Drawings of Scandinavian Plants 29–32

Rubus L. Subgen. Rubus

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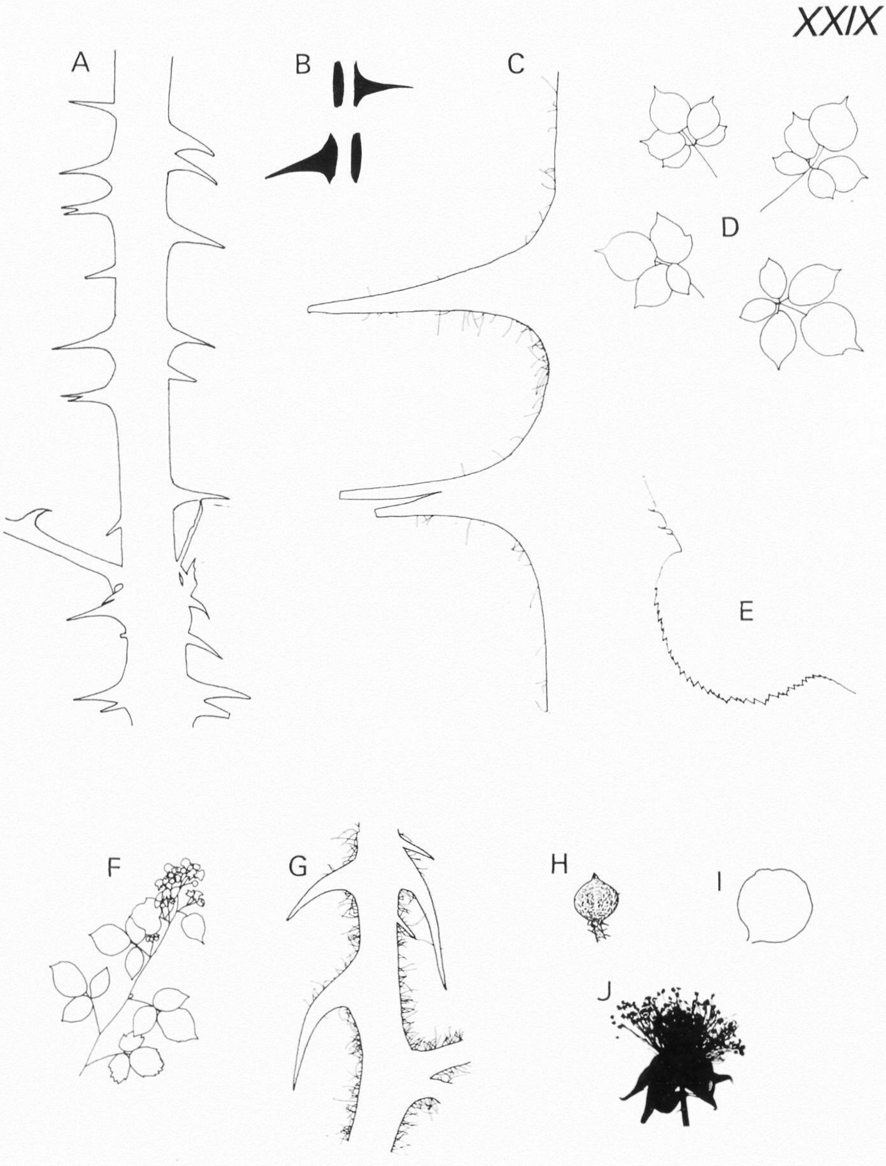
Rubus scheutzii LINDEBERG 1885

Stem arching, hairy; *prickles* 6—9 mm long, slightly recurved, base 5—8 mm long; *leaves* (3—) 5-foliolate, glabrous above, softly hairy beneath; *terminal leaflet* orbiculate with a rather long, narrow tip; *inflorescence* dense, rather long with a few interspersed leaves, glands absent; *flowers* 2—3 cm across; *sepals* grey-tomentose, normally without prickles; *petals* white, broadly obovate—circular; *filaments* 5—7 mm long.

Normally, the stem is ridged and strong; the prickles are rather numerous, stronger ones flat, brownish red like the stem, hairy, with a short yellow tip; the leaves are relatively small, quite green beneath; the basal leaflets have 2.5 cm long petiolules; the serration of the leaflets is fine but sharp; the prickles of the inflorescence are rather numerous, recurved—hooked; the sepals are deflexed. *R. scheutzii* grows on dry ground both in the open and in forests. The species occurs in the environs of Oskarshamn, a town on the east coast of southern Sweden.

