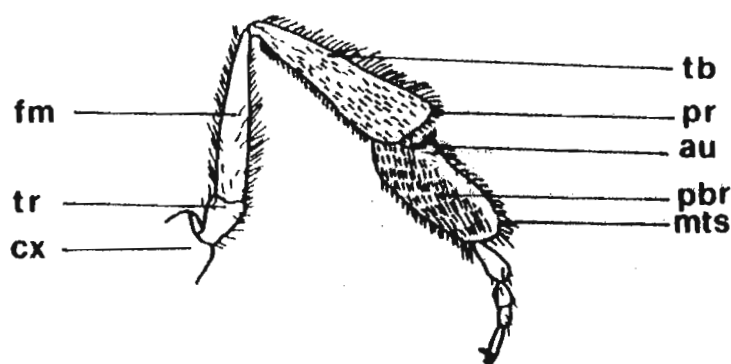


Fig. 28. Hind leg of a honey bee, inner surface, showing the pollen-transporting apparatus. au, auricle; cx, coxa; fm, femur; mts, first tarsal segment; pbr, pollen brush; pr, pollen rake or pecten; tb, tibia; tr, trochanter. The pollen is collected off the body hairs by the front and middle legs and deposited on the pollen brushes (pbr) of the hind legs. The pollen on the pollen brush of one leg is raked off by the rake (pr) on the other, the pollen falling on the surface of the auricle (au); the closing of the tarsus on the tibia forces the pollen upward, where it adheres to the floor of the pollen basket or corbicula (which is on the outer surface of the tibia). As this process is repeated, first on one side and then on the other, the pollen is packed into the lower ends of the pollen baskets until both are filled.

(from Borror, et al., 1981)

superficially resemble the honey bees (Apis spp.) but those caught were smaller and are thus suited to entering into the flowers of Oxalis. In addition to being smaller than honey bees, these bees have short tongues and only a rudimentary social system (Pesson, 1959; Dept. Agric. services, 1963; Linsenmaier, 1972; Grzimek, 1975; Borrer, et al, 1981; Wootton, 1985; Burton, et al, 1985; Scholtz and Holm, 1985).

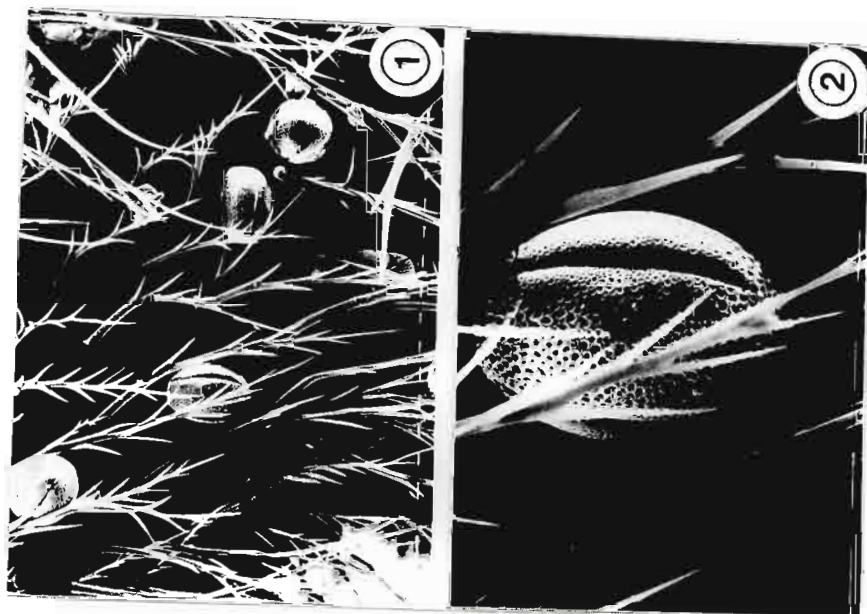
Farquharson (pers. comm., 1988) identified to genus level the following bee species collected on the different Oxalis species:

1. Halictus sp., sub-family Halictidae on O. latifolia,
2. Halictus sp., sub-family Halictidae and Ceratina sp., sub-family Xylocopinae on O. corniculata. An Apis sp. was also observed to visit the flowers,
3. two bee species were collected on O. semiloba; one was definitely a Halictus sp. whilst the other could possibly be a Halictus sp. and
4. Allodape sp., sub-family Xylocopinae was collected on O. pes-caprae.

Fig. 29. Pollen grains of *O. semiloba* on the abdomen of a bee

- 1. X896 1 bar = 10 um
- 2. X3500 1 bar = 10 um

bh = branched hair



Pollen was found adhered to the legs and abdomen (Fig. 29) of all species except Allodape sp. The "pollen baskets" of the pollen collecting bees occurred on the inner side of the coxae, close to the abdomen.

In addition to bees, butterflies were also observed visiting the flowers of O. corniculata, O. latifolia and O. pes-caprae. Butterflies observed visiting were the sooty blues (Zizeeria knysna; Family Lycaenidae) on O. corniculata, the Monarch butterflies (Danaus chrysippus, Family Danainae) on O. latifolia and possibly the African Common Whites (Belenois creona, Family Pieridae) on O. pes-caprae. No butterflies were caught. They were observed to alight on the platform provided by the wide mouth with their bodies in contact with the long stamen anthers. Their probosci could possibly trap pollen of the mid- and short stamen anthers.

Fruit formed only in the case of O. corniculata and O. semiloba. Thus only the insects visiting these two species could be regarded as pollinators. In the case of O. latifolia and O. pes-caprae, the insect visitors could perhaps successfully cause effective cross pollination if all three style lengths were present in Natal or if the self-incompatibility system were to break down.

Conclusion

The floral architecture of Oxalis is such that it enables a wide range of insects to visit the flowers. This could only result in an increase in outbreeding. Halictus spp. seem to be the major visitors of the flowers of Oxalis. Effective pollination was brought about only in the case of O. semiloba, where all three floral forms are present and O. corniculata where it appears as though the self-incompatibility system has broken down. Since pollination was not effective in the case of O. latifolia and O. pes-caprae, species which are homostylous in Natal, it would indicate that the self-incompatibility system is still working within these two species.

5.2.6 Seed dispersal

O. semiloba, O. corniculata, O. obliquifolia and O. smithiana all form fruit. Seeds of O. semiloba were germinated in a glass trough in order to determine whether or not they were viable (Fig. 30).

The success of the spread of O. corniculata is by means of seeds transported in the soils of cultivated plants. Thus the seeds of O. corniculata are viable. It appears as though the spread of O. obliquifolia



Fig. 30. Initial sequences in the germination of seeds of *O. semiloba*

and O. smithiana is mainly due to seeds that are projected away from the parent plant as the new bulbs that form on the rhizome are sessile and therefore do not grow far from the parent plants. Thus the seeds produced by these two species must be viable.

Seeds of the above four species, were projected some distance from the parent plant. This was made possible by the presence of a fleshy aril. When the seeds are mature, the outer walls of the capsule splits thus exposing the arillate seed to the atmosphere. Exposure to air causes the aril to dehydrate, split and suddenly curl away from the seed thus forcibly expelling the seed some distance from the parent plant. Studies on the seeds of O. corniculata and O. semiloba showed that the seeds were ejected mean distances of 72 mm and 391 mm respectively (Figs. 31 and 32, Table 11). Fig. 33 illustrates the method used to determine the distances which seeds of O. semiloba were shot.

5.2.7 Vegetative dispersal

O. corniculata reproduces vegetatively by means of stolons. All the other species of Oxalis in Natal reproduce vegetatively by means of bulbs. In the

Fig. 31. Distances seeds shot from a specific
point : O. corniculata

c = "capsule"

Seeds expelled when aril was pricked.

Seeds expelled without aril being pricked.

1) 4-5 seeds shot prior to experiment

2) c. 11 aborted ovules per capsule

3) c. 7 ovules per locule

4) seeds expelled without aril being pricked



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Fig. 32. Distances seeds shot from a specific
point : O. semiloba

c = "capsule"

1) 7 capsules used

2) 7 seeds shot 42 cm

3) 4 seeds shot 1 m

4) c. 4 ovules per locule but
2-3 seeds per locule

5) c. 11-12 seeds per capsule

6) c. 4-5 aborted ovules.



Table 11. Distances seeds projected from a specific point (mm).

<i>O. corniculata</i>	<i>O. semiloba</i>
221	4
233	4
120	4
117	4
65	14
13	30
40	25
85	62
12	70
17	105 ^x
8	42 ^x
5	146 ^x
6	165
8	188
5	155 ^x
5	140 ^x
7	67 ^x
7	110 ^x
75	200 ^x
62	75 ^x
59	230 ^x
120	420 ^x
157	420 ^x
193	420 ^x
160	420 ^x
$\bar{x} = 72 \text{ mm}$	420 ^x
	420 ^x
	420 ^x
	1000 ^x
	1000 ^x
	1000 ^x
	1000 ^x
	$\bar{x} = 274.4$
	$\bar{x}^x = 391$
	$\bar{x}^p = 51.8$

- all seeds were pricked

x = seeds projected using a heat source.

\bar{x}^x = average distance of those seeds projected using a heat source.

\bar{x}^p = average distance travelled by those seeds that were pricked.

- = unmarked figures in the column indicate distances travelled by seeds that were pricked.

Fig. 33. Method used to determine the distances seeds of O. semiloba were shot



case of O. latifolia, O. corymbosa and O. pes-caprae vegetative dispersal by means of bulbs is the only method of dispersal and propagation. All the offspring are therefore genetically identical to the parent plant.

In all the bulbous species, the bulbs are kept below the soil surface by means of contractile, adventitious roots. In the case of O. corymbosa, a single contractile root pulls some of the sessile bulbils that make up the bulb lower, some of the bulbs break off during this process and form new plants close to the parent plant. Long distance dispersal occurs only when the bulbils are physically spread e.g. by digging.

The contractile root of O. latifolia only pulls down the new parent growth. The stalked bulbils, which eventually give rise to new bulbs, break off during this process to form new plants. The fact that these bulbs are stalked, results in the new plants developing further away from the parent plant. In this "creeping" manner the colony is propagated and dispersed.

Vegetative reproduction in O. obliquifolia, O. smithiana and O. pes-caprae is also by means of sessile bulbs that form at the nodes of the rhizome.

When the new parent growth is pulled lower into the ground, these bulbs break off from the rhizome and produce new plants close to the parent colony.

The distance a new colony consisting of plants having only one style length occurs from a colony with all three style lengths will determine the amount of fruit formed in the homostylous colony. It was observed that in a colony of mid-styled plants of O. semiloba growing 5m or less from a colony that had all three style lengths, about 3 out of 5 flowers resulted in fruit whilst mid styled colonies growing 80-100m from the mixed colony, only one out of 5 flowers per umbel resulted in fruit.

5.3 Conclusions

O. semiloba, O. obliquifolia, O. smithiana and O. corniculata form fruit in Natal. With the exception of O. corniculata, these species were tristylous and therefore capable of producing fruit.

The self-incompatibility system appears to have broken down in O. corniculata and therefore this species is capable of producing fruit despite the fact that the flowers all are homostylous.

In all the other species the self-incompatibility systems are still very strong. Observations have shown that fruit and seed formation (indications of successful pollination) will occur only if there are at least two floral forms present 5m or less from each other. This is true for O. semiloba. The fact that no fruit of O. corymbosa, O. latifolia and O. pes-caprae have been found despite the fact that pollen and the stigmas of these species were found to be viable, and despite the fact that they do have insect visitors indicates that the self-incompatibility system is operating strongly within these species.

Those species that reproduce sexually and asexually, are capitalizing on the best of two worlds, so to speak. Asexual reproduction enables them to capitalize on present environmental conditions whilst sexual reproduction introduces genetic variation into the species. These genetic variations may prove useful to the survival of the species should the present conditions alter.

6. CONCLUSIONS AND AREAS FOR FUTURE STUDIES

Ross (1972) lists five species of Oxalis in Natal. The present study has shown that there are in fact seven species in Natal. Of the seven only 3 namely, O. smithiana, O. obliquifolia and O. semiloba are indigenous to this province. O. pes-caprae is indigenous to the Cape Province and the other three species have been introduced from overseas; O. corniculata, a cosmopolitan weed, originates from Europe whilst O. corymbosa and O. latifolia are indigenous to South America.

Various morphological and anatomical differences occur between species. These characters, mainly morphological, were used in the compilation of a key to the Natal species. The differences also showed the current circumscriptions of the taxa to be valid. The presence of bulbs and their uniform composition, the trifoliate leaflets, the overall floral morphology, the morphology of the pollen grains and the arillate seeds indicates a taxonomically cohesive group.

Contrary to previous reports, stomata on the adaxial surfaces of leaflets were of the anomocytic and not paracytic type.

Tristly is an unusual feature commonly associated with self-incompatible breeding systems. The incompatibility system appears to have broken down in O. corniculata. Investigations yielded that fruit formation does occur although all flowers are homostylous; in addition, fruit also formed when flowers

were self-pollinated. Thus O. corniculata appears to be facultatively xenogamous.

The self incompatibility system is still strong within the other species. This was best seen by the absence of fruit in O. corymbosa, O. pes-caprae and O. latifolia where flowers, in Natal at least, are homostylous. No fruit formed in these species despite the fact that both pollen was viable and stigmas receptive, and despite the fact that insects were observed visiting these species.

All three style lengths of O. smithiana, O. obliquifolia and O. semiloba occur in Natal, thus fruits formed. Solitary to semi-social bees as well as butterflies acted as pollinators.

With the exception of O. corniculata, all other species of Oxalis in Natal are strongly xenogamous.

All species are capable of vegetative propagation. In O. corymbosa, O. pes-caprae and O. latifolia the only means of reproduction is via vegetative propagation.

Areas for future study

There are several problems that still need to be addressed.

More specimens need to be collected within Natal in order to gain a better understanding of the distribution of the species

in the province.

Initial statistical comparisons of Sonder's (1860) two varieties of O. smithiana indicate that they may be sub-species rather than varieties. More specimens need to be examined. In addition cross-pollination experiments between these two varieties need to be conducted to aid in the determination of the status of these two taxa.

Statistical comparisons between specimens of Oxalis species collected within Natal and those from other provinces indicated that there possibly were significant differences between some morphological characters. These results need to be verified by comparing more specimens and by separately comparing specimens from Natal with specimens from each of the other provinces. If there still are significant differences, then upon compilation of a review of the genus within South Africa, an attempt should be made to avoid these characters when drawing up keys. Quantitative results in this genus should, however, be treated with caution as morphological characters within this genus are extremely plastic.

Plasticity of characters appears to be linked to environmental factors. A study should therefore be undertaken in order to determine the extent of environmental influences.

More field studies need to be undertaken in order to fully understand all aspects of pollination and of bulb migrations.

Exhaustive studies need to be carried out on the breeding systems of this genus.

Other areas that need to be addressed are:

1. determination of the mechanisms involved in the sleep movements of the leaflets,
2. determination of the mechanisms of photonasty and
3. determine the function of the calli.

Since this is an extremely large and complex genus, the fullest understanding can be gained by studying individual species exhaustively and ultimately pooling all the results.

7. TAXONOMY7.1 Genus Description

Oxalis L. in Sp. Pl. ed. 1 : 433-435 (1753);

D.C. in Prodr. 1 : 690 (1824); Benth. and Hook. in Gen. Pl. 1 : 276 (1862); Oliver in F.T.A. 1 : 295-297 (1868); Sond. in Fl. Cap. 1 : 312-351 (1860); Bailey in Std. Cyclop. Hort. 2 : 2417-2419 (1900); Knuth in Engler's Das. Pflanz. 95 (iv. 130): 43-389 (1930); Exell and Medonca in C.F.A. : 261-262 (1937); Salter in J.S.A. Bot. Suppl. Vol. 1 (1944); Thonner in Flowering Plants of Africa : 291 (1962); Eiten in Amer. Midl. Nat. 69 : 257-309 (1963); Exell in Fl. Zam. 2 : 149 (1963); Phillips in Genera of South African Plants : 431 (1951); Young in Watsonia 4 : 51-69 (1958); Ross in Flora of Natal : 211 (1972); Dyer in Genera of Southern African Flowering Plants : 279 (1975); Compton in Flora of Swaziland : 291 (1976).

Type: Garc. A.A. n.415, t.2 (1730) (iconotype).

Oxys Tourn. ex Adans. in Fam. ii : 388 (1763).

Sassia Molina in Sagg. Chile. 145 (1782).

Caulescent or acaulescent; prostrate or erect; glabrous or pubescent herb; up to 300m tall in Natal. Roots fibrous in non-bulbous species; in bulbous species roots adventitious; fleshy, translucent, contractile, variable lengths and widths. Bulbs present in all South African species except O. corniculata; outer protective scales brown, papery; inner nutritive scales white to pale orange, fleshy; variously ovoid in shape, 10-25mm long, 8.7-11.8mm broad; shallow or deep seated. Rhizome present or absent, where present of variable lengths, 32.4-59.6mm. Leaves arising from stolons in non-bulbous species and from apices of nutritive scale of bulbous plants, lengths and widths variable; may or may not sleep diurnally or when stressed: petiole lengths variable, usually shorter than scapes or peduncles; in bulbous species forming a basal rosette; variously pubescent: leaflets trifoliolate, lengths and widths extremely variable within and between species; variously lobed and shaped; sessile or with short petiolules; glabrous or pubescent. Peduncles or scapes arising from stolon or bulb; either umbellate or scape-like; lengths variable; umbels of 2-20 flowers; scapes with solitary flowers; glabrous or pubescent. Pedicels variously pubescent. Bracts variable lengths; at the base of peduncles or more than half way up the scape where they are opposite or alternate, with or without apical calli. Flowers bisexual, actinomorphic. Calyx variously oblong,; variously pubescent; with or without apical calli;

sepals 5, free or basally connate. Corolla shades of pink, purple, white and yellow; regular, contorted in bud; 5-merous; diurnal and photonastic: petals 5; lengths and widths variable depending on season and habitat, basally with or without claws, partially fused in throat region, apex cuneate. Filaments 10; two or three lengths per species, two lengths per flower; long filaments 5.4-8.5mm long, dentate or edentate; mid-filaments 5.3-5.9mm long, dentate or edentate; short filaments 3-4.3mm long, edentate; connate; variously pubescent. Gynoecium tristylous or homostylous; long gynoecia 7.6-9.1mm long, mid-gynoecia 5-6mm long, short gynoecia 3-4mm long: ovary superior; 5-loculed; variously pubescent, 3-many ovules per locule: styles 5, persistent, variously pubescent: stigmas 5, green, papillate. Fruit present or absent; where present a loculicidally dehiscent, 5-angled, globose or oblong capsule. Seeds arillate, ovoid or dorsiventrally flattened, variously ornamented, brown, one to several per locule.

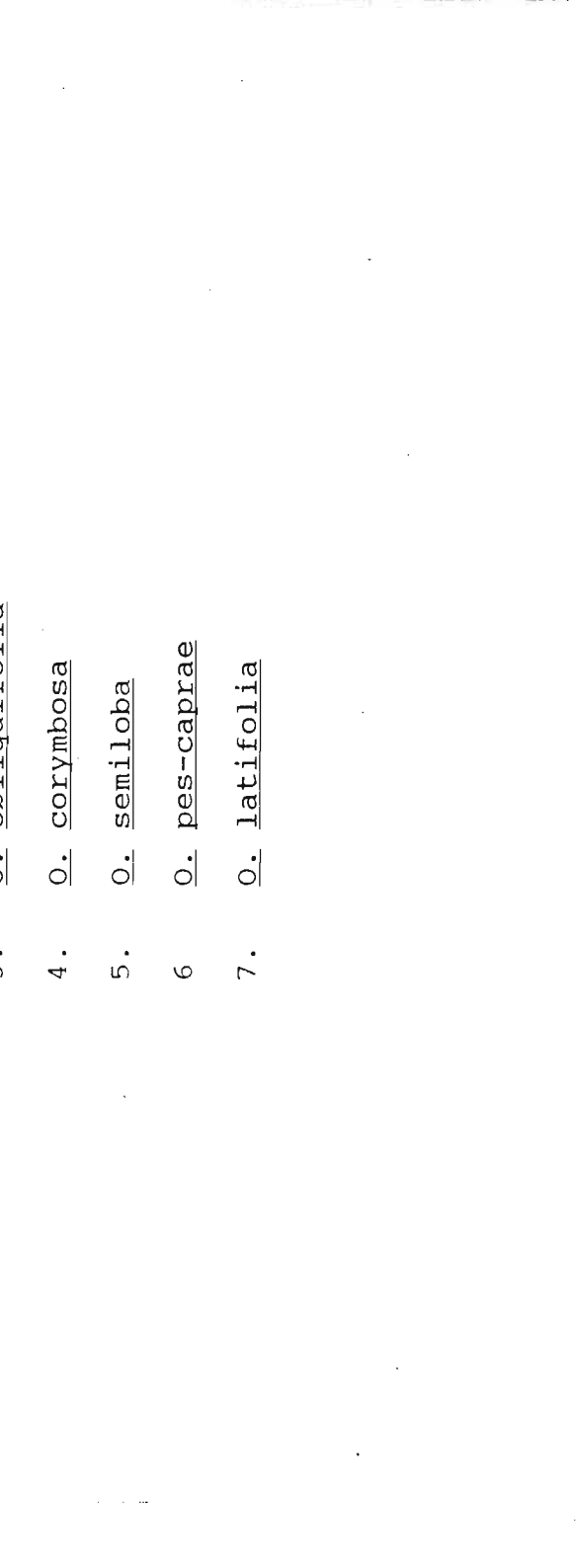
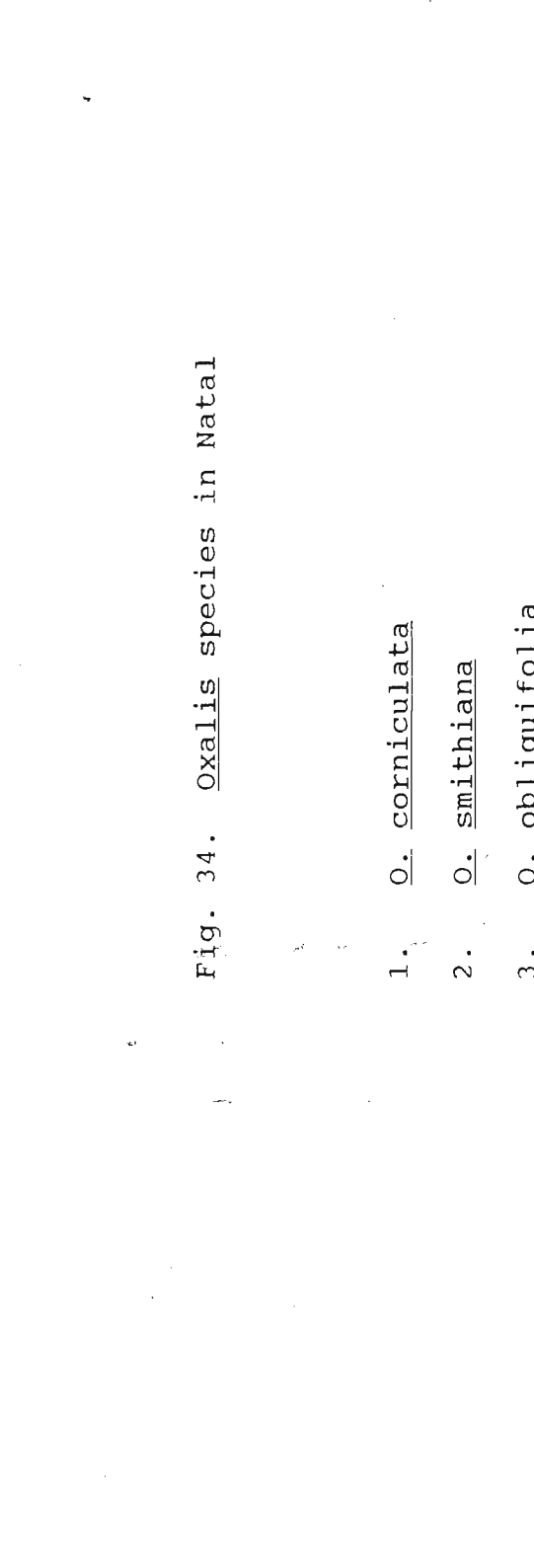
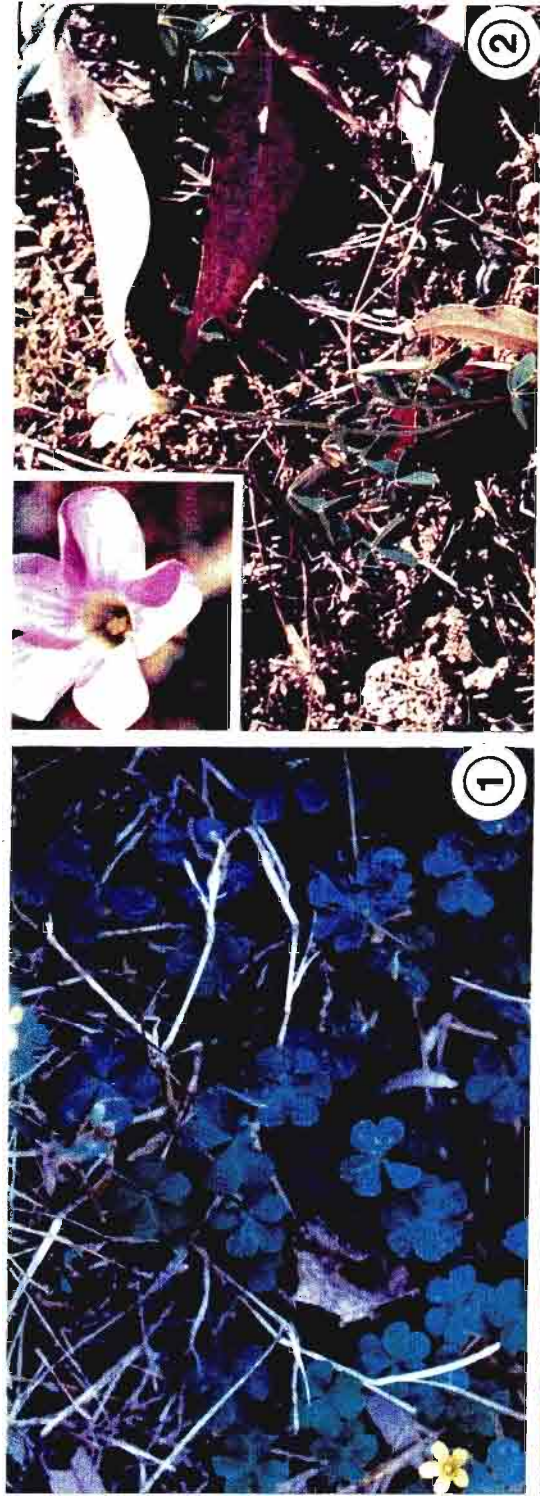
7.2 Key to the Natal species of Oxalis

1. Leaves cauline O. corniculata
- 1a. Leaves radical 2.
2. Leaflets very broadly cuneate-obcordate to broadly obdeltoid; bilobed to mid-point or almost to petiole, lobes five times longer than broad..... O. smithiana
- 2a Leaflets obovate, obcordate or obdeltoid; apices obtuse to slightly emarginate or bilobed, lobes less than five times longer than broad..... 3.
3. Leaflets transversely obovate; apical leaflet apex obtuse to slightly emarginate; apical leaflets broader than lateral ones; lateral leaflets obovate, apices obtuse; flowers, solitary..... O. obliquifolia
- 3a. Leaflets broadly obcordate or obdeltoid; bilobed above or to mid-point of mid-vein; inflorescence an umbel or compound umbel..... 4.

4. Leaflets broadly obcordate;
 inflorescence a compound umbel;
 "bulbils" sessile O. corymbosa
- 4a. Leaflets obcordate or obdeltoid;
 inflorescence an umbel..... 5.
5. Leaflets broadly obcordate;
 flowers salmon pink O. semiloba
- 5a. Leaflets transversely obdeltoid to
 broadly transversely obdeltoid;
 flowers yellow or purple 6.
6. Leaflets transversely obdeltoid,
 less than five times broader than
 long; corolla yellow O. pes-caprae
- 6a. Leaflets broadly transversely
 obdeltoid; five times broader
 than long; corolla purple O. latifolia

Fig. 34. Oxalis species in Natal

1. O. corniculata
2. O. smithiana
3. O. obliquifolia
4. O. corymbosa
5. O. semiloba
6. O. pes-caprae
7. O. latifolia



7.3 Species Descriptions

7.3.1 O. corniculata L. Sp. Pl. : 435 (1753);

Thunb. in Diss. 20.: Jacq t.s (1781); Thunb. in Fl. Cap. 1 (22) : 538 (1823); DC. in Prodr. 1 : 692 (1824); Sonder in Fl. Cap. 1 : 351 (1860); Bak. f. in Journ. Linn. Soc. Bot. 40 : 35 (1911); Bews in Flora of Natal and Zululand : 116 (1921); Knuth in Engl. Pflanzenr. 4(130) : 146 (1930); Salter in J.S.A. Bot. Suppl. Vol. 1 : 73 (1944); Exell and Mendonca in C.F.A. 1(2) : 261 (1955); Exell in Fl. Zam. 2 : 150 (1963); Guillarmod in Flora of Lesotho : 200 (1971); Ross in Flora of Natal : 211 (1972).

Type: Clus. hist. 2 : 249 (1583) (iconotype)

O. stricta L. in Sp. Pl. : 435 (1735).

O. perennans Haw. in Misc. : 181 (1768).

O. prostrata Haw. in Misc. : 181 (1768).

O. rubens Haw. in Misc. : 182 (1768).

O. dillenii Jacq. in Oxal.: 28 (1794).

O. ambigua A. Rich., Bot. Vog. Astroll (276) : 296 (1794); Salib. in Trans. Linn. Soc. 2 : 242 (1794).

O. repens Thunb. in Prodr. Pl. Cap. : 82 (1794).

O. florida Salisb. in Prod. : 322 (1796).

O. pusilla Salibs. in Prod. : 322 (1796).

Types: from S.A. & Ceylon (syntypes).

O. villosa Types: from S.A. & Ceylon (syntypes).

Bieb. in Fl. Taur. Canc. 1 : 355 (1808).

O. lyoni Pursh in Fl. Am. Sept. 1 : 322 (1814).

O. furcata Ell. in Sketch 1 : 527 (1821).

O. recurva Ell. in Sketch 1 : 526 (1821).

O. lupulina H.B. and K. in Nov. Gen. et. Sp. V: 243
(1822).

O. glauca Rafin. ex D.C. in Prodr. 1 : 692 (1824).

O. pumilla Urv. in Mem. Soc. Linn. iv : 616 (1826).

O. monodelpha Roxb. ex Wight and Arn. in Prod. 142
(1834).

O. acetosella Blanco in Fl. Filip. ed 1 : 388 (1837).

O. ciliifera A. Cunn. in Ann. Nat. Hist., Ser. 1 (3)
: 316 (1839).

O. crassifolia A. Cunn. in Ann. Nat. Hist., Ser. 1
(3) : 316 (1839).

O. divergens A. Cunn. in Ann. Nat. Hist., Ser. 1 (3)
: 317 (1839).

O. propinqua A. Cunn. in Ann. Nat. Hist., Ser. 1 (3)
: 314 (1939).

- O. urvillei A. Cunn. in Ann. Nat. Hist., Ser. 1 (3) : 315 (1839).
- O. lutea Steud. in Nom. ed 1 : 579 (1840).
- O. minima Steud. in Nom. ed. 1 : 579 (1840).
- O. humistra Willd. ex Steud. in Nom. ed 2 (2) : 240 (1841).
- O. ceratilis E. Mey. in Drege Zwei. Pfl. Docum. : 72 (1843) (nomen nudum).
- O. procumbens Steud. ex A. Rich. in Tent. Fl. Abyss. : 123 (1847).
- O. tropaeoloides Hort. ex Vilm. in Fl. Pl. Terre ed 1 : 584 (1865).
- O. europaea Jord. - F. Schultz in Arch. Fl. Fr. et Allem. : 309, 311 (1872).

Ruderal, caulescent, erect or prostrate, much branched, pubescent herb. Bulb absent. Roots fibrous. Stems prostrate or erect, pubescent, length variable. Leaves cauline or terminal : petioles pubescent, weak, procumbent, 16-66mm long (x = 40mm),

arising from stem nodes, winged below basal articulation : leaflets 3, broadly cuneate-obcordate or sub-bilobed, 5-15mm long ($x = 14.3\text{mm}$), 6.5-35.0mm broad ($x = 14\text{mm}$), glabrous or slightly pubescent above, pilose below, margins ciliate, sleep diurnally or when stressed. Peduncles axillary, 14-132mm long ($x = 50\text{mm}$); umbels; 1-6 flowered. Bracts at pedicel base, 1.9-4.9mm long ($x = 2.7\text{mm}$), ecallose. Pedicels densely pubescent, refract in fruit. Flower bisexual, actinomorphic, hypogynous. Sepals 5, free, 3-5mm long ($x = 3.9\text{mm}$), 0.3-1.5mm broad ($x = 1.1\text{mm}$); ecallose. Corolla regular, 5-merous, 5-9.9mm long ($x = 6.8\text{mm}$), 2.1-9.0mm broad and the throat ($x = 4.2\text{mm}$), funnel-shaped, diurnal ; petals free, contorted in bud, yellow, cuneate. Filaments 10, didynamous, connate; long filaments 4-5mm long ($x = 5.4\text{mm}$); short filaments 2.5-3.0mm long ($x = 3.1\text{mm}$); mature stamens glabrous or sparsely pubescent. Gynoecium homostylous; 3.5-6.0mm long ($x = 5.2\text{mm}$) : ovaries 5, connate superior, pubescent with reversed adpressed hairs; ovules numerous per chamber, anatropous: styles 5, persistent, pubescent: stigmas 5, papillate, green. Fruit 5-angled capsule, pubescent, loculicidally dehiscent, 9-20mm long ($x = 14.4\text{mm}$), 2.0-4.3mm broad ($x = 2.5\text{mm}$). Seeds numerous, arillate, flat; brown when mature. (Figs. 34.1; 35).

Diagnostic features

Prostrate, creeping habit. Bulbless. Dorsiventrally flattened seeds. Pedicels refracted in fruit.

Flowering period

Throughout the year.

Fruiting period

Throughout the year.

Distribution

Widespread cosmopolitan weed. Figure 36 - indicates the known distribution in Natal.

Habitat

Ruderal. Occurs in disturbed areas.

Additional

The morphology of this species is extremely variable; sometimes the stem is "woody" and erect. Leaflet size is also variable depending upon the habitat; the moister and the shadier the habitat, the larger the leaflets.

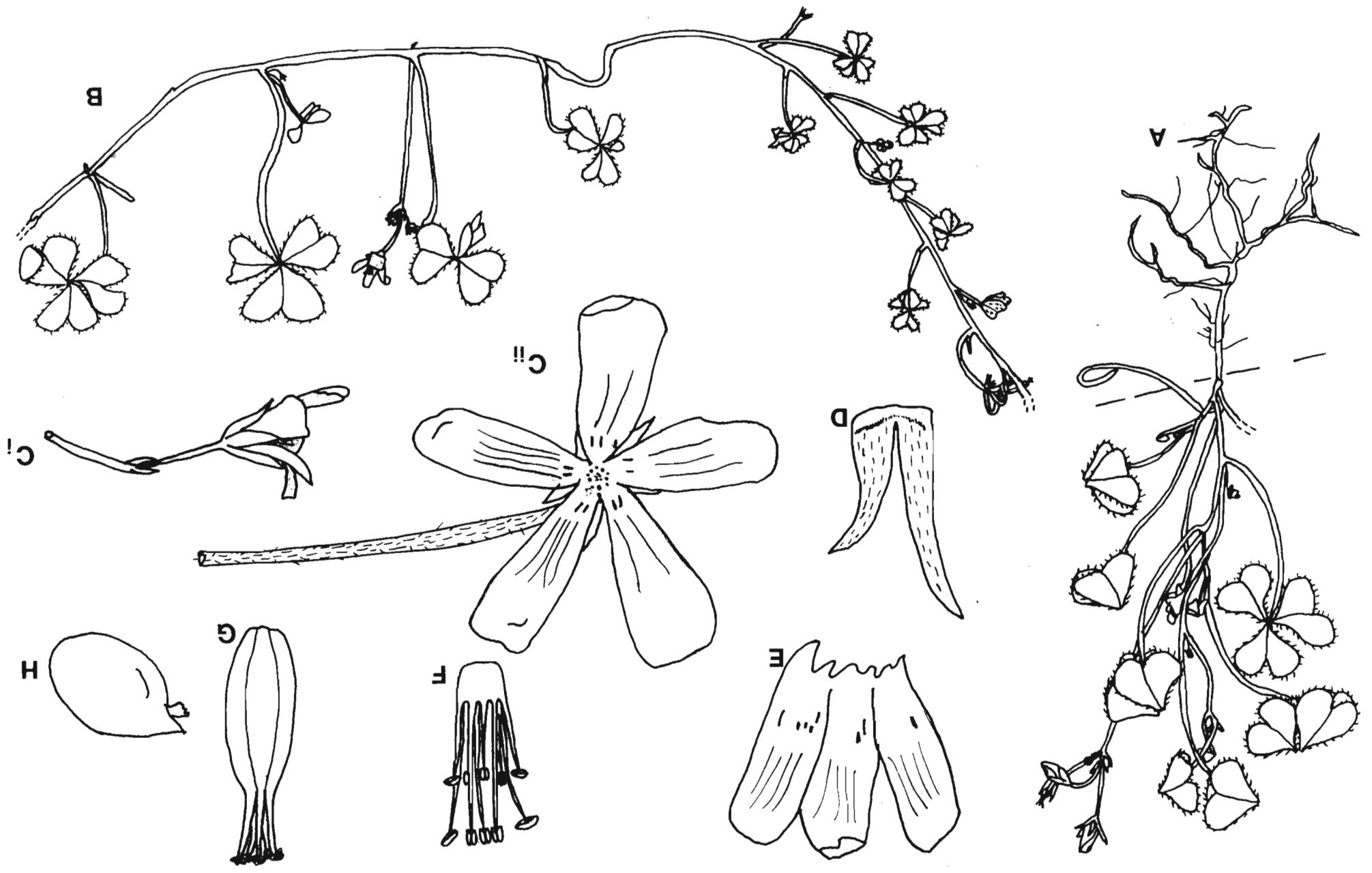


Fig. 35. Vegetative and floral morphology of *O. corniculata*
 (Harding, 212; Naidoo, 31)

- A. Plant (erect form) X1
- B. Plant (creeping form) X1
- Ci. Side view of flower X4
- Cii. Dorsal view of flower X9
- D. Calyx lobes X13
- E. Corolla lobes X6
- F. Stamens X8
- G. Gynoecium X10
- H. Ovule X20

--- = ground level

Common names of O. corniculata are: lady's sorrel, oxalis, suring and woodsorrel.

African names of O. corniculata are: Bodila-ba-thaba (Sotho), detembu (Manyika), isi Tate eskulu (Zulu), Kajampuni (Ganda), kidadeishi (Sukuma), manjenju (Chagga) and moogwani (Lobedu).

In India O. corniculata is used as an anti-dysenteric and an anti-septic. In Mexico and in South Africa it is used as a potherb. The Sotho use it as a wash for snake bites.