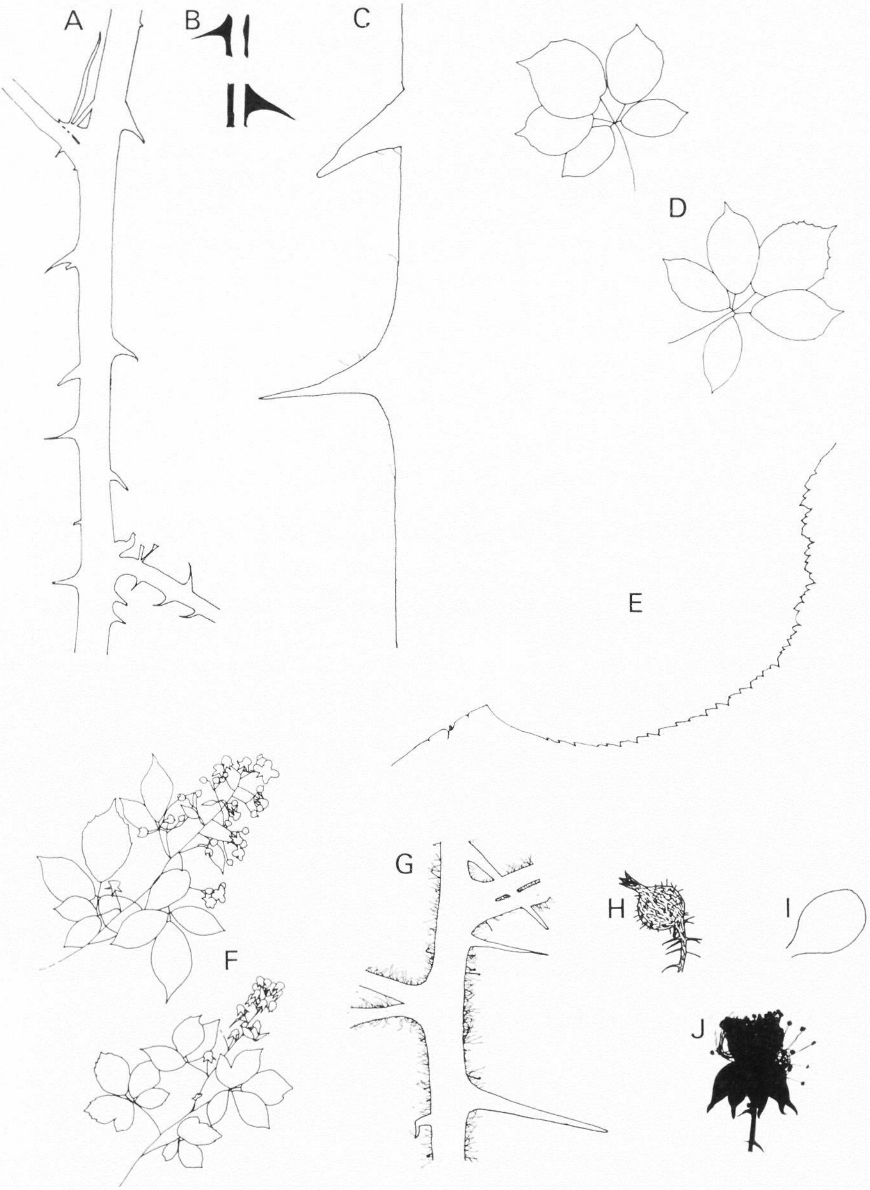
GENERAL LEGEND FOR THE PLATES

First-year growth (*primocane*): A. Stem with prickles. 1 : 1. — B. Prickles, drawn from the side and from above. 1 : 1. — C. Stem with prickles, glands, and hairs. 4 : 1. — D. Leaves (without serration and petiole diameter shown). 1 : 8. — E. Margin of a terminal leaflet with a petiolule. 1 : 2. — *Second-year growth* (*floricane*): F. Inflorescences (without prickles, serration of the leaves, and axis diameters shown). 1 : 8. — G. Rachis with prickles, glands, and hairs. 4 : 1. — H. Floral bud with prickles. 1 : 1. — I. Petal (without hairs). 1 : 1. — J. Flower (without petals, glands, and hairs). 1 : 1.