Natal Specimens Examined

Natal. - 2632 (Bela Vista): Ndumu Hill, Ndumu Game Reserve (-CD), Pooley 709 (NH, NU); Ndumu Game Reserve, 1 m N.E. of rest camp (-CD), Ross 1900 (NH, PRE). - 2829 (Harrismith) : Harts Hill near Colenso (-DD), Strey 9951 (NH, PRE); Van Reenen (-AD), Bews 1395 (NU). - 2830 (Dundee) : Dundee (-AA), Vinden 7 (UD-W); Talana Dam, Dundee (-AB), Truscott 51 (PRE). - 2831 (Nkandla) : "Imfulazane", Melmoth (-CB), Mogg 6091 (PRE); Ngoye Mountain, Ubisana Valley (-DC), Venter 788 (NH). - 2832 (Mtubatuba) : Egodeni, Hluhluwe Game Reserve (-AA), Hitchins 362 (NH, PRE);

Game Reserve (-AA), Ward 2412 (PRE); Maphelane Nature Reserve (-AD), MacDevette 244 (NH). - 2929 (Underberg) : Research Station, Estcourt (-BB), West 423 (PRE); Estcourt (-BB), West 1335 (NH, PRE). - 2930 (Pietermaritzburg) : "Glen Arum", Balgowan (-AC), Mogg 5562 (PRE); 1 km S. of Curry's Post (-AC), Moll 1184 (NU, PRE); Karkloof Falls, (-AC), Moodley 33 (UD-W); Greytown District (-BA), Wylie 22382 (PRE), s.n. (NH); along railway line 13 km from Greytown (-BA), Wylie 27956 (PRE); Baynes Drift (-BC), Moll 1953 (NU, PRE); Wembley, Pietermaritzburg (-CB), Garrett 19 (NU, PRE); Scottsville (-CB), Hans Meidner 60 (NU); Commercial Road, Pietermaritzburg (-CB), Harding 212 (NH); Oribi (-CB), Lawson 16 (NU); cultivated in the laboratory of NU (-CB), Nicholas 564 (NU); growing in street guttering along Commercial Road, Pietermaritzburg (-CB), Nicholas and Moss 1427 (NH, NH, PRE); Byrne Forest floor, Richmond (-CC), Galpin 12010 (PRE); Hella-Hella Valley (-CC), Stirton 8654 (PRE); Nagle Dam, Camperdown (-DA), Wells 1402 (NU). - 2931 (Stanger) : Amatikulu Nature Reserve (-BA), Ward 742 (NH); Verulam (-CA), Moll 1987, 1991 (NU, PRE); Umdloti (-CA), Ross 1989 (NH, PRE); Hawaan Forest, S. bank of Umhlanga River (-CA), Ross 2210 (NH, PRE); Wentworth (-CC), Abraham 61 (UD-W); Salisbury Island (-CC), Chetty 86 (UD-W); Berea (-CC), Forbes 569 (NH); Prospect (-CC), Forbes 590 (NH);

Reservoir Hills (-CC), Khan 7 (UD-W); Overport (-CC), Maharaj 2 (UD-W); Wentworth (-CC), Moodley 63 (UD-W); Asherville (-CC), Naidoo 31 (UD-W); on UD-W campus (-CC), Padia 22 (UD-W); Sydenham (-CC), Ramkissoo 12 (UD-W); Pigeon Valley, Durban (-CC), Schrire 678 (NH); Salisbury Island (-CC), Singh 60 (UD-W); Botanic Station Garden (-CC), Strey 5235 (PRE); Merebank East (-CC), Ward 5224 (NH, UD-W); Durban (-CC), Wood 20 (NH); Durban (-CC), Wood 394 (NU). - 3030 (Port Shepstone) : Isipingo Beach (-BB), Ward 1364 (NU); Umtamvuna Nature Reserve (-CC), Abbott 2252 (NH); St. Michaels-on-sea (-CD), Nicholson 1861 (PRE); Margate (-CD), Theron 853 (PRE). - 3130 (Port Edward) : Umtamvuna Nature Reserve, Clearwater (-AA), Abbott 2754 (NH).

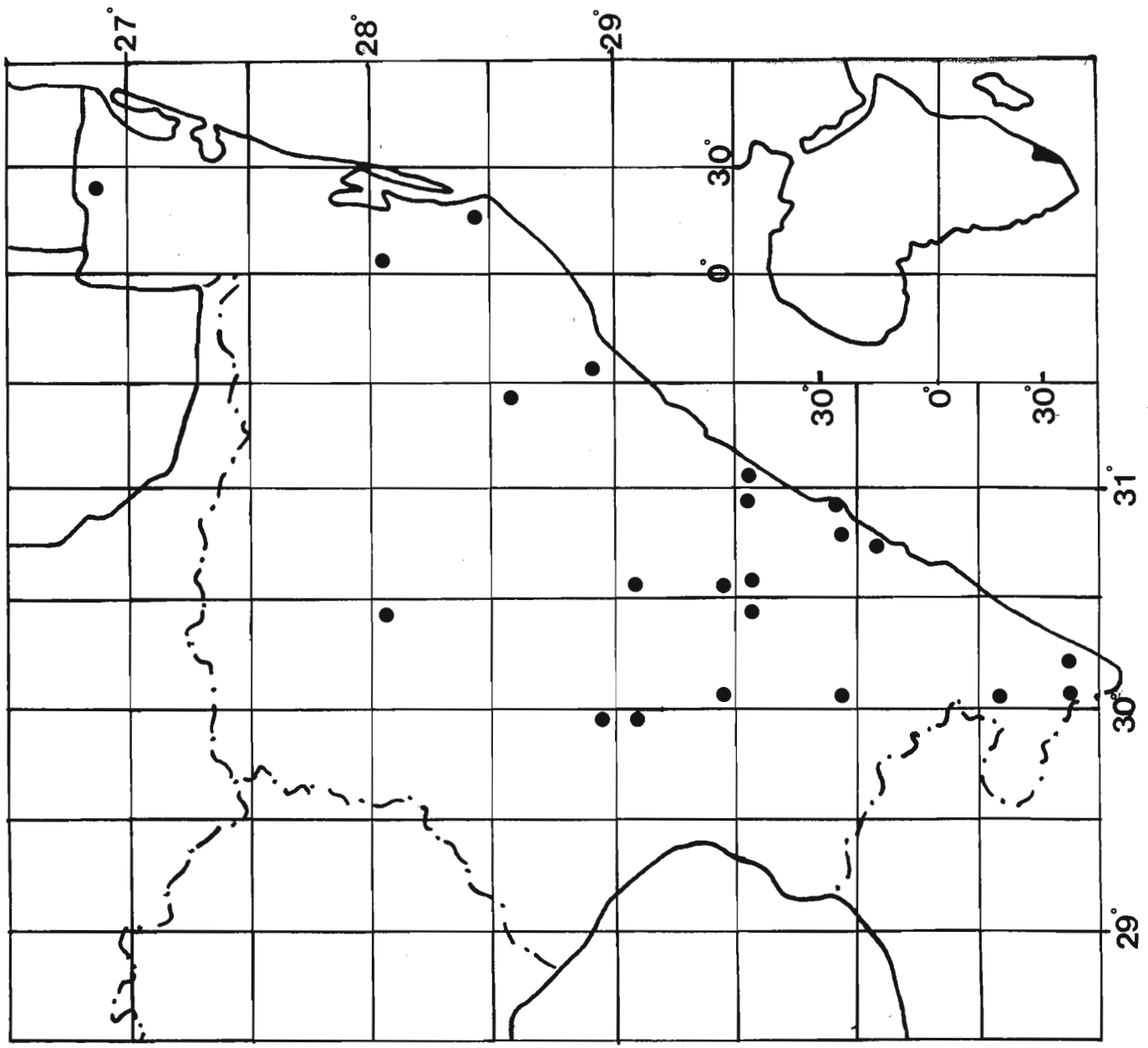


Fig. 36. Recorded distribution of *O. corniculata*

7.3.2 O. smithiana E. and Z. in Enum. : 94 (1835);

Salter in J.S.A. Bot. Suppl. vol. 1 : 136-137 (1944);
Guillarmod in Flora of Lesotho : 201 (1971); Ross in
Flora of Natal : 211 (1972); Compton in Flora of
Swaziland : 291 (1976).

Type: Eckl. and Zeyhr. 739 (SAM, syntype!).

O. gracilicaulis Eckl. and Zeyhr. in Enum. : 91
(1835).

O. tristis Eckl. and Zeyhr. in Enum. : 93 (1835).

O. candida Eckl. and Zeyhr. in Enum. : 94 (1835).

Type: Eckl. and Zeyhr. 740 (SAM, syntype!).

O. numerosa Eckl. and Zeyhr. in Enum. : 94 (1835).

Type: Eckl. and Zeyhr. 741 (?BM, syntype).

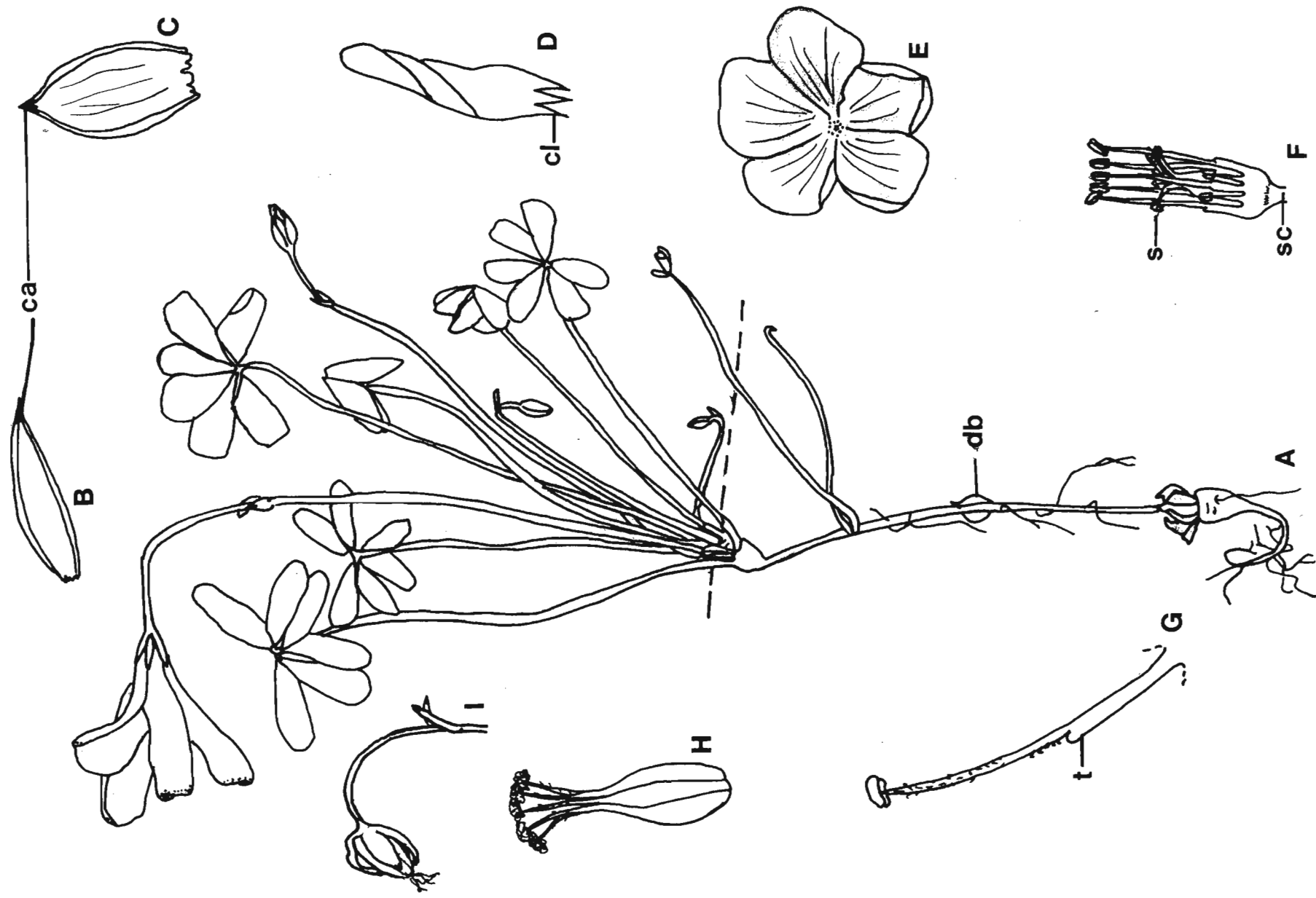
O. bisulca E. Mey. in Drege Zwei. Pfl. Docum. : 147
(1843).

O. rectangularis E. Mey. in Drege Zwei. Pfl. Docum.
: 147 (1843).

O. smithii var. latiloba (Eckl. and Zeyhr.) Sond. in
Fl. Cap. 1 : 342 (1860).

Erect, apparently acaulescent, glabrous to very sparsely pubescent herb; up to 225mm tall. Root present, fleshy, translucent, contractile. Bulb present, 7.5-23mm long (x = 14mm), 4-15mm broad (x = 8.9mm); ovoid, acute at apex, outer protective scales papery, brown with orange streaks. Rhizome present, 7-77mm long (x = 37.1mm); new bulbs and adventitious roots arise from nodes. Leaf digitately trifoliolate; few per bulb : petioles 31-167.5mm long (x = 75.5mm); semi-terete, shorter than scapes, outer petioles (approx. 50mm long) shorter than inner ones (approx. 80-90mm long) : leaflets 9-28.9mm long (x = 17.4mm); very broadly cuneate-obcordate or attenuate-obcordate in outline, 10.5-38.6mm broad (x = 19.8mm) in outline; very deeply lobed; narrow, linear lobes much diverged; leaflets sleep diurnally or when stressed. Scapes 41-212.3mm long (x = 95.6mm); erect, gives rise to a solitary flower; often more scapes than petioles per bulb. Bracts 2, 1.5-4.5mm long (x = 3mm), opposite or alternate with apical calli. Flower bisexual, actinomorphic and hypogynous. Sepals 5, free 5-10mm long (x = 6.8mm), 1-2.3mm broad (x = 1.9mm); lanceolate with diffuse apical calli. Corolla 5-merous, regular, diurnal and photonastic; contorted in bud and on closing: petals 5, mauve or white, throat greenish, 12-23.5mm long (x = 17.8mm), 3-12mm broad (x = 5.8mm), rounded at apex, shortly connate in throat region, basally free, with

Fig. 37. Vegetative and floral morphology of *O. smithiana*
(Moodley and Reddy, 2)



- A. Plant X1
- B. Bract X4
- C. Sepal X3
- D. Closed corolla X2
- E. Opened flower X2
- F. Arrangement of reproductive organs in mid-styled flowers X4
- G. Longer stamen X8
- H. Mid-styled gynoecium X10
- I. Fruit X4 (Strey, 545)

ca = calli
 cl = claw
 db = developing bulb
 s = stigma
 sc = scape
 t = tooth

a proximal claw. Filaments 10, 3 lengths in Natal, 2 per flower, connate, pubescent, the longer filaments dentate, long filaments 7mm long (x = 7mm), mid-filaments 5-6mm long (x = 5.3mm); short filaments 3-4mm long (x = 3.8mm). Gynoecium tristylous, long gynoecium 6-8mm long (x = 7.6mm), mid-gynoecium 5-6mm long (x = 5.3mm), short gynoecium 1.5-4mm long (x = 3mm) : ovaries 5, fused, pubescent, 6-8 ovules per locule : styles 5, free, pubescent, persistent : stigmas 5, free; green, papillate. Fruit a loculicidal capsule, 10.5-13mm long (x = 10mm), 3-4mm broad (x = 3.8mm) downward pointing when mature, about 5 seeds per capsule (Figs. 34.2; 37).

Diagnostic features

Petioles and scapes semi-terete; leaflets deeply lobed with narrow lobes; bracts with calli; flowers mauve or white.

Flowering period

August to March.

Fruiting period

October to December; maximum in November.

Distribution

Widespread in Natal (Fig. 38). Found at altitudes ranging from 100-2000m.

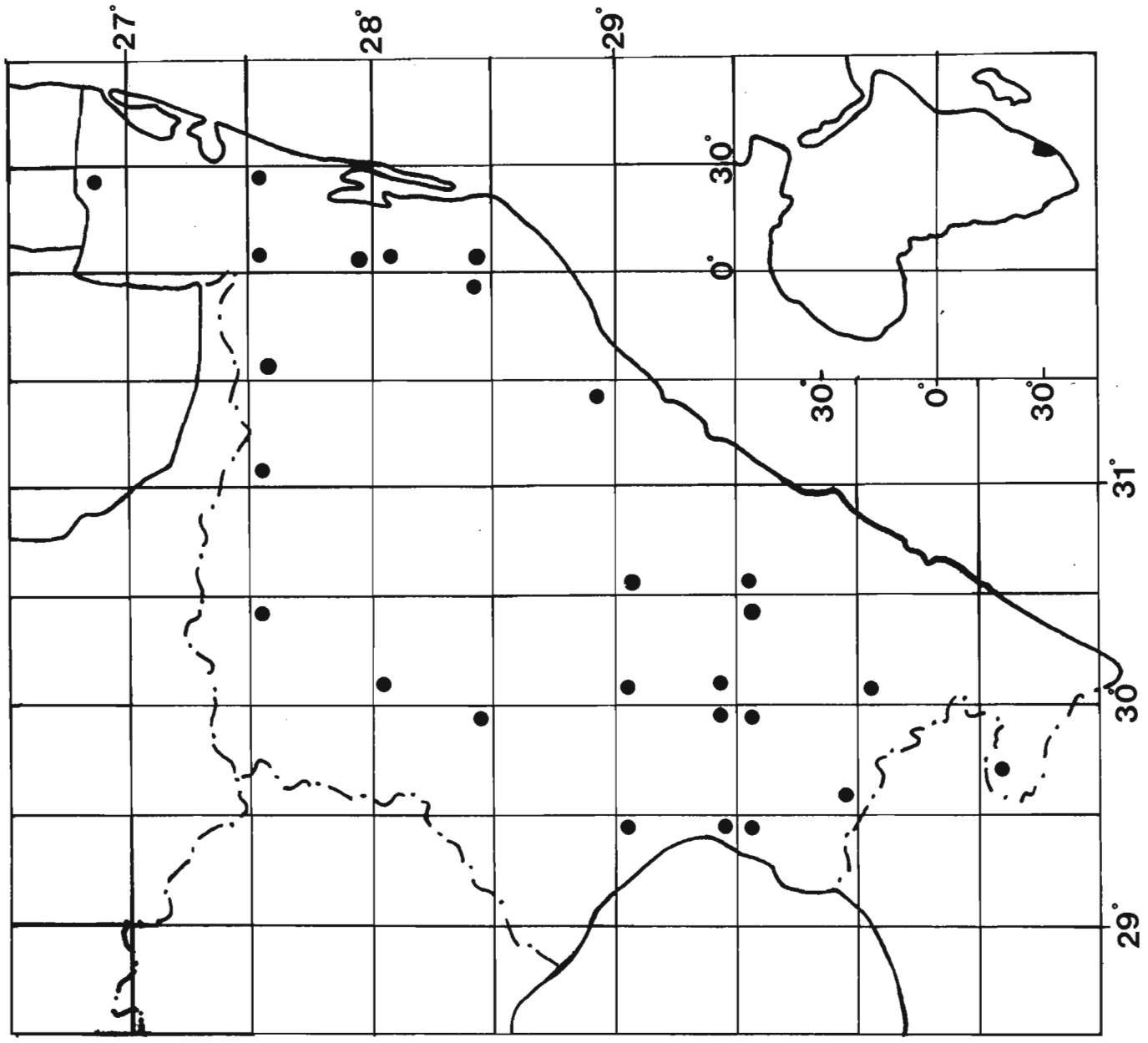


Fig. 38. Recorded distribution of *O. smithiana*

Habitat

Found in a wide range of habitats ranging from grasslands to forests. Has been collected in recently disturbed soils, recently burned grassveld, amongst long grass where humidity is high and beneath pine and eucalyptus trees in a SAPPI forest.

Additional

Statistical Comparison of O. smithiana var. α and O. smithiana var. in Natal

Ecklon and Zeyher (1834 - 1837) based these two varieties of O. smithiana upon flower colour. Var. α comprised specimens with white flowers that bloomed in July whilst var. β comprised specimens with mauve flowers blooming in October.

Salter (1944) disregarded Ecklon and Zeyher's (l.c.) sub-division of species of O. smithiana and lumped together all specimens of O. smithiana, regardless of their flower colour.

The present author decided to adopt Salter's (l.c.) classification. However, it was decided to undertake statistical analysis in order to determine whether there were any significant quantitative differences between the two varieties described by Ecklon and

Zeyher (l.c.). Only herbarium specimens were utilised in order to maintain some degree of uniformity.

The results yielded (Table 5) should, however, be treated with caution as only a limited number of specimens were studied. The results provide an indication of areas in which further studies are necessary.

Several characters proved to be significantly different. These characters were: leaflet lengths and widths and bulb, sepal and fruit lengths. All differences were significant at $P < 0.01$.

Leaflet lengths and width as well as the bulb, sepal and fruit lengths of O. smithiana var. α proved to be significantly longer or wider than those of O. smithiana var. β . However, with the exception of the fruit, large numbers of specimens (± 35) of O. smithiana var. were compared with relatively smaller number (± 10) of O. smithiana var. α . Therefore the most conclusive finding, at this stage, is that the fruit of O. smithiana var. α are significantly longer than those of O. smithiana var. β .

Further work on these two varieties may indicate that they are sub-species rather than varieties of O. smithiana. These two varieties are, however, not always geographically separated.

The Xhosa name for O. smithiana is umMuncwane. The bulb is known as inKolwane or iZotho. The Xhosas dry and powder the bulbs and use it as a treatment for tapeworms.

Natal Specimens Examined

Natal. - 2632 (Bela Vista) : Ndumu Forest, (-CD), Edwards 21189 (BOL). - 2730 (Vryheid) : Farm Retirement, Utrecht (_CB), Marsh 106 (PRE). - 2731 (Louwsberg) : grassland adjacent to airstrip, Itala Nature Reserve (-CA), McDonald 243 (NU); 3.2 km west of Magut, Ngotshe (-DA), Codd 1963 (PRE); Magut (-DA), van der Merwe 2738 (PRE). - 2732 (Umbombo) : mountain pass near Josini Dam (-CA), Stirton 495 (PRE); Mkuze Game Reserve (-CB), Goodman 393 (NU); 12.6 km from Hluhluwe turnoff on the way to Mkuze (-CC), Retief 229 (PRE). - 2829 (Harrismith) : Mabelane (-BD), Evans 332 (NH). - 2830 (Dundee) : Kranzkop (-AA), Haygarth 24884 (PRE). - 2831 (Nkandla) : Mpila Hill, Umfolozi Game Reserve (-BD), Bourquin 492 (NH, NU, PRE); hillside, Eshowe (-CD), Galpin 12160 (PRE). - 2832 (Mtubatuba) : Hluhluwe

Game Reserve (-AA), Hitchins 64 (PRE); Hluhluwe Game Reserve, Nyimane (-AA), Hitchins 356 (PRE); Hluhluwe Game Reserve (-AA), Ward 1449 (NH, NU), Ward 2410 (NH, NU, PRE); 16 km from Mtubatuba, Nongoma (-AC), Strey 5454 (PRE). - 2929 (Underberg) : Cathkin Park, Drakensberg (-AB), Galpin 11771 (PRE); Giant's Castle Game Reserve, Muden Valley (-AB), Trauseld 469 (NU, NPRES); Giant's Castle (-AD), Symons 15655 (PRE); Kamberg (-BD), Ruddock 73 (NU); Kamberg (-BD), Wright 1867 (NU); Cobham Forest Station (-CB), Hilliard and Burt 13324 (NU); Frontbeck (-CB), Hilliard and Burt 13369 (NU); Ndlovini (-CB), Hilliard and Burt 13372 (NH); 10-11 km N-NW of Castle View Farm (-CB), Hilliard and Burt 13604, 15369 (NU); Mpendle (-DB), Levett 70 (NH). - 2930 (Pietermaritzburg) : Meteor Ridge, Mooi River (-AA), Mogg 6994 (PRE); Caversham (-AC), Mogg 1430 (PRE); 5 km N.W. of Howick (-AC), Moll 1176 (PRE); Karkloof Falls (-AC), Moodley 35 (UD-W); Cooper Street Hill, Greytown (-BA), Buthelezi 319 (NH); Cooper Street Hill, Greytown (-BA), Moodley and Reddy 3 (UD-W); Greytown (-BA), Wylie s.n. (NH, PRE); Town Hill (-CB), Huntley 233 (NU); World's View (-CB), Moll 2625 (PRE, NU); hill slopes of World's View, Pietermaritzburg (-CB), Moodley and Reddy 4 (UD-W); hill near Camperdown (-DA), Medley-Wood 4965 (BOL). - 3029 (Kokstad) : at the foot of the Ingeli Mountains (-DA), Ward 169 (NU). - 3030 (Port Shepstone) : Sutton Estate, SAPPI (-AA), Shirley s.n. (NU).

7.3.3. O. obliquifolia Steud. ex A. Rich. in Tent.
Fl. Abyss. 1 : 123 (1847)

Oliver in F.T.A. 1 : 295 (1868); Knuth in Engl.
Pflanzenr. 4, 130 : 348 (1930); Salter in J.S.A.
Bot. Suppl. Vol. 1 : 154-155 (1944); Exell and Men-
donca in C.F.A. 1(2) : 262 (1951); Brenan in Mem.
N.Y. Bot. Gard. 8(3) : 231 (1953); Wilezek in F.C.B.
7 : 8 (1958); Exell in Fl. Zam. 2 : 155 (1963);
Guillarmod in Flora of Lesotho : 201 (1971); Ross in
Flora of Natal : 211 (1972); Compton in Flora of
Swaziland : 291 (1976).

Type: Quartin Dillon and Ant. Petit, s.n. (? syn-
types; BM, K).

Erect; apparently acaulescent herb. Root trans-
lucent, fleshy, contractile. Bulb ovoid or globose,
attenuate at base, acute or shortly rostrate at apex,
8-22mm long (x = 12.7mm), 4-15mm broad (x = 8.7mm);
outer scales dark brown, roughly veined. Rhizome
6-102mm long (x = 32.4mm), slender, amplexicaul
scales at nodes, about 5m long, brown. Leaves tri-
foliolate : petioles 8.9-101.7mm long (x = 47.5mm);
erect,

pink pubescent, outer ones shorter than inner ones; outer shortly stipulate below basal articulation : leaflets sub-sessile, broader than long; median leaflet about 2mm longer and 3-8mm broader than lateral leaflets, median leaflet retuse, lateral leaflets cuneate, 5.1-16.7mm long ($x = 8.9\text{mm}$), 6.3-17.7mm broad ($x = 11.2\text{mm}$); dorsally glabrous or sparsely pubescent, margins ciliate, mid-vein dorsally conspicuous on median leaflet only; ventrally pubescent, sometimes purple; apices rounded, without sinuses; leaflets do not sleep diurnally or when stressed. Scapes 19-182mm long ($x = 77.4\text{mm}$); arising from bulb, sparsely pubescent when mature, pink; flowers solitary. Bracts 2; linear-lanceolate, ecallose, opposite or alternate, 2-7mm long ($x = 4.2\text{mm}$); the lower 0.9-2mm from calyx; pubescent. Flower bisexual, actinomorphic, hypogynous. Sepals 5, free, oblong or ovate-lanceolate, sub-actue, ecallose, 4-8mm long ($x = 5.7\text{mm}$), 1.3-2.6mm broad ($x = 2\text{mm}$); sparsely pubescent with tufts of trichomes at apices. Corolla regular, 5-merous; upper parts of corolla pink or rosy violaceous, tube yellow, throat and upper parts separated by a white band; broadly funnel-shaped, 10-22mm long ($x = 16.8\text{mm}$); throat 2.1-18mm broad ($x = 6.4\text{mm}$) : petals sub-cuneate, clawed at base, sparsely pubescent. Filaments 10,

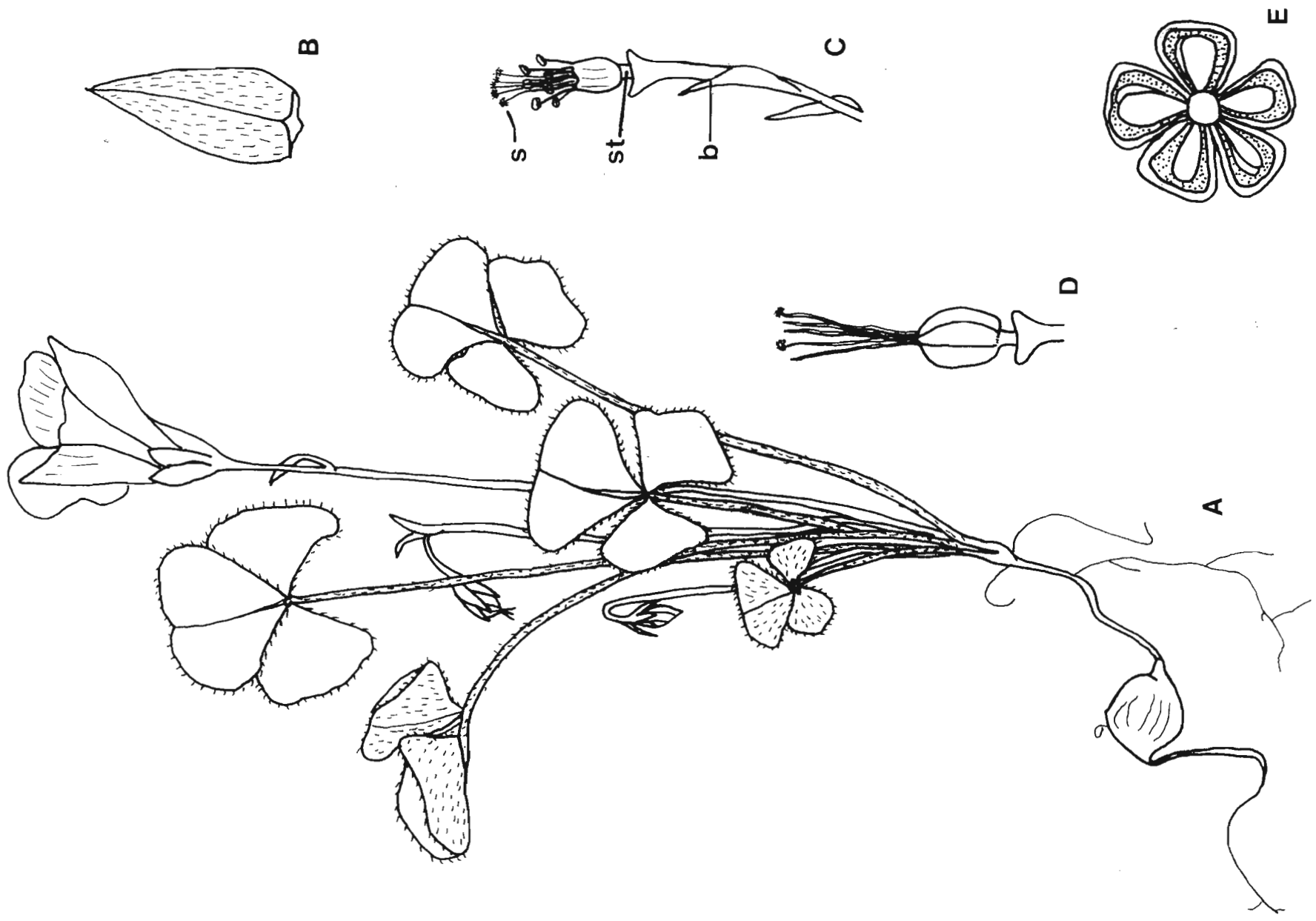


Fig. 39. Vegetative and floral morphology of *O. obliquifolia* (long-styled flowers) (Moodley and Reddy 3)

- A. Plant X3
- B. Sepal X7
- C. Diagrammatic representation of arrangement of reproductive organs X5
- D. Fruit X8
- E. T/S of fruit X9

b = bract
s = style
st = stalk

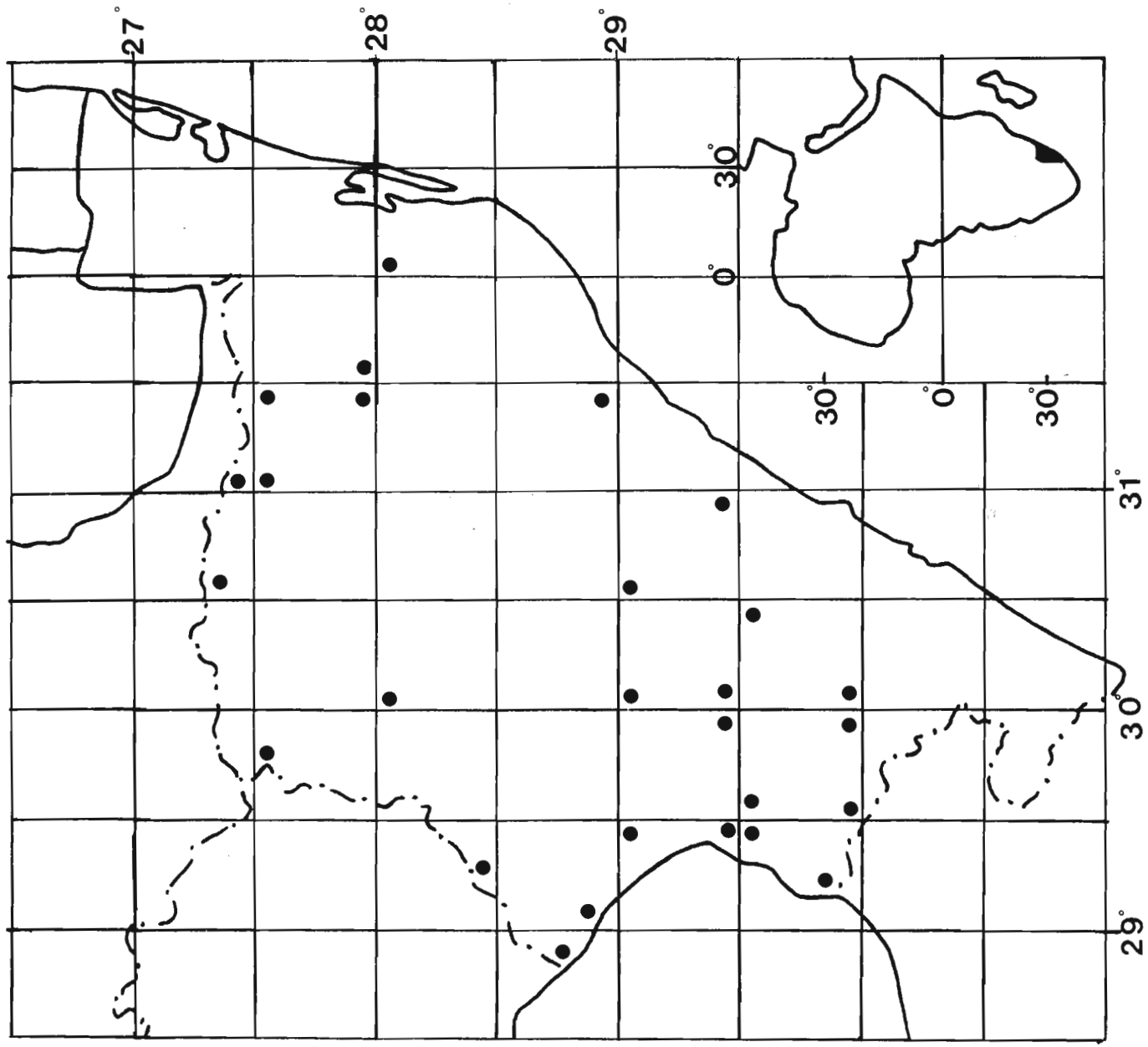


Fig. 40. Recorded distribution of *O. obliquifolia*

biseriate, usually basally connate, of three lengths; long filaments 5-10mm long ($x = 8.5\text{mm}$); median filaments 4-7mm long ($x = 5.9\text{mm}$); short filaments 3-6mm long ($x = 4.3\text{mm}$); pubescent, shortly toothed or gibbose. Gynoecium tristylous; 5-styled; long gynoecia 7-10mm long ($x = 8.7\text{mm}$); median gynoecia 6-8mm long ($x = 6.4\text{mm}$); short gynoecia 3-5mm long ($x = 4.4\text{mm}$) : ovary superior, 5-loculate, about 6 ovules per chamber; pilose on upper half : styles pilose ; stigma 5, papillate, green. Fruit loculicidally dehiscent, 5-angled capsule, 7mm long, 3-4mm broad ($x = 3.4\text{mm}$); mainly in June. Seeds arillate brown when mature; about 4 seeds per locule (Figs. 34.3; 39).

Diagnostic Features

Leaflet apices rounded, without sinuses; sepals oblong, ecallose.

Flowering period

September to June.

Fruiting period

December to June.

Distribution

Occurs mainly in the south western regions of Natal; especially along the escarpment. Has also been collected in the northern regions of Natal. O. obliquifolia is found at altitudes ranging from 700-2960mm (Fig. 40).

Habitat

Occurs in moist, shady areas e.g. in woodlands or amongst long grass in open veld regions.

Additional

The South African form of this species, according to Salter (1944), differs from the typical Abyssinian form by being much larger and more pilose.

Oliver (1868) stated that O. obliquifolia is nearly allied to O. convexula Jacq. (a Cape species) and is thus rather a variety than a distinct species.

According to Salter (1944) however, O. obliquifolia is closely related to O. convexula. Salter (l.c.) states that there is the possibility that the two species merge into one another but that O. obliquifolia generally seems to be larger, more

robust without septal calli. In addition, O. convexula has a succulent stem, which O. obliquifolia does not have.

A study of the genus Oxalis within the South African context needs to be undertaken before firm conclusions can be drawn.

The Swazi venacular for O. obliquifolia is simunyane.

Natal specimens examined

Natal. - 2729 (Volksrust) : Kranskop (-DB), Wortman 12 (NU). - 2730 (Vryheid) : near Grootspuit, granite koppie (-BC), Strey 8029 (NH, PRE). - 2731 (Louwsberg) : Itala Nature Reserve (-AC), Brown and Shapiro 14, 91, 465 (PRE); Craigadam Farm, Itala Nature Reserve (-CA), MacDonald 445 (NU); Itala Nature Reserve (-CB), Porter and Ward 193 (NH); Ngome (-CD), Strey 9337 (NH, PRE); Ngome State Forest (-CD), van Wyk 7052 (PRE); Ngome (-DC), Gerstner 3684 (NH). - 2828 (Bethlehem) : Royal National Park, Fairy Glen (-DB), Ross 2251 (NU, PRE); Royal National Park, Fairy Glen (-DB), Schelpe 1494 (NU); Mount-Aux Sources (-DD), Schelpe 1358 (NH); Mahai Valley, Mont-Aux Sources (-DD), Schelpe 1544 (NU); Tugela Falls (-DD), Wood 3505 (NH). - 2829 (Harrismith) : Farm Nolens Volens, east of Van Reenen (-AC),

Jacobsz 1582 (PRE); Van Reenen (-AB), Wood 12141
 (NH); Cathedral Peak Forest Research Station (-CC),
Killick 1077, 1309 (PRE). - 2830 (Dundee) :
 Kranskop, Greytown (-AA), Galpin 14763 (PRE);
 Fairbreeze Farm, Dannhauser (-AA), Nqwenya 52 (NH);
 top of Impati Mountain (-AA), Shirley 66 (NH). - 2831
 (Nkandla) : Eshowe (-CD), Lawn 1461 (NH). - 2832
 (Mtubatuba) : Umbhombhe, Hluhluwe Game Reserve (-AA),
Bourquin 681 (PRE). - 2929 (Underberg) : Cathkin
 Park, Drakensberg (-AB), Galpin 1172 (PRE); path to
 Grotto, Cathkin Park (-AB), Howlett 3, 79 (NH);
 Gaint's Castle Game Reserve (-AB), McKeowan 45a (NU);
 Giant's Castle Game Reserve, Mumden Valley (-AB),
Trauseld 470 (NU, PRE); Cathkin Park Hostel (-AB),
West 20 (PRE); Giant's Castle (-AD), Bruyns-Haylett
60 (NU); Kransberg (-BD), Gordon-Gray 42 (NU);
 Rosetta (-BD), Mogg 4122 (PRE); Kamberg (-BD),
Wright 1695, 2002 (NU); Bamboo Mountain (-CB), Grice
 s.n. (NU); Garden Castle Forest Reserve, jeep track
 to Crystal Waters (-CC), Hilliard and Burt 1388846
 (NU, PRE); vicinity of Tarn Cave, above Bushman's
 Nek (-CC), Hilliard and Burt 17372 (PRE);
 Drakensberg Garden (-CC), Werdermann and Oberdieck
1420 (PRE); Knifelands "Glengariff Farm" (-DC),
Rennie 995 (NU). - 2930 (Pietermaritzburg) : Meteor
 Ridge, Mooi River (-AA), Mogg 6995 (PRE); Karkloof
 Falls (-AC), Moodley 34 (UD-W); Howick (-AC),
 Schlechter 3300 (PRE); Howick (-AC),

Wood 11638 (NH); Karkloof (-AC), Wylie s.n. (NH);
Greytown (-BA), Galpin 14670 (PRE); Cooper Street
Hill, Greytown (-BA), Moodley and Reddy 2 (UD-W);
Greytown (-BA), Wylie 22381 (PRE); King's Cliff
near Appelbosch Mission (-BD), Stirton 733 (PRE);
Boston, Impendle (-CA), Beattie 20 (NU); Redruth
(-CA), Wright 1325 (NU); on hillside of World's
View, Pietermaritzburg (-CB); Moodley and Reddy 4
(UD-W); Cedara (-CB), Phillips 3455 (PRE); 1 km
along Fort Nottingham Road from Nottingham Road
(-CC), Pienaar 508 (PRE); Arnold's Hill (-CD),
Wylie s.n. (NH); Botha's Hill (-DC), Hutchinson,
Forbes and McLean 11 (NH).