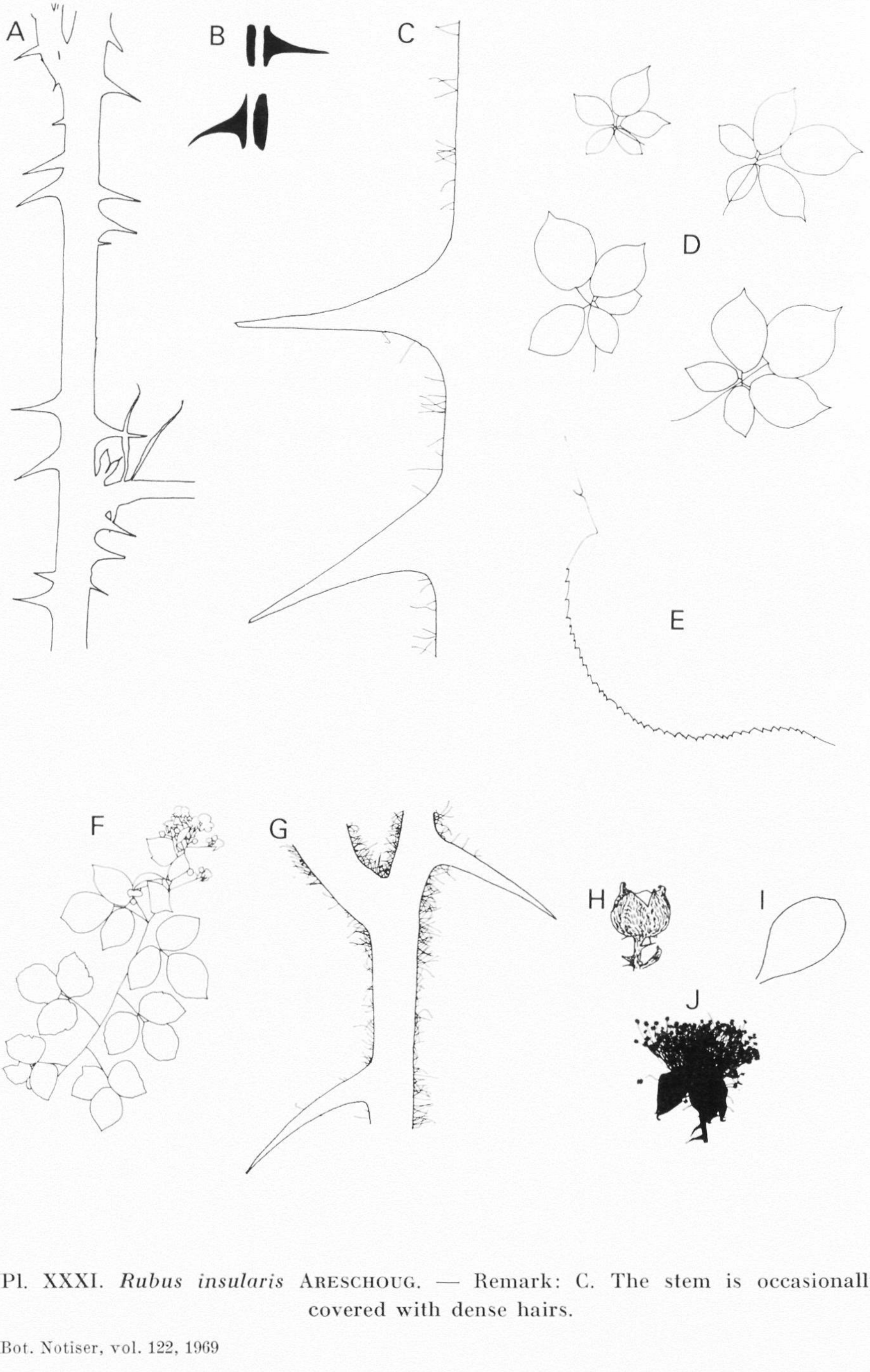
Pl. XXIX. *Rubus scheutzii* LINDEBERG. — Remark: E refers to a 5-foliolate leaf.