7.3.4 O. corymbosa D.C. Prodr. 1 696 (1824);

Exell in Cat. Vasc. Pl. S. Tome : 124 (1944);

Hutchinson and Dalziel in Flora of West Tropical
Africa 5(1) : 159 (1954); Wilczek in F.C.B. 7 : 9
(1958); Exell in Fl. Zam. 2(1) : 149-155 (1963).

Type: D.C. Prodr. 1 : 696 (NU, iconotype!).

O. martiana Zucc. in Denschr. Akad. Muench 9 : 144
(1824); Knuth in Engl. Pflanzenr. 4(130) : 250
(1930).

Type: From Brazil

O. urbica A. St. Hil. in Fl. Bras. Mer. 1 : 126
(1825).

O. bipunctata R. Grah. in Edinb. N. Phil. Journ. :
176 (1827); Hook. in Bot. Mag., t2781 (1827).

Acaulescent, pubescent herb. Root at "bulb" base,
fleshy; translucent, contractile. "Bulb" close to
soil surface, grossly spherical, 20-30mm long (x =
26.7mm), 18-20mm broad (x = 24.3mm); composed of
numerous small, sessile bulbils of uniform size,
5-6mm long (x = 5.3mm), 4mm broad (x = 4mm); outer
protective scale leaves brown with three distinct

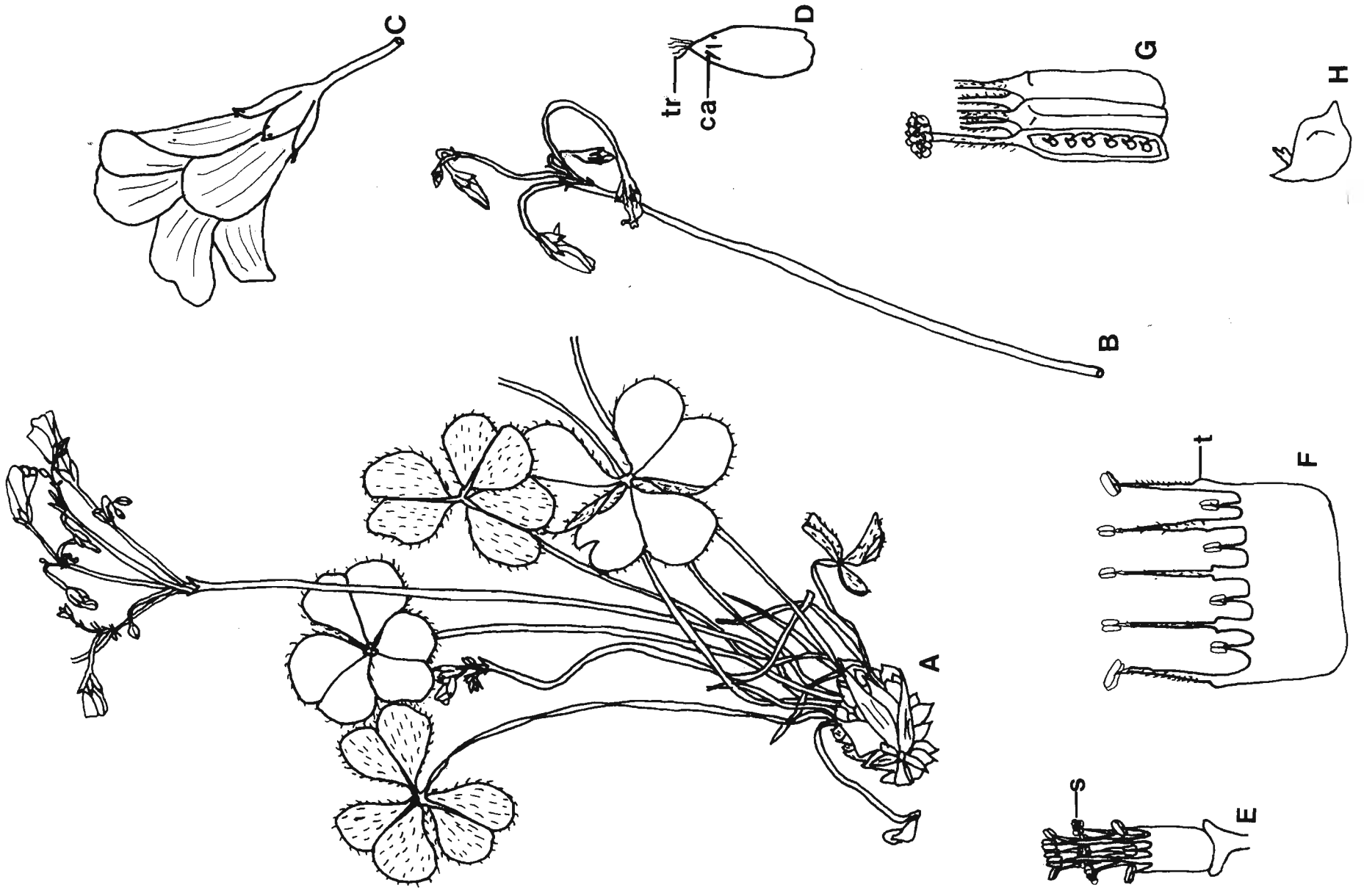
central ridges. Rhizome absent. Leaves digitately trifoliolate; sleep at night or when stressed : petioles 159.3-240mm long (x = 189.8mm); pubescent : leaflets 20.3-29.9mm long (x = 25.6mm), 20.7-34.4mm broad (x = 28.5mm); obovate, broader than long, sinus deep; dorsally sparsely pubescent; ventrally pubescent more so along margins, impresso-punctate with brown "dots" along ventral margins; margins ciliate. Peduncles 240-270mm long (x = 254.5mm); basally pubescent when mature, giving rise to many-flowered compound umbel. Inflorescence branches 27.5-43.8mm long (x = 33.3mm); pubescent. Bracts 2-2.5mm long (x = 2.3mm); at base of inflorescence branches; outer margins papery; each with a single apical callus. Pedicels 9-36.3mm long (x = 21.5mm); pubescent. Bracteoles 1-1.5mm long (x = 1.2mm); 2 calli at apices of each. Flower bisexual and actinomorphic, hypogynous. Sepals 5, free; 4.7-4.9mm long (x = 4.8mm), 1.3-2mm broad (x = 1.6mm); oblong or ovate lanceolate, sub-acute; 2 distinct orange apical calli; apical tufts of trichomes. Corolla 5-merous; regular; diurnal and photonastic : petals lilac to mauve; the throat greenish; 11.3-17.5mm long (x = 13.9mm); 4.5-6.5mm broad (x = 5.5mm); petals shortly connate throat region; basally free, clawed, apically cuneate. Filaments 10, of two lengths; connate; long filaments 5-6mm long (x = 5.5mm), dentate; pubescent; short filaments 3mm

long (x = 3mm), edentate, glabrous to sparsely pubescent. Gynoecium mid-styles only; 4mm long (x = 4mm); ovary 5-loculed, sparsely pubescent with a few glandular hairs; 5-7 ovules per locule : styles 5; densely pubescent : stigmas 5, green, papillate. Fruit absent (Figs. 34.4; 4.1).

Fig. 41. Vegetative and floral morphology of O. corymbosa

- A. Plant X0.5 (James, s.n.)
- B. Peduncle with flowers X0.5 (James, s.n.)
- C. Flower X3 (Moodley & Reddy, 1)
- D. Sepal X4 (Moodley & Reddy, 1)
- E. Arrangement of reproductive organs X15 (Moodley & Reddy, 1)
- F. Stamens X25 (Moodley & Reddy, 1)
- G. Gynoecium X60 (Moodley & Reddy, 1)
- H. Ovule with aril X7 (Moodley & Reddy, 1)

Ca = calli
 S = stigma
 t = tooth
 tr = trichomes



Diagnostic features

Acaulescent; "bulb" composed of a number of sessile bulbils; leaflets obovate, ventrally impresso-punctate with brown "dots"; inflorescence a compound umbel; bracts and bracteoles with calli; petals lilac to mauve; styles densely pubescent; fruit absent.

Flowering period

July to September.

Distribution

A common weed of parks and suburbia. Figure 42 indicates areas in which specimens were collected.

Habitat

Cool, moist, shady areas that are infrequently disturbed.

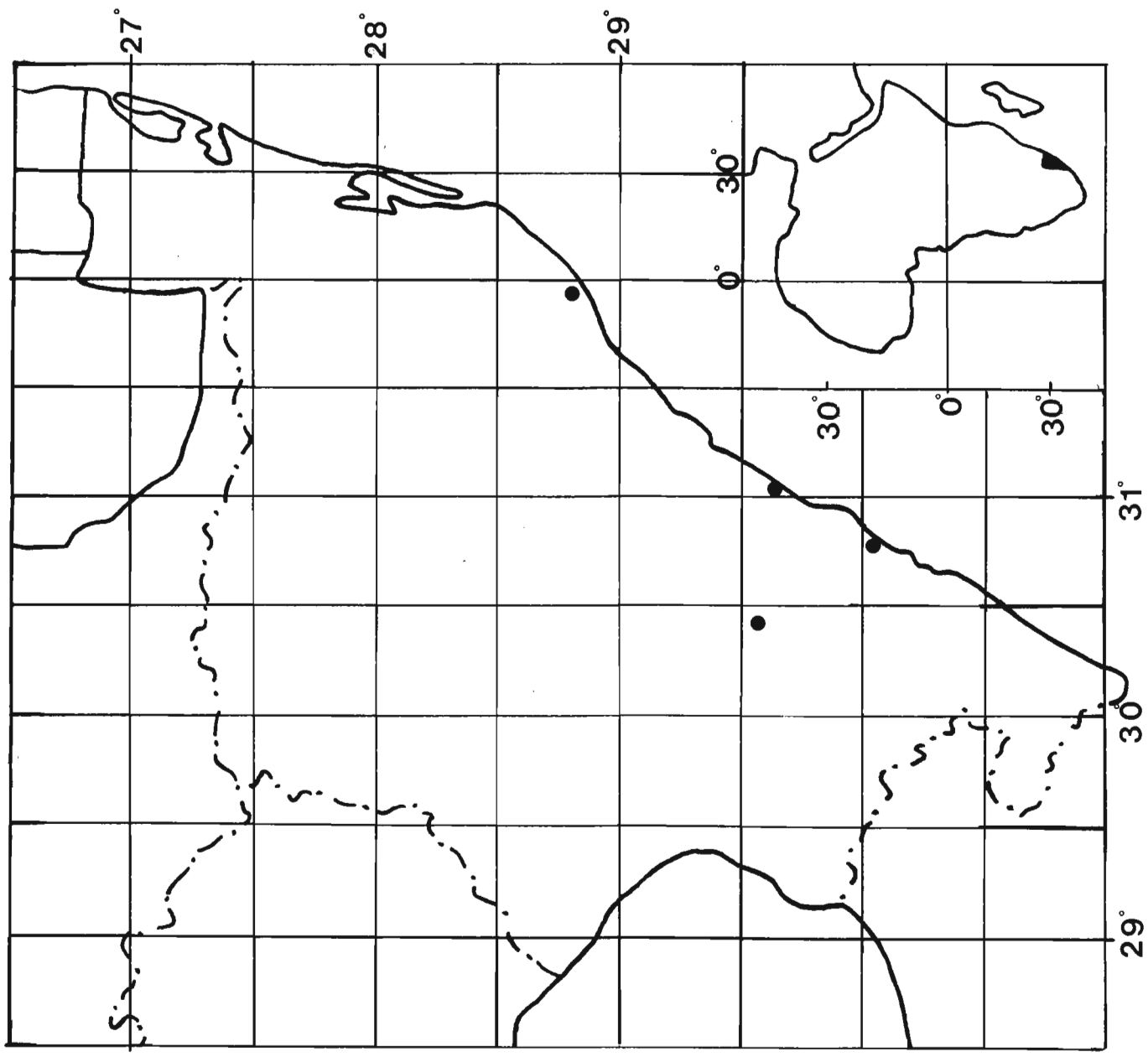


Fig. 42. Recorded distribution of *O. corymbosa*

Additional

This cosmopolitan weed originates from South America and apparently forms no fruit in Africa. It is often confused with O. latifolia and therefore is not extensively collected. Salter (1944) and even later publications make no mention of its presence in South Africa. This is perhaps the first time that O. corymbosa is recognised as occurring in Natal.

Natal Specimens Examined

Natal. - 2831 (Nkandla) : Empangeni Village (-DD), Venter 2075 (PRE). - 2930 (Pietermaritzburg) : Pietermaritzburg (-CB), James s.n. (NU); Alexandra Park, Pietermaritzburg (-CB), Moodley and Reddy 1 (UD-W); Wylie Park, Pietermaritzburg (-CB), Moodley and Reddy 2 (UD-W). - 2931 (Stanger) : Botanic Station Garden, Berea (-CC), Strey 5230 (NH). - 3030 (Port Shepstone) : Isipingo (-BB), Jankee 15 (UD-W).

7.3.5 O. semiloba Sond. in Fl. Cap. 1 : 350 (1860);

Oliver in F.T.A. 1 : 292-297 (1868); Hiern. in Cat. Afr. Pl. Welw. 1 : 109 (1896); Exell in Journ. of Bot. 15 Suppl. polypet : 52 (1927); Knuth in Engl. Pflanzenr. 4(130) : 306 (1930); Gossweiler and Mendonca in Cart. Fitogeogra. Angol. : 163 (1939); Salter in J.S.A. Bot. Suppl. Vol. 1 : 87 (1944); Exell and Mendonca in C.F.A. : 262 (1955); Exell in Fl. Zam. 3 : 153 (1963); Guillarmod in Flora of Lesotho : 200 (1971); Ross in Flora of Natal : 211 (1972).

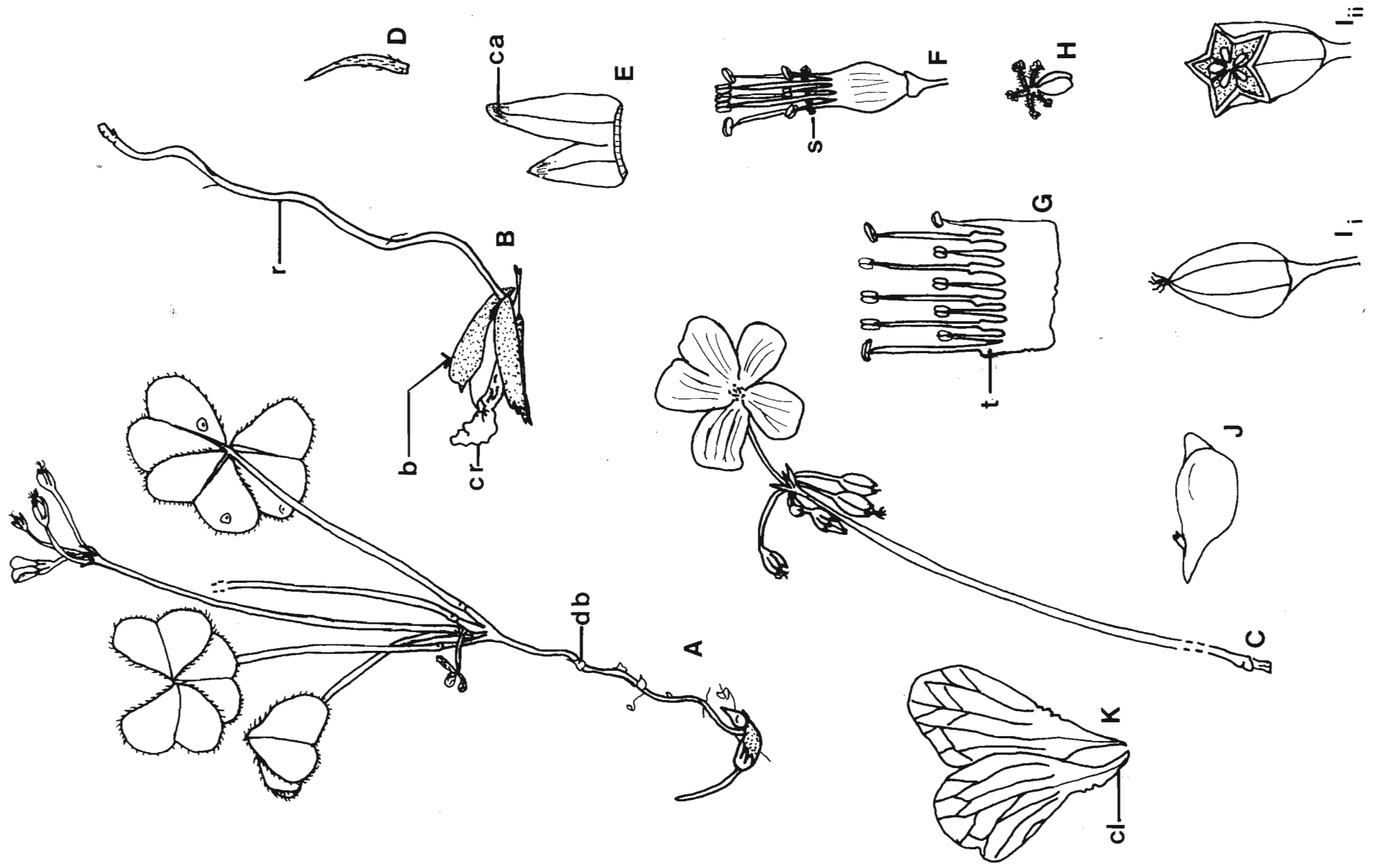
Type: Burke, Zey. 271 (? isotype, LY).

Acetosella semiloba (Sond.) Kuntz. in Rev. Gen. Pl. 1 : 91 (1891).

Apparently acaulescent, slightly pubescent herb; up to 200mm tall. Root fleshy, translucent, contractile. Bulb present, narrowly ovoid; 5-22mm long (x = 14.5mm), 3-11mm broad (x = 8.9mm); outer protective scales thin, papery, shiny, pale brown; inner nutritive scales fleshy, white. Rhizome present; 20-132mm long (x = 55.3mm). Leaves trifoliolate : petioles glabrous to sparsely pubescent; 39.1-157mm long (x = 100.4mm); terete, winged above basal articulation : leaflets obcordate; bilobed, lobes

divaricate, apices ovate; ventrally paler, glabrous to sparsely pubescent; margins ciliate. Peduncle pubescent; umbellately 4-13 flowered; arising from bulb; 92.8-270mm long ($x = 170.0\text{mm}$). Bracts at pedicel bases; 2-6mm long ($x = 4.1\text{mm}$); pubescent; 1-2 apical calli present. Flower bisexual, actinomorphic, hypogynous. Sepal lobes 5; fused at base; oblong; apically obtuse with diffuse, pale brown calli; sparsely pubescent. Corolla 5-merous; regular; 9.3-22.5mm long ($x = 15.8\text{mm}$), 2-17mm ($x = 5.9\text{mm}$) at the throat; diurnal and photonastic: petals salmon pink; contorted in bud and on closing, clawed at base, shortly connate in throat region, apically cuneate. Filaments 10, connate; sparsely pubescent; 3 filament lengths in Natal; 2 lengths per flower; long filaments dentate, 7-10mm long ($x = 7.5\text{mm}$); mid-filaments edentate, 4-8mm long ($x = 5.4\text{mm}$), short filaments edentate; 2.5-7mm long ($x = 3.9\text{mm}$). Gynoecium tristylous; long gynoecium 8.5-10mm long ($x = 9.1\text{mm}$), mid-gynoecium 5-6.5mm long ($x = 5.5\text{mm}$); short gynoecium 3-5mm long ($x = 3.7\text{mm}$): ovary superior, 5-loculed, glabrous, approx. 3 ovules per locule; styles 5, pubescent, stigmas 5, green; papillate. Fruit loculicidally dehiscent 5-angled capsule; 5-7mm long ($x = 5.9\text{mm}$), 3.4mm broad ($x = 3.3\text{mm}$). Seed arillate, 5-7mm, reddish-brown; ovate with acute apex (Figs. 34.5; 43).

Fig. 43. Vegetative and floral morphology of *O. semiloba*
(short styled flowers)
(Reddy, 2)



- A. Plant X0,7
 - B. Contractile root, bulb and rhizome X1,5
 - C. Peduncle with flowers X1
 - D. Bract X7
 - E. Calyx lobes X5
 - F. Diagrammatic representation of the arrangement of reproductive organs in short-styled flowers
 - G. Stamens (long and medium) X4
 - H. Short gynoeceium X4
 - Ii. Fruit (capsule) X4
 - Iii. Arrangement of seeds within capsule X4
 - J. Ovule with aril X10
 - K. Clawed corolla lobes X3
- b = bulb
 - ca = calli
 - cl = claw
 - cr = contractile root
 - db = developing bulb
 - r = rhizome
 - s = stigma
 - t = tooth

Diagnostic features

Bilobed, obcordate leaflets with ovate apices; bracts with apical calli; salmon pink flowers in umbels.

Flowering period

September to May.

Fruiting period

February to May; peaking in March.

Distribution

Widespread in Natal (Fig. 44). Well collected in the southern half of Natal. Occurs from 36.6m to 1799m above sea level.

Habitat

A wide range of shady habitats; such as grasslands, moist slopes, disturbed ground and forests.

Additional

O. semiloba is often confused with the introduced Mexican weed - O. latifolia.

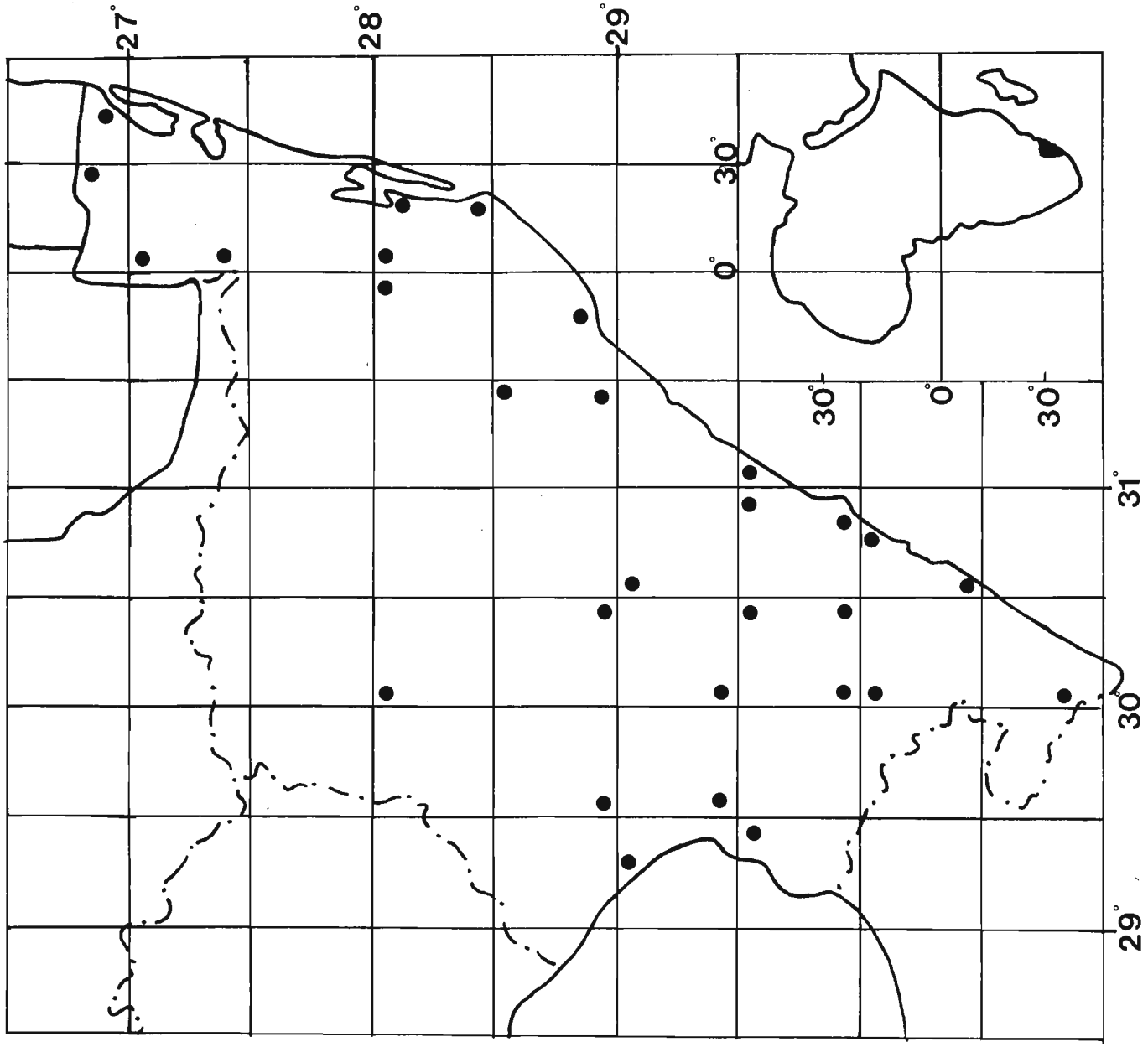


Fig. 44. Recorded distribution of *O. semiloba*

Salter (1944) recognises O. semiloba as a "group" species. According to Salter (lc.), the name seems to cover a polymorphic group of plants. More intensive field studies need to be conducted in order to confirm this.

O. semiloba is known as isi Neingu or isi Nimga by the Zulus who use it as an antimycotic.

Natal Specimens Examined

Natal. - 2632 (Bela Vista) : foot of Ndumu Hill, Ndumu Game Reserve (-CD), Oatley C8 (NU, PRE); Ndumu Hill, Ndumu Game Reserve (-CD), Pooley 515 (UD-W); Kosi Bay Nature Reserve (-DD), Goodman 740 (NU). - 2732 (Umbombo) : Nhlole Pan, Pongola Pan System (-AA), Cawood 23 (NU); Mfongosi (-AC), Watt and Brandwijk 1051 (PRE). - 2829 (Harrismith) : Qudeni (-DC), Gerstner 632 (PRE). - 2830 (Dundee) : Kranskop 3 km N of the Post Office, "The Ranch" (-AA), Codd 9667 (PRE); Kranskop (-AA), Haygarth 22764 (PRE); Muden (-CD), Manning 17 (NU). - 2831 (Nkandla) : Palm Ridge Farm (-BB), Harrison 474 (NH, PRE); Eshowe (-CD), Gerstner 2022 (NH); Mpusheni Falls (-CD), Lawn 519, 937, 1971 (NH); Eshowe (-CD), Lawn 1830 (NH); turn-off to Grey's Apiaries, near Richards Bay (-DD), Cawood 1 (NU); Hamewith near Mtunzini (-DD), Mogg 414 1, 11 (PRE); Mtunzini, Uqupu Lake area (-DD),

Venter 2556 (PRE); Mtunzini, U.C.Z. Nursery (-DD),
Venter 3384 (PRE). - 2832 (Mtubatuba) : Hluhluwe
(-AB), Ward 2497 (MH, NU); Hlabisa, St. Lucia Park
(-AD), Dutton 41 (PRE); DukuDuku U117 (-AD), Strey
5549 (NH). - 2929 (Underberg) : Giant's Castle Game
Reserve (-AB), McKeowan 456 (NU); Giant's Castle
Game Reserve, Main Cave area (-AB), Trauseld 1025
(NU, PRE); Loteni River Flood Plain, Loteni Nature
Reserve (-BC), Phelan 229 (NU); Polela District,
"Sunset Farm" (-CB), Rennie 874, 1284 (NU); Kamberg
(-BC), Wright 2051 (NU). - 2930. (Pietermaritzburg)
: Bishopstowe (-CB), Bampton and Hackland s.n. (NU);
Bisley (-CB), Breyshaw 63 (NU); River Banks, Pieter-
maritzburg (-CB), Harding 136 (NH); Oribi (-CB),
Lawson 17 (NU); along driveway, Woodlands Secondary
School, Pietermaritzburg (-CB), Moodley and Reddy 6
(UD-W); Allandale Football Ground, Allandale Drive,
Pietermaritzburg (-CB), Moodley and Reddy 7 (UD-W);
Broughton (-CB), Most 4 (NU); Town Bush Valley
(-CB), Niewoudt 86 (NU); Road to Albert Falls,
Pietermaritzburg (-CB), Reddy 2 (UD-W); Byrne, Rich-
mond (-CC), Galpin 20086 (BOL); Hella-Hella Valley
(-CC), Stirton 8650 (PRE); Byrne, Keerom (-CC),
Strey 11258 (NH, NU); Umlazi (-CD), Thieler 10026
(PRE); Arnold's Hill (-CD), Wylie s.n. (NH);
Itafamasi (-DB), Wood 550 (NH). - 2931 (Stanger) :
Maidstone, North Coast (-CA), Hillary 34 (NU); Berea
(-CC), Forbes 492, 580a (NH); bank slopes, Univer-
sity of

Natal - Durban Campus (-CC), Naicker s.n. (UD-W);
campus, University of Durban-Westville (-CC), Padia
21 (UD-W); Berea, Durban (-CC), Strey 4548 (PRE).
- 3029 (Kokstad) : Weza, Ingeli Slopes (-DA), Strey
6460 (NH, NU). - 3030 (Port Shepstone) : Ixopo Dis-
trict (-AA), Bredin s.n. (NU); Umkomaas, Pinetown
(-BB), van O' Bruyn 218 (PRE); Isipingo Beach (-BB),
Ward 974 (NU); Umzinto, Hazelwood (-BC), Baijnath
321 (NU); Vernon Crookes Nature Reserve (-BC),
Holmes and Balkwill 2906 (NU); Umtamvuna Nature
Reserve (-CC), Abott 1049 (NH).

7.3.6 O. pes-caprae L. Sp. Pl. : 434 (1753);

Jacq. in Oxal. Monogr. : t6 (1794); Salter in J.S.A. Bot. Suppl. Vol. 1 : 75-76 (1944); Bailey and Bailey in Hortus Third : 805 (1977).

Type: Burmann. Afr. : 80, t29 (iconotype).

O. biflora Burm. in f. Fl. Cap. Prod. : 13 (1768).

O. cernua Thunb. in Diss. Oxal. : 14, t2 (1781);
Thunb. in Fl. Cap. : 537 (1823); Sonder in Fl. Cap.
1 : 348 (1860).

O. dentata E. and Z. in Enum. : 84 (1834-1837).

O. anthelmintica A. Rich. in Tent. Fl. Abyss. : 124
(1847).

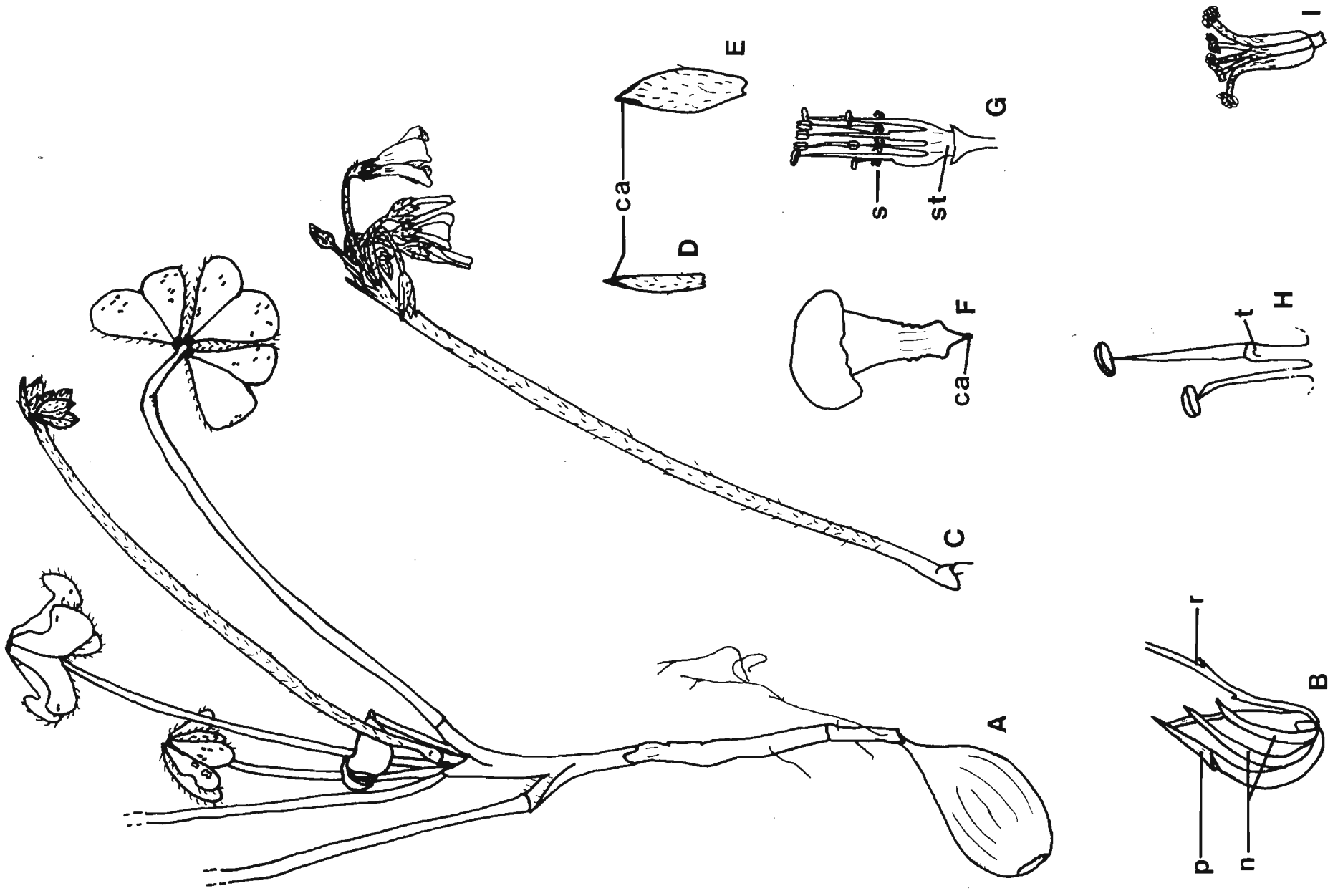
O. kuibisensis R. Kunth in Beiblatt. Bot. Jahb. 61 :
3 (1927).

Erect, robust, apparently acaulescent, sparsely pubescent; perennial herb, up to 300mm tall. Root fleshy, translucent, contractile. Bulb present, ovate-oblong, attenuate at apex, up to 25mm long and 10mm broad; outer protective scales papery, brown

with indistinct vertical ridges. Rhizome present, up to 37mm long; upper portion thick and fleshy with distinct nodes. Leaves numerous, trifoliolate : petioles 30-120mm long, thick, petiolules short, sparsely villous, characteristically reddish : leaflets broadly cuneate-obcordate, bi-lobed or sub-bilobed, broader than long, up to 21.1mm long and 19.9mm broad, attenuate at apex, dorsally glabrous, often with purple streaks, ventrally pubescent; margins ciliate; sleep at night or when stressed. Peduncles arising from bulb, up to 196.3mm long, sparsely pubescent; twice as thick and twice as long as petioles; 3-20 flowers per umbel. Bracts at pedicel bases; callus-tipped, calli 2, blackish. Pedicels sparsely pubescent, basally articulate, 5-20mm long ($x = 14.1$ mm). Flower bisexual, actinomorphic, hypogynous. Sepal lobes 5; connate at base; lanceolate or oblong-lanceolate; 6-7mm long ($x = 6.1$ mm); 1-2 orange apical calli per sepal lobe, if two then of unequal lengths; sparsely pubescent. Corolla regular; 5-merous; broadly funnel-shaped; 15-25mm long ($x = 20.9$ mm); luminescent yellow with concolorous throat; contorted in bud; diurnal and photosnastic : petals broadly cuneate, obliquely sub-truncate at apex, clawed at base with a prominent callus on each claw. Filaments 10, basally connate; only long and medium filament lengths occur in Natal, the longer 5-7mm long, pubescent, dentate; the

shorter 3-4.5mm long, glabrous. Gynoecium only the short styled forms occur in Natal : ovary superior; 5-chambered; oblong; pubescent on upper half; 6-9 ovules per locule : styles 5, pubescent with glandular and eglandular trichomes admixed : stigmas 5, green, papillate. Fruit absent in Natal (Figs. 34.6; 4.5)

Fig. 45. Vegetative and floral morphology of *O. pes-caprae*
(Moodley and Reddy, 8)



- A. Plant X1
- B. Section of bulb X2
- C. Peduncle with flowers X0,5
- D. Bract X6,5
- E. Calyx lobe X4
- F. Corolla lobe X3
- G. Diagrammatic representation of the arrangement of reproductive organs of short-styled flowers X6
- H. Long and medium stamens X8
- I. Short gynoecium X7

ca = calli
n = nutritive scale
p = protective scale
r = rhizome
s = stigma
st = stalk
t = tooth

Diagnostic features

Many-flowered umbels with luminescent yellow flowers; leaflets broadly cuneate-obcordate, dorsally streaked with purple; short petiolules reddish.

Flowering period

April to September.

Distribution

Has been collected from Pietermaritzburg and Balgowan (Fig. 46).

Habitat

Variable; found growing in cool, moist wooded areas as well as open, fairly dry exposed areas.

Additional

O. pes-caprae has become weedy and has spread to many parts of the world. It has become widely naturalized in the tropics and sub-tropics.

Thus far O. pes-caprae has been located in only two areas in this province. Both these areas are in the Pietermaritzburg District; namely on a farm near

Balgowan and in the herb garden of local Botanical Gardens.

An investigation into the origins of the specimens at the Botanical Gardens, revealed that O. pes-caprae had been planted by the local branch of the Herb Society. Since then it has become slightly weedy and 3-4 small colonies occur away from the original colony.

According to Don-Wauchope (pers. comm., 1988) O. pes-caprae is rich in vitamin C and therefore was one of the first South African herbs to be eaten by sailors. It is for this reason that O. pres-caprae has been chosen as the emblem of the Herb Society of South Africa.

Common and vernacular names of O. pes-caprae are: Bermuda Buttercup; geelsuring; kalwersuring; pyp-suring; suringwortel; varksuring and wildesuring.

Natal specimens examined

Natal. - 2930 (Pietermaritzburg) : sub-section 34, Farm Geelhoutboom, Balgowan (-AC), Harris 20 (NU); Herb garden, Botanical Gardens, Pietermaritzburg (-CB), Moodley and Reddy 8 (UD-W).