XXX



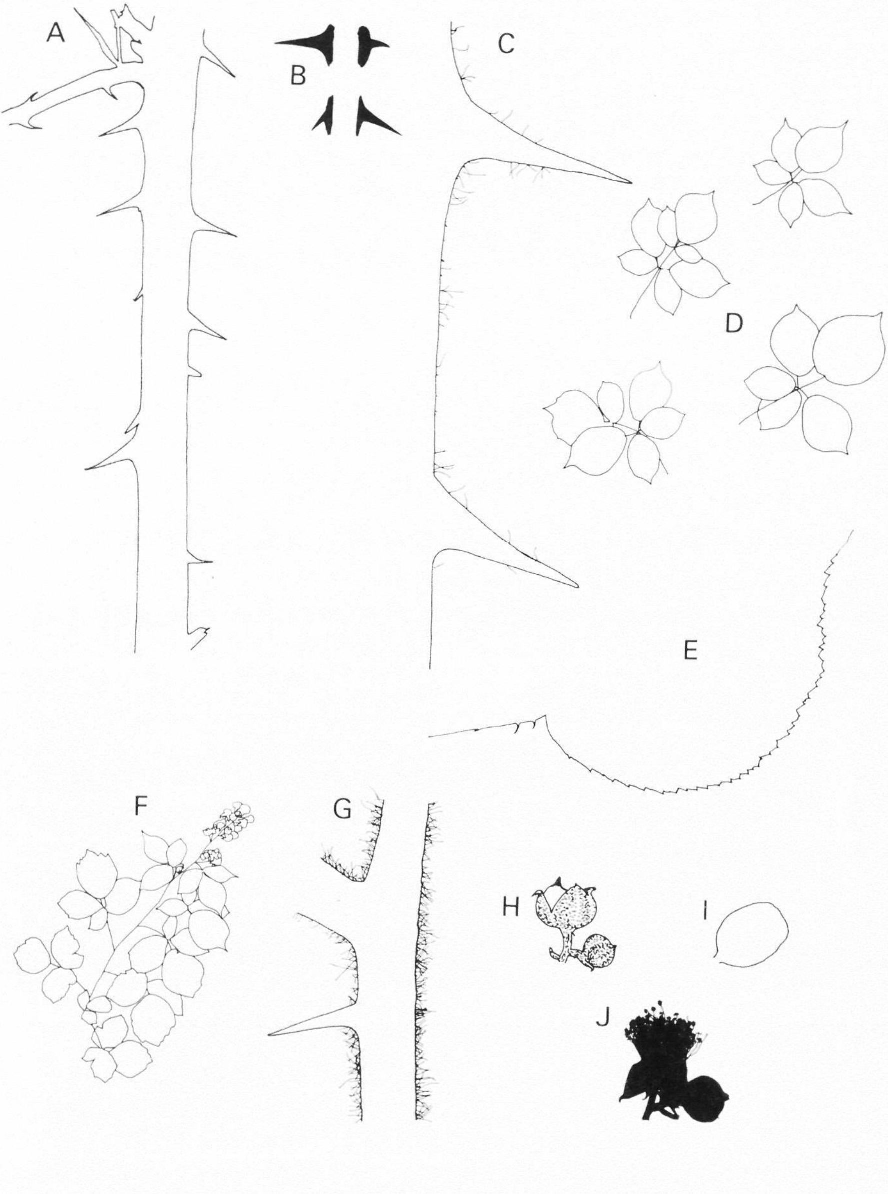
Pl. XXX. *Rubus pyramidalis* KALTENB.

XXXI



Pl. XXXI. *Rubus insularis* Areschoug. — Remark: C. The stem is occasionally covered with dense hairs.

XXXII



Pl. XXXII. *Rubus polyanthemus* LINDEBERG. — Remarks: E refers to a 5-foliolate leaf. — F. Larger inflorescences often occur.

Rubus pyramidalis KALTENB. 1845

Stem arching, hairy, glands few or none; *prickles* 5—8 mm long, somewhat recurved, straight or sometimes slightly bent, base 3—6 mm long, narrow; *leaves* 5-foliolate, glabrescent above, provided with shining, rather rigid hairs beneath, seldom also greyish tomentose; *terminal leaflet* orbicular, ovate or elliptic, acuminate; *inflorescence* pyramidal, large, lax, or, when smaller, dense and long, usually without leaves, glands present; *flowers* about 2.5 cm across; *sepals* grey-tomentose with glands and prickles; *petals* pale pink, broadly obovate; *filaments* about 5 mm long.

Normally, the stem is low-arching or procumbent, with five flat sides; the prickles are rather numerous, and relatively weak; the leaves are large; the basal leaflets have 3—5 mm long petiolules; the serration of the leaflets is coarse and uneven; the prickles of the inflorescence are scattered, long, subulate, and rather weak; the sepals are acuminate and deflexed. *R. pyramidalis* has been found NE of Höganäs in NW Skåne (Scania), on northern Sjælland, on Fyen, at Skive in the central part of Jylland, and in Sønderjylland.

Rubus insularis ARESCHOUG 1881

Stem arching, hairy, often rather densely; *prickles* 6—9 mm long, patent, sometimes falcate, base 4—9 mm long, narrow; *leaves* 5-foliolate, rather hairy above, provided with rather rigid hairs beneath, somewhat shining, green, seldom grey-felted; *terminal leaflet* broadly ovate—elliptic with a rather short and broad tip; *inflorescence* lax, broad, relatively short, leafy, glands absent; *flowers* about 3 cm across; *sepals* grey-tomentose; *petals* deep pink, obovate with an elongate base; *filaments* 5—6 mm long.

Normally, the stem is high-arching, rather strong, deep red, with five flat sides; the prickles are scattered, flat, hairy, pale or with the colour of the stem; the leaves are dark green; the terminal leaflet, except the tip, is three times longer than the petiolule; the serration of the leaflets is uneven and fine; the prickles at the apex of the inflorescence are numerous, long and subulate; the sepals are deflexed and acuminate, and have scattered prickles but no glands. *R. insularis* grows in boggy forests and pasturelands. In Sweden the species occurs in different parts of Skåne and at Öströ east of Varberg on the west coast; in Denmark the species is rather common except in northern Jylland.