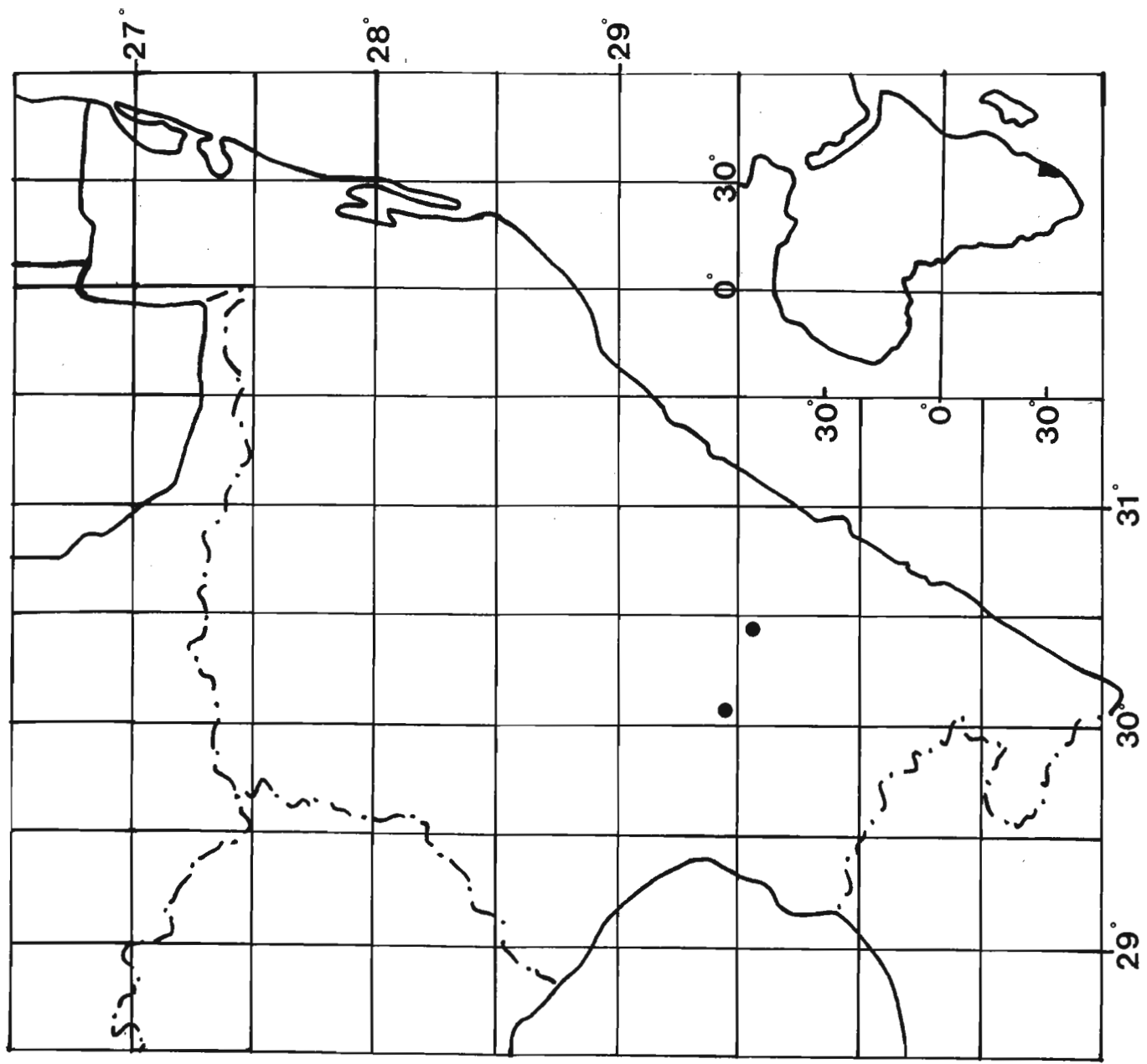


Fig. 46. Recorded distribution of *O. pes-caprae*

7.3.7 O. latifolia H.B. and K. in Nov. Gen. et sp.

V : 237, t467 (1822);

Knuth in Engl. Pflanzenr. 5(130) : 273 (1930); Salter in J.S.A. Bot. Suppl. Vol. 1 : 73 (1944); Wilczek F.C.B. 7 : 11 (1958); Exell in Fl. Zam. 2 : 155 (1963); Ross in Flora of Natal : 211 (1972); Bailey and Bailey in Hortus Third : 805 (1977).

Type: From Mexico, H.B. and K., t467 (iconotype).

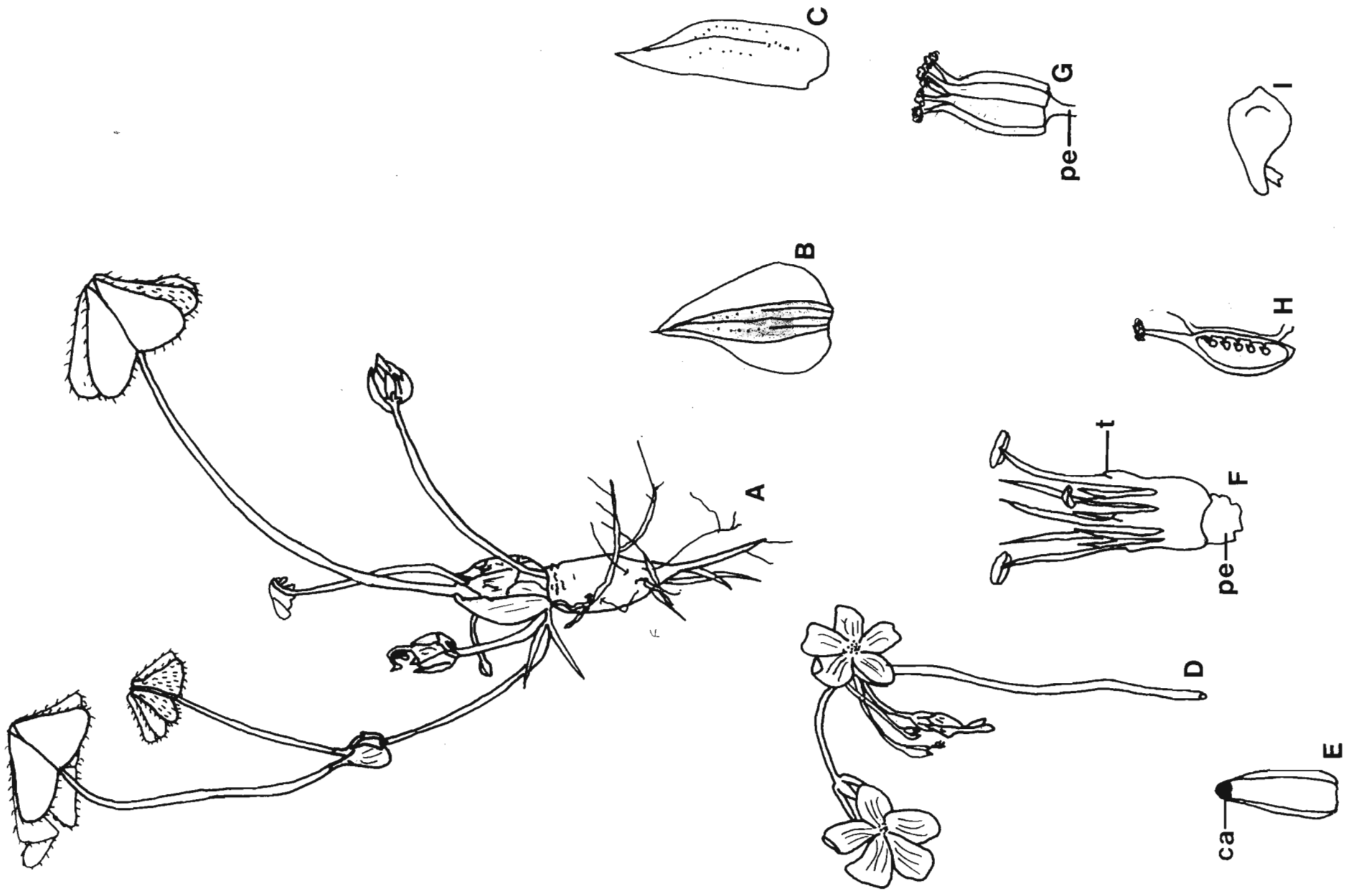
Erect; acaulescent herb; 150-250mm tall; sparsely pubescent. Root large, fleshy, translucent, contractile, 10-34mm long (x = 24.7mm), 9-10mm broad (x = 9.3mm); secondary roots arise from contractile root. Bulb present, ovoid or globose; 6-15mm long (x = 10mm); 6-20mm broad (x = 11.8mm); outer protective scales papery, brown; inner nutritive scales fleshy, white with orange vertical ridge; numerous stalked bulbils arising from bulb base; 5-9 long (x = 7mm), 4-6.5mm broad (x = 5.3). Rhizome absent. Leaves trifoliolate, with short, pubescent petiolules : petioles sparsely pubescent; 54-217.7mm long (x = 114.8mm); arising from apices of nutritive bulb scales : leaflets 15-38.8mm long (x = 26.2mm), 23-39.1mm broad (x = 33.1mm), very broadly obdeltoid, widely incised on upper margin 10-20mm deep; lobes

broadly ovate-obcuneate, apices obtuse; dorsally glabrous, ventrally sparsely pubescent, margins ciliate. Peduncles arising from bases of nutritive bulb scales; 120-322mm long ($x = 171.6\text{mm}$); umbels 6-13 flowered. Bracts at pedicel base; minute; ecallose. Pedicel glabrous. Flower bisexual, actinomorphic, hypogynous. Sepal lobes 5, basally connate, lanceolate-oblong; 5-6mm long ($x = 5.5\text{mm}$), 1-1.9mm broad ($x = 1.4\text{mm}$), with 2 conspicuous orange apical calli. Corolla regular; 5-merous; contorted in bud; diurnal and photonastic; 12-17mm long ($x = 14.3\text{mm}$); throat greenish; 4-7mm broad : petals partially connate; violaceous, widely cuneate; clawed at base. Filaments 10, basally connate; 2 filament lengths; long filaments 5-8mm long ($x = 6.1\text{mm}$); pubescent, shortly dentate; short filaments 2-4mm long ($x = 3\text{mm}$); sparsely pubescent, edentate. Gynoecium homostylous, 4-6mm long ($x = 4.8\text{mm}$); ovary superior, 5-chambered, 5-angled, sparsely pubescent; ovules arillate; 6-8 ovules per chamber; styles 5, medio-stylar; sparsely pubescent; stigmas 5, green, papillate. Fruit absent (Figs. 34.7; 47).

Fig. 47. Vegetative and floral morphology of *O. latifolia*
(Moodley, 36)

- A. Plant X1
- B. Protective scale X5
- C. Nutritive scale X6
- D. Peduncle with flowers X
- E. Calyx lobe X
- F. Stamens X
- G. Gynoecium X
- H. Arrangement of ovules in ovary X
- I. Ovule with aril X7

ca = calli
 pe = pedicel
 t = tooth



Diagnostic features

Acaulescent with stalked bulbils; leaflets very broadly obdeltoid; flowers in "simple" umbels; corollas violaceous.

Flowering period

June to February.

Distribution

Widespread weed. Herbaria have few specimens of this species because of its easy availability. Figure 48 indicates the regions where specimens examined have been collected.

Habitat

Ruderal of disturbed areas. Salter (1944) made the following observation "Introduced from Mexico : a troublesome weed of cultivation".

Additional

O. latifolia is often confused with O. semiloba in South African herbaria. The specific name is derived from the word "latifolius" meaning broad-leaved. Gross leaf morphology and flower colour distinguish

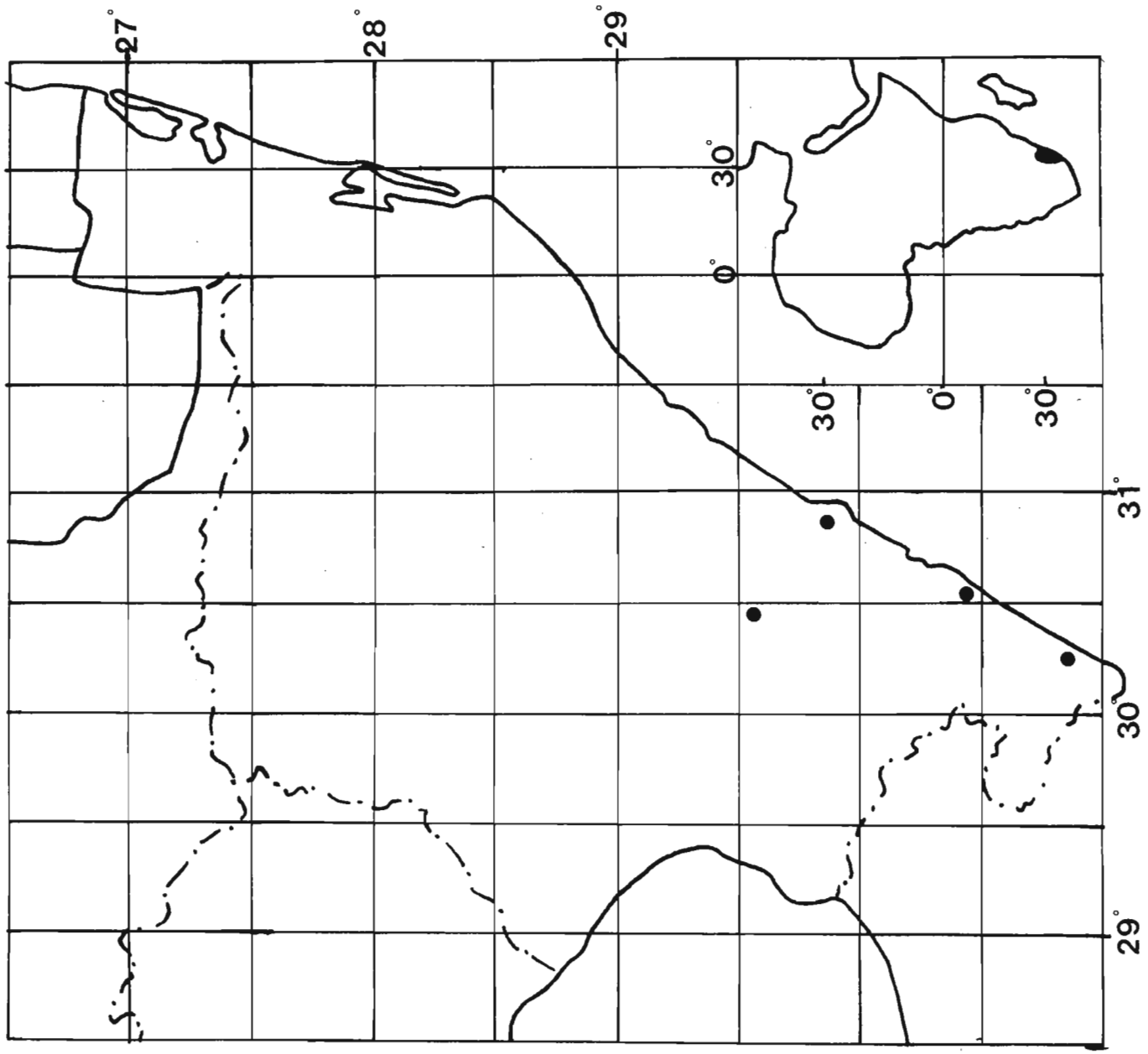


Fig. 48. Recorded distribution of *O. latifolia*

O. latifolia from O. semiloba.

Introduced to South Africa from South America, this species of Oxalis spreads rapidly, on cultivated lands, by means of runners. O. latifolia is dreaded by cereal farmers because it is the alternate host of the fungal rust of maize. In addition, O. latifolia growing in cultivated areas act as nutrient drains; thus depriving commercial crops of essential nutrients.

Common and vernacular names of O. latifolia are rooisuring and tuinsuring.

Natal specimens examined

Natal. - 2930 (Pietermaritzburg) : Town Bush Valley (-CB), Canham 44 (NU); Town Hill (-CB), Cawood 4 (NU); weed in garden, Pietermaritzburg (-CB), Moodley 32 (UD-W); Pietermaritzburg (-CB), Moodley 36 (UD-W); in field of "Evergreen Farm", near Albert Falls (-CB), Moodley and Reddy 5 (UD-W); vacant field in Mountain Rise, Pietermaritzburg (-CB), Reddy 1 (UDW); Pietermaritzburg (-CB), Sim 19145 (NU); Pietermaritzburg (-CB), Tennant 3358 (PRE). - 2931 (Stanger) : Durban (-CC), Rogers 1475 (BOL); Botanic Station, Berea (-CC), Strey 4548 (NH). - 3030 (Port Shepstone) : Hazelwood, Umzinto (-BC), Baijnath 321

(UD-W); St. Michaels-on-the-Sea (-CD), Nicholson
1886 (PRE).

8. REFERENCES

- Adams, R.S. and Salter, T.M. 1950. Flora of the Cape Peninsula. Cape Town : Juta.
- Altschul, von S.R. 1973. Drugs from Little known Plants. Cambridge : Harvard Univ. Press.
- Bailey, L.H. 1900. The Standard Cyclopaedia of Horticulture, Vol. 2. New York : MacMillan Co.
- Bailey, L.H. and Bailey, E.Z. 1977. Hortus Third. New York : MacMillan Co.
- Batten, A. and Bokelmann, H. 1966. Wild Flowers of the Eastern Cape Province. Cape Town : Books of Africa.
- Bayer, M.B., Perry, B.L. and Wilbraham, L.A. 1978. Oxalis L. Veld and Flora, 64(3) : 82-84.
- Bentham, G. and Hooker, J.D. 1862. Genera Plantarum I. Reprinted 1965. New York : Wheldon and Wesley.
- Bews, J.W. 1921. Flora of Natal and Zululand. Pietermaritzburg : City Printing Works.
- Bonner, J. and Varner, J.E. 1965. Plant Biochemistry. New York : Academic Press.
- Borror, D.J., de Long, D.M. and Triplehorn, C.A. 1976. An Introduction to the Study of Insects. 4th ed. Philadelphia : Saunders College.
- Borror, D.J., de Long, D.M. and Triplehorn, C.A. 1981. An Introduction to the Study of Insects. 5th ed. Philadelphia : Saunders College.

- Burton, J., Yarrow, I.H.H., Allen, A.A., Parmenter, L. and Lansbury, I. 1985. The Oxford Book of Insects. London : Peerage Books.
- Butler, C.G. 1962. The World of the Honeybee. London : Collins.
- Chopra, R.N., Chopra, I.C., Handa, K.L. and Kapur, L.D. 1958. Chopra's Indigenous Drugs of India. Calcutta : Dhur and Sons.
- Compton, R.H. 1976. The Flora of Swaziland. Journal of South African Botany, Supplementary Vol. 2, p. 291.
- Cronquist, A. 1981. An Integrated System of Classification of Flowering Plants. New York : Columbia Univ. Press.
- Cruden, W.R. 1977. Pollen-ovule ratios : A conservative Indicator of Breeding Systems in Flowering Plants. Evolution, 31(1), 32-46.
- Cutler, D.F. 1978. Applied Plant Anatomy. London : Longman.
- Cutler, D.F., Alvin, K.L. and Price, C.E. 1982. The Plant Cuticle. London : Academic Press.
- Davey, A.J. 1946. On the Seedlings of Oxalis hirta L. Annals of Botany, 10, 237-256.
- De Candolle, A.P. 1824. D.C. Prodromus I. Paris : Lehr.
- Department of Agriculture Technical Services. 1963. Common Names of Insects. Plant Protection Institute.
- de Wit, H.C.D. 1965. Plants of the World. London : Thames and Hudson.
- Duddington, C.L. 1969. Evolution in Plant Design. London : Faber and Faber.