R. insularis belongs to a group of blackberries that are related to *R. villicaulis* KOEHLER. In the parish of Bro in the middle of Bohuslän on the Swedish west coast, plants have been collected that WATSON (1958) namned *R. broensis* and *R. septentrionalis* respectively. If the later species correspond to *R. confinis* LINDEBERG (non P. J. MUELLER), as WATSON presumes, it also is found on the southernmost coast of Norway (Grimstad, Lyngdal). NEUMAN (1901), as well as LINDMAN (1926), treats *R. septentrionalis* as a subspecies of *R. villicaulis*, and *R. broensis* as a variety of the former. I have not had the opportunity to study these two blackberries thoroughly, neither in the herbarium nor in the field, to have an opinion of my own.

Rubus polyanthemus LINDEBERG 1883

(*Rubus pulcherrimus* NEUMAN 1883)

Stem arching, hairy; *prickles* 4—8 mm long, straight, somewhat recurved, base 4—8 mm long, relatively broad; *leaves* 5—7-foliolate, glabrescent above, grey-tomentose beneath, sometimes greenish; *terminal leaflet* from a 5-foliolate leaf broadly obovate, from a 7-foliolate leaf cuneate, both with a short tip; *inflorescence* long, dense, glands present; *flowers* 2—2.5 cm across; *sepals* tomentose, light grey; *petals* pink—white, broadly obovate or orbiculate; *filaments* about 5 mm long.

Normally, the stem is rather low-arched, terete—angled, rather strong, green, sparsely hairy with no glands; the prickles are scattered, relatively strong with subulate tips; the leaves are dark green; the terminal leaflet from a 5-foliolate leaf, except the tip, is three times longer than the petiolule; the serration of the leaflets is fine and relatively sharp; the inflorescence is leafless with few, small, straight prickles at the apex; the sepals are deflexed and acuminate, and have neither glands nor prickles. *Rubus polyanthemus* grows on dry pasturelands and along the edges of woods. In Sweden the species occurs at Mölle and on the island of Hallands Väderö in north-western Skåne; in Denmark the species is found rarely on Sjælland, in Jylland at Grenå in the east, at Sundeved in the south, and on Als.

In the next paper, I shall deal with *R. lindebergii* P. J. MUELLER, *R. armeniacus* FOCKE, *R. thyrsanthus* FOCKE, and *R. vestervicensis* C. E. GUSTAFSSON.

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Chromosome Morphology in Aegean Populations of Leopoldia Parl. (Liliaceae)

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ABSTRACT

An investigation of the karyotypes and chromosome numbers in different populations of the genus *Leopoldia* PARL. [*Muscari* MILL. sect. *Leopoldia* (PARL.) BAK.] from several Aegean islands has been carried out. Three different levels of ploidy are found, viz. 2n=18, 36, and 54. Structural alterations are common on the diploid and tetraploid levels (structural hybridity). The origin of structural hybridity in some tetraploids is assumed to be due to hybridization. The variation of satellites in size, number and distribution is often considerable. The diploid *Leopoldia* from the area can, besides one population, M 50, be divided into two groups on the basis of their karyotypes. The tetraploid and hexaploid have the same general karyotype.

INTRODUCTION

The taxonomy of *Leopoldia* PARL. [*Muscari* MILL. sect. *Leopoldia* (PARL.) BAK.] is very confusing in the Aegean region of Greece (cf. RECHINGER 1943 p. 728). A taxonomic understanding of the genus in the area can apparently only be achieved by experimental investigations. STUART (1966) published a key to the species of *Muscari* including *Leopoldia* PARL. Since his delimination of taxa seems oversimplified, I have chosen to place the present material in the following preliminary taxonomic groups:

1. Diploid field populations: *Leopoldia comosa* (L.) PARL. s.str.

2. Diploid phrygana populations and tetraploid populations: *Leopoldia holzmanni* HELDR., *L. pharmacusana* HELDR., *L. sartoriana* HELDR., *L. weissi* FREYN. and *L. trojana* HELDR.

3. The diploid population M 50 is morphologically and cytologically very similar to *Leopoldia longipes* (BOISS.) A. LOS.

4. The hexaploid population M 31: *Muscari cycladicum* DAVIS & STUART.

5. The hexaploid population M 60 is different from M 31 in some morphological characters and may be *Leopoldia theraea* HELDR.

In this report some results of studies of metaphase chromosomes are presented.

In *Leopoldia,* diploids (2n=18), tetraploids (2n=36) and hexaploids (2n=54) have been reported (GARBARI 1968, STUART 1966, DAVIS & STUART 1967). All of these levels of ploidy have been found in the Aegean.

GARBARI (1968) pointed out that the chromosomes in *Leopoldia* can be grouped into three distinct classes on the basis of length: long (L), medium (M) and short (S). Diploids have 4 L+6 M+8 S. The general karyotype can be written (A B ccc dddd)n (LEWITSKY & TRON 1930). The present investigation confirms these statements.

Structural hybridity has been observed several times. DELAUNAY (1915) and GARBARI (1969) found satellites on only one of the long subtelocentric chromosomes of *Leopoldia tenuiflora* (TAUCH.) HELDR. SATO (1942 p. 94) found a dissimilarity between the two homologous, long, submetacentric chromosomes of *L. comosa* (L.) PARL., which was suggested to be due to an inversion. GARBARI (1969) directed attention to structural hybridity in some karyotypes of *L. holzmanni* HELDR. and *L. comosa* (L.) PARL. In these taxa the two long, submetacentric chromosomes have different arm indexes. In the present investigation, many cases of structural hybridity have been observed.

MATERIAL AND METHODS

Bulbs from ca. 90 *Leopoldia* populations from 46 Aegean islands were collected in 1967. A list of localities and code numbers for the 27 collections presented in this paper is given in the appendix. Cytological investigations have been made on material kept in cultivation in the greenhouse of the Botanical Garden, Lund, Sweden.

The squash technique described by ÖSTERGREN and HENEEN (1962) has, with some modifications, been used in this investigation. Instead of using pure 8-hydroxyquinoline solution at 10°C as the pretreatment, a mixture of 2 mM 8-hydroxyquinoline solution and 0.2 % colchicine solution (1: 1) was used. With this pretreatment a good contraction and spreading of the chromosomes was obtained. As fixative Carnoy (absolute ethylalcohol and acetic acid, 3: 1) was used. After staining with the Feulgen reagent, the roots were treated with a 10 % water solution of pectinase for about two hours.

As an estimation of pollen fertility, the percentage of pollen stainable in cotton blue has been calculated. Counts of pollen (200—300 pollen grains each time) were carried out on three successive days. The mean values of these three counts are presented below.

Chromosome measurements have been made from camera lucida drawings with a constant magnification (×4770). Since the chromosome complement