- Dyer, R.A. The Genera of Southern African Flowering Plants.
Pretoria : Department of Agriculture Technical Services.
- Ecklon, F. and Zeyher, K.L.P. 1835. Enumeratio plantarum
africae australis extratropicae, Vol. 1.
- Erdtman, G. 1966. Pollen Morphology and Plant Taxonomy. New
York : Hafner Publishing Co.
- Engler, H.G.A. 1927. Bot. Jharb. Berlin : Akademie Verlag.
- Engler, H.G.A. 1930. Pflanzenreich - Oxal. Berlin : Akademie
der Wissenschaften.
- Esau, K. 1960. Plant Anatomy. New York : Wiley and Sons.
- Exell, A.W. 1963. Oxalidaceae. In : Exell, A.W., Fernandes,
A. and Wild, H. Flora Zambesiaca, Vol. 2. London : Crown
Agents.
- Fagerberg, W.R. and Culpepper, G. 1984. A Morphometric study
of anatomical changes during sunflower leaf development
under low light. Botanical Gazette, 145(3), 346-350.
- Fahn, A. 1974. Plant Anatomy. 2nd ed. United Kingdom :
Pergamon.
- Galil, J. 1968. Vegetative Dispersal in Oxalis cernua.
American Journal of Botany, 55(1), 68-73.
- Gill, N.T. and Vear, K.C. 1966. Agricultural Botany. London :
Duckworth and Co.
- Graf, A.B. 1978. Exotic Plant Manual. New Jersey : Roehrs
Co.
- Grzimek, B. 1975. Grzimek's Animal Life Encyclopaedia, Vol.
2. New York : van Nostrand Reinhold Co.

- Guillarmod, A.J. 1971. Flora of Lesotho. Lehre : Verlag.
- Haberlandt, G. 1914. Physiological Plant Anatomy. London : MacMillan.
- Hall, M.A. 1978. Plant Structure, Function and Adaptation. London : MacMillan Press.
- Harper, J.L. 1977. Population Biology of Plants. London : Academic Press.
- Heslop-Harrison, Y. and Shivanna, K.R. 1977. The receptive surface of the Angiosperm Stigma. Annals of Botany, 41, 1233-1258.
- Heywood, V.H. 1978. Flowering Plants of the World. Oxford : Oxford Univ. Press.
- Hsu, P. 1986. Problems with regard to reproductive biology in Plant Taxonomy. (Abstract). Acta Bot. Yunnanica, 7(4), 457-467.
- Hutchinson, J. and Dalziel, J.M. 1954. Flora of West Tropical Africa, 5(1), 2nd ed. London : Crown Agents.
- Hylander, C.J. and Johnston, E.F. 1960. The MacMillan Wild Flower Book. New York : MacMillan Co.
- Imms, A.D. 1971. Insects' Natural History. London : Collins.
- Kevan, P.G., Longair, R.W. and Gadawski, R.M. 1985. Dioecy and pollen dimorphism in Vitis riparia (Vitaceae). Canadian Journal of Botany, 63, 2263-2267.
- King, L.J. 1966. Weeds of the World. New York : Interscience.
- Leistner, O.A. and Morris, J.W. 1976. South African Place Names. Annals of the Cape Provincial Museums, Vol. 12. Grahamstown : Cape Provincial and Albany Museums.

- Levyns, M.R. 1929. A Guide to the Flora of the Cape Peninsula. Cape Town : Juta.
- Levyns, M.R. 1974. Seasonal changes in Oxalis purpurea. Veld and Flora, 4(2), 23-26.
- Lindley, J. 1858. School Botany. London : Bradbury and Evans.
- Lindley, J. 1867. The Vegetable Kingdom. 2nd ed. London : Bradbury and Evans.
- Linley, K. and Baker, B. 1972. Flowers of the veld. Salisbury : Longman.
- Linnaeus, C. 1753. Species Plantarum, Vol. 1.
- Linsenmaier, W. 1972. Insects of the World. New York : McGraw-Hill.
- Lowson, J.M. 1959. Text Book of Botany. London : Univ. Tutorial Press.
- Lucas, A. 1971. Wild Flowers of the Witwatersrand. Cape Town : Purnell.
- Ludlow, M.M. 1981. External factors influencing photosynthesis and respiration. In : Dale, J.E. and Milthorpe, F.L. The Growth and Functioning of leaves. Cambridge : Cambridge Univ. Press.
- Marloth, R. 1925. The Flora of South Africa Cape Town : Darter Bros.
- Martin, J.J. and Juniper, B.E. 1970. The Cuticle of Plants. Great Britain : Edward Arnold.
- McClellan, R.C. and Ivimey-Cook, W.R. 1956. Textbook of Theoretical Botany, Vol. 2. London : Longmans, Green and Co.

- Metcalfe, C.R. and Chalk, L. 1950. Anatomy of the Dicotyledons, Vol. 1. Oxford : Clarendon Press.
- Metcalfe, C.R. and Chalk, L. 1979. Anatomy of the Dicotyledons, Vol. 1. 2nd ed. Oxford : Clarendon Press.
- Millerd, A., Morton, R.K. and Wells, J.R.E. 1963a. Oxalic acid synthesis in shoots of Oxalis pes-caprae L. Biochemical Journal, 86, 57-62.
- Millerd, A., Morton, R.K. and Wells, J.R.E. 1963b. Enzymic synthesis of oxalic acid in Oxalis pes-caprae. Biochemical Journal, 88, 281-287.
- Milne, L. and Milne, M. 1967. Living Plants of the World. Great Britain : Nelson.
- Mulachy, D.L. 1964. The Reproductive Biology of Oxalis priceae. American Journal of Botany, 51(10), 1045-1050.
- National Botanical Gardens of South Africa Kirstenbosch. 1980. Wild flowers of South Africa. Cape Town : Struik.
- Nobel, P.S., Zaragoza, L.J. and Smith, W.K. 1975. Relation between Mesophyll surface area, photosynthetic rate and illumination level during development for leaves of Plectranthus parviflorus Henckel. Plant Physiology, 55, 1067-1070.
- Oliver, D. 1868. Flora of Tropical Africa, Vol. 1. London : Reeve.
- Ornduff, R. 1964. The Breeding System of Oxalis suksdorfii. American Journal of Botany, 51(3), 307-314.
- Ornduff, R. 1972. The Breakdown of trimorphic incompatibility in Oxalis section Corniculatae. Evolution, 26, 52-65.

- Ornduff, R. 1974. Heterostyly in South African Plants. Journal of South African Botany, 40, 169-187.
- Ornduff, R. 1975. Pollen flow in Lythrum junceum, a tristylos species. New Phytologist, 75(1), 161-166.
- Pearse, R.O. 1978. Mountain Splendour. Cape Town : Timmins.
- Perry, F. 1972. Flowers of the World. London : Hamlyn.
- Pesson, P. 1959. The World of Insects. London : Harrap.
- Phillips, E.P. 1951. The Genera of South African Flowering Plants. 2nd ed. Pretoria : Government Printers.
- Pirone, P.P., Dodge, B.O. and Rickett, H.W. 1960. Diseases and Pests of Ornamental plants. 3rd ed. New York : Ronald Press.
- Proctor, M. and Yeo, P. 1973. The Pollination of flowers. London : Collins.
- Radford, A.E., Dickison, W.C., Massey, J.R. and Bell, C.R. 1974. Vascular Plant Systematics. New York : Harper and Row.
- Reyneke, W.F. 1975. Trekwortels. Veld and Flora, 61(1), 11.
- Richard, A. 1847. Tentamen florae Abyssinicae, Vol. 1.
- Richard, A.J. 1986. Plant Breeding Systems. London : Allen and Unwin.
- Ridley, H.N. 1930. The Dispersal of Plants throughout the World. Ashford : Reeve.
- Ross, J.H. 1972. The Flora of Natal. Pretoria : Government Printer.

- Salter, T.M. 1944. The Genus Oxalis in South Africa. Journal of South African Botany, supplementary, Vol. 1.
- Schery, R.W. 1954. Plants for Man. London : Allen and Unwin.
- Scholtz, C.H. and Holm, E. 1985. Insects of Southern Africa. Durban : Butterworths.
- Schrire, B.D. 1984. A Taxonomic Revision of the tribe Desmodieae (Leguminosae - Papilionoideae). Unpublished M.Sc. Dissertation, Univ. of Durban-Westville.
- Seliskar, D.M. 1985. Effect of reciprocal transplanting between extremes of plant zones on morphometric plasticity of five plant species in an Oregon salt marsh. Canadian Journal of Botany, 63, 2254-2262.
- Smith, C.A. 1966. Common Names of South African Plants. Pretoria : Government Printer.
- Sonder, O.W. 1860. Oxalideae. In : Harvey, W.H. and Sonder, O.W. Flora Capensis, Vol. 1. Kent : Reeve.
- Stearn, W.T. 1967. Botanical Latin. London : Nelson.
- Street, H.E. and Opik, H. 1970. The Physiology of Flowering Plants. London : Edward Arnold.
- Steudel, E.G. 1843. Pl. Schimp. Abyss.
- Thonner, F.R. 1962. The Flowering Plants of Africa. Herts : Wheldon and Wesley.
- Thunberg, C.P. 1823. Flora Capensis, vol. 1 (22).
- Trauseld, W.R. 1969. Wild Flowers of the Natal Drakensberg. Cape Town : Purnell.

- Usher, G. 1966. A Dictionary of Botany. London : Constable.
- van der Pijl, L. 1969. Principles of dispersal in Higher plants. Berlin : Springer-Verlag.
- von Denffe, D., Shumacher, w., Magdefrau, K. and Ehrendorfer, F. 1976. Strasburgers Textbook of Botany. London : Longman.
- Vuilleumier, B.S. 1967. Evolution of heterostyly in angiosperms. Evolution, 21, 210-226.
- Ward, C.J. 1980. The Plant Ecology of the Isipingo Beach Area, Natal, South Africa. Department of Botanical Research Institute of Agriculture and Fisheries.
- Watt, J.M. and Breyer-Brandwijk, M.G. 1962. The Medicinal and Poisonous Plants of Southern and Eastern Africa. 2nd ed. Edinburgh : Livingston.
- Whalley, P. 1979. The Orders of Insects. London : Hamlyn.
- Wootton, A. 1984. Insects of the World. Hong Kong : Lee-Fung Asco.
- Wright, W.G. 1963. Wild Flowers of South Africa - Natal. Cape Town : Cape and Transvaal Printers.
- Yeo, P.F. 1975. Some aspects of heterostyly. New Phytologist, 75, 147-153.
- Zuccarini, J.G. 1824. Monographie der amerikansichen Oxalis-Arten. Munich : Denkschriften Akad.

9. APPENDIXA. List of Collectors of Natal SpecimensO. corniculata

Abbott
 Abraham
 Bews
 Chetty
 Forbes
 Galpin
 Garrett
 Harding
 Hitchins
 Khan
 Lawson
 Maharaj
 McDevette
 Meidner
 Mogg
 Moll
 Moodaley
 Moodley
 Moodley &
 Reddy
 Naidoo
 Nicholas
 Nicholas &
 Moss
 Nicholson
 Padia
 Pooley
 Ramkissoo
 Reddy
 Ross

Schire
 Singh
 Stirton
 Strey
 Theron
 Truscott
 Venter
 Ward
 Wells
 West
 Wood
 Wylie

O. smithiana

Bourquin
 Buthelezi
 Codd
 Edwards
 Evans
 Galpin
 Goodman
 Haygarth
 Hilliard &
 Burt
 Hitchins
 Huntley
 Levett
 Marsh
 McDonald
 Medley-Wood
 Mogg
 Moodley
 Moodley &
 Reddy
 Retief
 Ruddock
 Shirley
 Stirton
 Strey
 Symons
 Trauseld
 van der
 Merwe
 Ward

Wright
 Wylie

A. (continued....)

O. obliquifolia

Beattie
 Bourquin
 Brown &
 Shapiro
 Bruyns-
 Haylett
 Galpin
 Gerstner
 Gordon-
 Gray
 Grice
 Hilliard &
 Burtt
 Howlett
 Hutchinson
 Forbes &
 McLean
 Jacobsz
 Killick
 Lawn
 McDonald
 McKeowan
 Mogg
 Moodley
 Moodley &
 Reddy
 Ngwenya
 Phillips
 Pienaar

O. corymbosa

James
 Jankee
 Moodley &
 Reddy
 Strey
 Venter

A. (continued...)

O. semiloba

Abbott
 Bampton &
 Hackland
 Bredin
 Breyshaw
 Cawood
 Codd
 Dutton
 Forbes
 Galpin
 Gerstner
 Goodman
 Harding
 Harrison
 Haygarth
 Hillary
 Holmes &
 Balkwill
 Lawn
 Lawson
 Manning
 McKeowan
 Mogg
 Moodley &
 Reddy

Most
 Naicker
 Niewoudt
 Oatley
 Padia
 Phelan
 Pooley
 Reddy
 Rennie
 Stirton
 Strey
 Thieler
 Trauseld
 van O'Bruyn
 Venter
 Ward
 Watt &
 Brandwijk
 Wood
 Wright
 Wylie

O. pes-caprae

Harris
 Moodley &
 Reddy

A. (Continued....)

O. latifolia

Baijnath

Canham

Cawood

Moodley

Moodley &

Reddy

Nicholson

Reddy

Rogers

Sim

Strey

Tennant

B. Specimens of Oxalis spp. examined from other parts of Southern Africa

O. smithiana

- 2531 (Komartipoort) : Saddleback Range, Barberton
(-CC), Galpin 675 (BOL).
- 3026 (Aliwal North) : Eland's Hoek, near Aliwal North
(-DA), Bolus 211 (BOL).
- 3028 (Matatiele) : Thaba Tsueu (-AB), Page s.n.
(BOL).
- 3218 (Clanwilliam) : Boontjies River (-DB), Leipoldt
19126, 19127 (BOL).
- 3219 (Wuppertal) : Bangor Farm, Middelberg (-AA),
Bolus (III) 15177 (BOL).
- : Middleberg (-AA), Guthrie 4061
(BOL).
- 3224 (Graaf-Reinet) : Farm Portlock near Graaf-Reinet
(-BC), Allez 15066 (BOL).
- : Graaf-Reinet (-BC), Bolus 463
(BOL).
- 3225 (Somerset East) : Mountain sides, Boschberg near
Somerset East (-DA), Bolus 436
(BOL).
- 3226 (Fort Beaufort) : Hogsback, near Alice (-DB),
Barker 20006, 20007 (BOL).

B. (Continued...)

- 3227 (Stutterheim) : Grassy valleys, near Komgha
(-DB), Flanagan 803 (BOL).
- 3322 (Oudtshoorn) : Near North station, top of Mon-
tague Pass, George (-CD), Guthrie
21932 (BOL).
- 3323 (Willowmore) : Witte Els Bosch Peak, summit
(-CD), Esterhuysen 679a (BOL).
- : Flats, Witte Els Bosch (-CD),
Fourcade 1137 (BOL).
- 3325 (Port Elizabeth) : Near Witteklip, Uitenhage (-CC),
Holland 3685 (BOL).
- : Uitenhage (-CD), Ecklon and
Zeyher 739 (SAM), Pillans 6648
(BOL).
- : Redhouse, near Port Elizabeth
(-DC), Paterson 469 (BOL).
- 3326 (Grahamstown) : Alexandria, sandflats (-CB),
Johnson 888 (BOL).
- : Nanqua's Kop, between Grahamstown
and Port Elizabeth (-DA), Bolus
s.n. (BOL).
- 3327 (Peddie) : Grassveld, East London (-BB),
Page 16434 (BOL).
- 3419 (Caledon) : Hangklip Mountain (-BD), Galpin
1630 (BOL).
- : Bushman's River Mouth (-DA), van
Niekerk 3119 (BOL).

B. (continued...)

- 3424 (Humansdorp) : Eerste River (-AA), Fourcade 1182 (BOL).
 : Flats east of Kabeljous River Mouth (-BB), Fourcade 6391 (BOL).

O. semiloba

- 2329 (Pietersburg) : Modjadjis (-Cd), Rogers 18090 (BOL).
 2426 (Mochudi) : Mochudi (-AC), Harbor s.n. (BOL).
 2824 (Kimberley) : Kimberley (-DB), Wilman 15024 (BOL).
 2832 (Butterworth) : Butterworth in mealie land (-AC), Pegler 2022 (BOL).
 : Kentani, valleys (-AD), Pegler 220 (BOL).
 3226 (Fort Beaufort) : Auckland Forest, Amatole Range (-DB), Lewis-Grant 2785 (BOL).
 3227 (Stutterheim) : Grassy valleys near Komgha (-DB), Flanagan 1281 (BOL).
 3326 (Grahamstown) : Cape, Aexandria, Nanaga (-CB), Johnson 949 (BOL).

B. (continued...)

O. obliquifolia

- 2127 (Francistown) : Penhalonga (-BC), Teague 347
(BOL).
- 2430 (Pilgrims Rest) : Macmac Creek (-DD), Mudd s.n.
(BOL).
- : Machadodorp, Lydenberg (-DD),
Rogers 18181 (BOL).
- 2527 (Rustenberg) : Rustenberg (-CA), Nation 95
(BOL).
- 2530 (Lydenburg) : Hills near Belfast (-CA), Bolus
11741 (BOL).
- 2628 (Johannesburg) : Swamp near Kempton Park (-AA),
Hutchinson 2617 (BOL).
- 2631 (Mbabane) : Mbabane, Open veld near miller's
house (-AC), Burtt-Davy 1856
(BOL).
- : Ukutula, Mbabane (-AC), Compton
25292 (BOL).
- 3023 (Britstown) : Bothaville (-AB), Broom s.n.
(BOL).

B. (continued...)

O. corniculata

- 2429 (Zebediela) : Flat's End, Ratels Bosch (-AD),
Fourcade 560 (BOL).
- 2527 (Rustenburg) : Rustenburg (-CA), Nation 27
(BOL).
- 2922 (Prieska) : Prieska (-DA), Bryant s.n. (BOL).
- 3026 (Aliwal North) : Elands Hoek near Aliwal North
(-DA), (BOL).
- 3225 (Somerset East) : Somerset East (-DA), Bolus 307
(BOL).
- 3227 (Stutterheim) : Grassy valley near Komgha (-DB),
Flanagan 1279 (BOL).

O. pes-caprae var. sericea

- 3116 (Van Rhynsdorp) : Between Van Rhynsdorp and Van
Rhyns Pass (-DA), Salter 716
(BOL).
- : Summit of Gifberge (-DC), Salter
7289 (BOL).
- 3218 (Clanwilliam) : North side, Pakhuis Pass (-BB),
Leipoldt 19229 (BOL).
- : Summit of Pakhuis Pass (-BB),
Salter 8136 (BOL).

B. (continued...)

- 3318 (Cape Town) : Mowbray (-CD), Bolus 3954 (BOL).
 : Kalabas Kraal Station, Malmesbury
 (-DC), Bolus 12635 (BOL).
 : Stellenbosch (-DD), Doesburgh
24257 (BOL).
 3326 (Grahamstown) : Middle northern slopes of Signal
 Hill (-BC), Pillans 2482 (BOL).

O. pes-caprae var. Form B

- 2623 (Morokweng) : Mostert's Farm, Mowbray (-BB),
Dodd 1760 (BOL).
 2628 (Johannesburg) : Elsburg (-AA), Davis 2436 (BOL).
 3218 (Clanwilliam) : Piquetberg Mountains, east slope
 of Avontuur Mountain (-AD), Pil-
lans 7388 (BOL).
 3219 (Wuppertal) : Between Citrusdal and Clanwilliam
 (-CA), Bolus 20192 (BOL).
 : 30 km north of Citrusdal (-CA),
Salter 7242 (BOL).
 3318 (Cape Town) : Dassen Island, Saldanha (-AC),
Brooke I (BOL).
 3319 (Worcester) : Worcester (-CB), Esterhuysen
23135 (BOL).

B. (Continued...)

- 3319 (Worcester) : Osplaats, Worcester (-CB), Pillans s.n. (BOL).
- 3322 (Oudtshoorn) : Karoo, on the road to Oudtshoorn
18 km from Doom River (-CA),
Fourcade 4726 (BOL).
- 3418 (Simonstown) : Bank at Roadside, Fish Hoek
(-AB), Pillans 2556 (BOL).