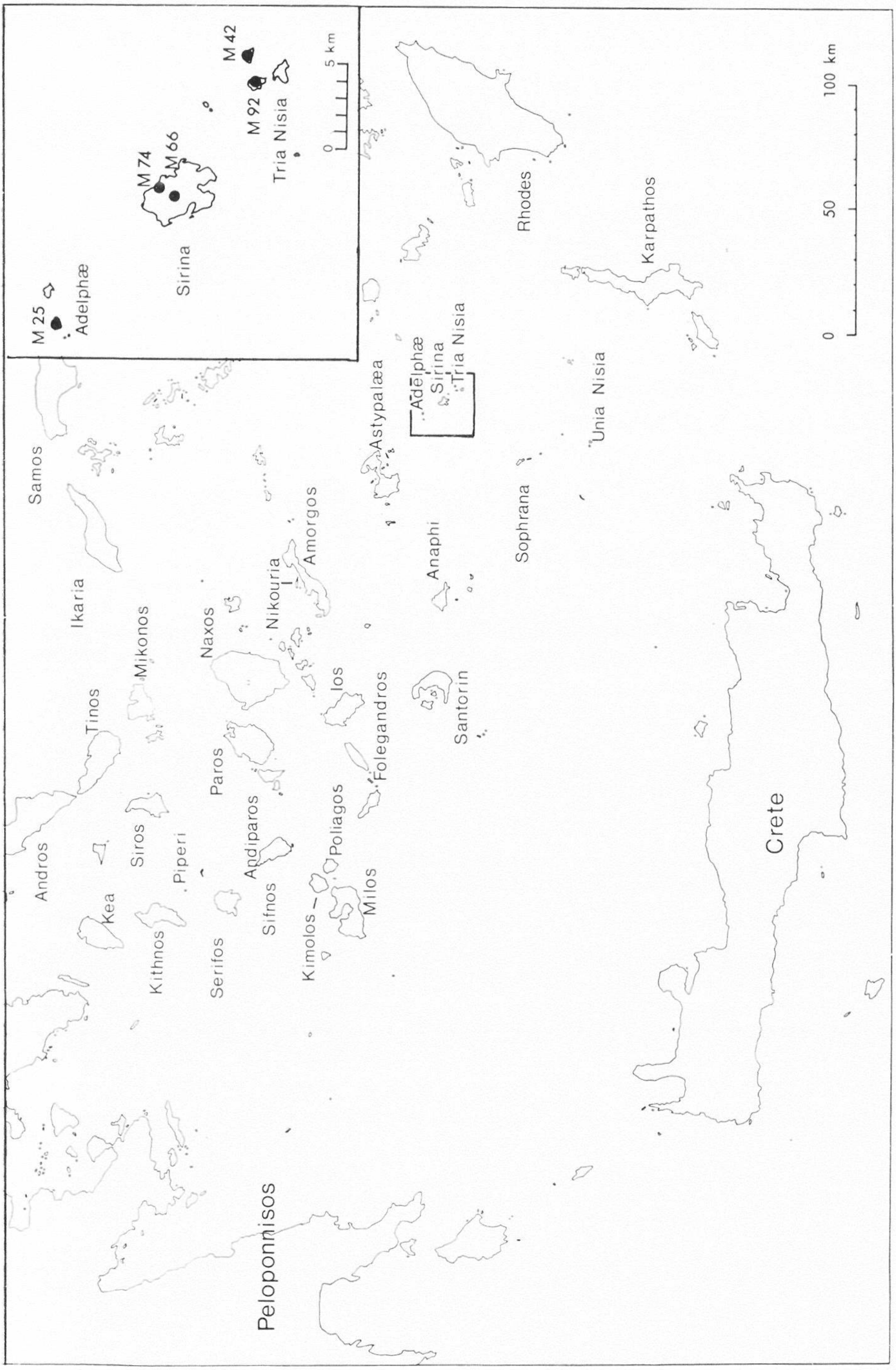


Fig. 1. Central and southern part of the Aegean.

of *Leopoldia* always has one group of chromosomes that are markedly longer than the others, it has been practible to use these long chromosomes for a detailed investigation. The rest of the complement has been neglected because of the difficulties in recognizing the small individual chromosomes.

The relative length of one chromosome is defined here as the total length of the chromosome calculated as a percentage of the total length of the haploid set of long chromosomes at the various levels of ploidy.

Generally, the chromosomes of diploid populations are longer than the chromosomes of tetraploid populations, whereas the lengths of the chromosomes in the hexaploids are more or less equal to the tetraploids.

IDIOGRAM CONSTRUCTION AND SOURCES OF ERROR

Within every individual, a mean value for arm index and a mean value for relative length for each chromosome pair has been calculated.

In tetraploid populations, it has often been possible to distinguish only two groups (4+4) of long chromosomes. Here, a mean value for arm index and a mean value for relative length has been calculated for each group.

Because of the variation among individuals within a population, the idiograms have been constructed in two different ways.

1. The idiogram was constructed on the basis of the average mean value for arm index and relative length for all individuals in the population if the variation with regard to these values among individuals in a population lies within the variation range manifested by the metaphase plates in a single individual.

2. An idiogram was constructed for each deviating individual if there was a significant difference among individuals in the same population with respect to arm index and relative length.

The chromosomes are placed and paired in the tables on the basis of increasing arm index values.

In all chromosome measurements, several sources of error exist. To show how great the sum of these errors is in this investigation, the measurements from one population (diploid) are presented (Table 1). The table is chosen to be representative for the normal magnitude of deviations in the present measurements.

The figures in Table 1 show that the variation of arm index is rather limited for the submetacentric chromosomes 1 and 2. The arm index for the subtelocentric chromosomes 3 and 4 has a wide variation. A very restricted variation in the length of the single, short arm will increase or decrease greatly the quotient (arm index) between the two arms. This is not the case if the chromosomes are more or less meta-

Table 1. Measurements of the 4 long (2 pairs) chromosomes in population M 92. The figures to the left in the table are code figures. For example M 92-7-1 means population M 92, individual 7 and root-tip number 1. The chromosomes are arranged in the table with respect to increasing arm-index values. Material: *Leopoldia comosa* (L.) PARL. s. str.

Chromosome	1	1	2	2	3	3	4	4
	arm index	rel. length	arm index	rel. length	arm index	rel. length	arm index	rel. length
M 92-7-1	1.35	40.34	1.58	37.76	13.60	62.66	16.25	59.22
	1.50	41.35	1.50	41.35	12.16	59.39	14.48	57.89
	1.22	37.83	1.45	41.69	14.40	59.45	14.80	61.00
	1.34	38.98	1.37	41.15	12.33	57.76	16.20	62.09
M 92-7-2	1.36	40.94	1.52	41.73	14.40	60.62	23.00	56.69
	1.31	38.93	1.54	42.74	17.25	55.72	19.50	62.59
	1.25	37.50	1.30	38.33	12.00	65.00	13.20	59.16
Mean value (M) ...	*1.33*	*39.41*	*1.47*	*40.68*	*13.73*	*60.09*	*16.78*	*59.81*
M 92-8-2	1.29	40.00	1.46	37.94	13.75	60.51	14.00	61.53
	1.36	37.60	1.55	38.49	13.60	61.08	17.75	62.76
(M)	*1.33*	*38.80*	*1.51*	*38.22*	*13.68*	*60.80*	*15.88*	*62.15*
M 92-9-1	1.22	40.35	1.32	38.01	12.00	60.81	12.00	60.81
	1.34	38.98	1.47	41.15	10.42	57.76	11.28	62.09
	1.20	38.59	1.45	37.89	10.00	61.75	13.66	61.75
	1.25	39.41	1.50	40.14	9.12	59.12	9.50	61.31
M 92-9-2	1.33	38.88	1.40	38.09	14.80	62.69	18.00	60.31
	1.45	40.16	1.64	36.88	17.00	59.01	18.50	63.93
	1.40	37.64	1.52	41.56	11.50	58.82	18.75	61.96
(M)	*1.31*	*39.14*	*1.47*	*39.10*	*12.12*	*59.99*	*14.53*	*61.74*
M 92-11-2	1.27	40.16	1.27	40.16	10.28	63.45	11.66	56.22
	1.54	38.88	1.63	40.27	11.71	61.80	13.16	59.02
(M)	*1.41*	*39.52*	*1.45*	*40.22*	*11.00*	*62.63*	*12.41*	*57.62*
Average mean value	*1.35*	*39.22*	*1.48*	*39.56*	*12.63*	*60.88*	*14.90*	*60.33*
Mean value of the two homologous	—	*1.42*	*39.39*	—	—	*13.77*	*60.61*	—

centric like numbers 1 and 2. The variation in relative length in chromosomes 3 and 4 is more or less the same as for chromosomes 1 and 2.

It is evident from the table that it is impossible, with the technique used, to demonstrate minor differences among the chromosomes. The last decimal in the table is of course quite unreliable.

OBSERVATIONS

Diploid populations

On the diploid level, two different karyotypes exist. One has two subtelocentric and two submedian, long chromosomes. This type is more or less strictly restricted to cultivated areas and will in the following

Table 2. Diploid field population, e.g. *Leopoldia comosa* (L.) Parl. Arm indexes for the four long chromosomes arranged according to increasing values. Mean value with min. and max. values.

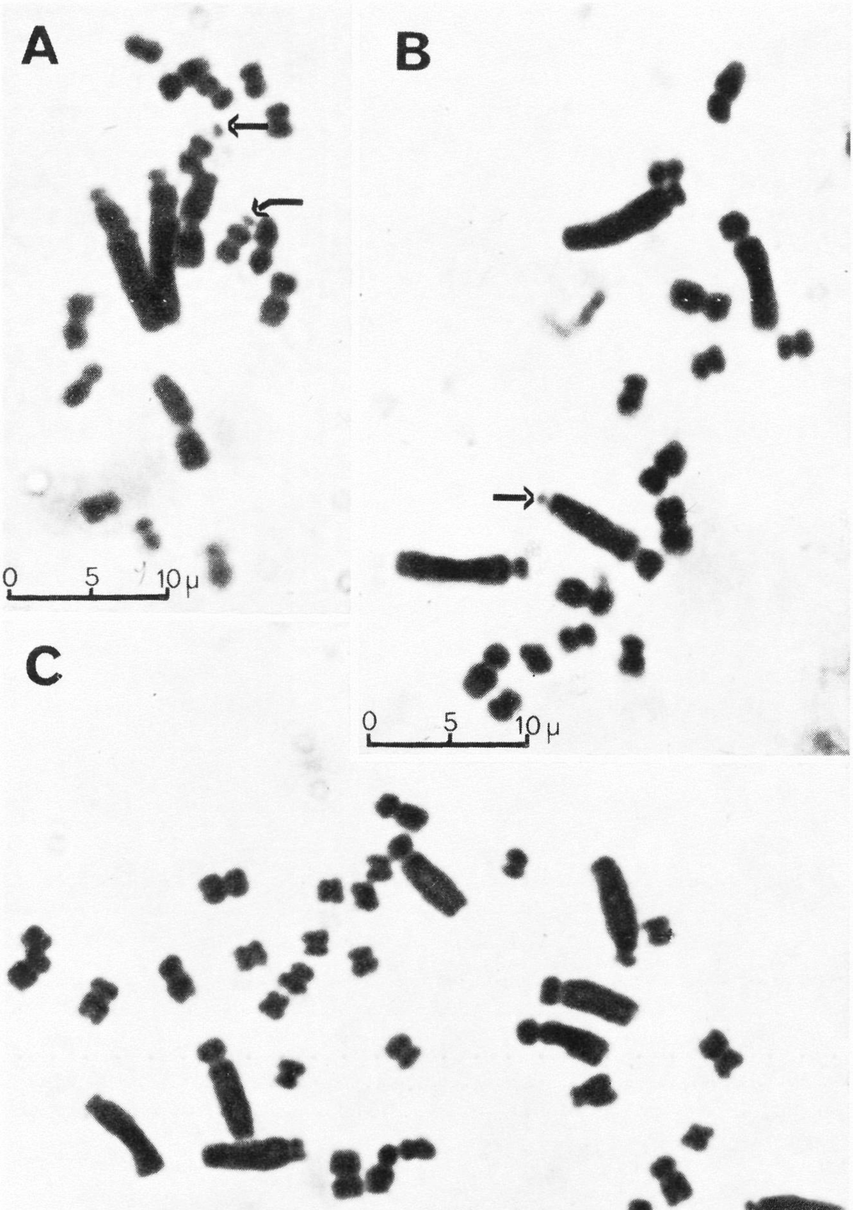
Population	No. of plants	No. of plates	Chromosome 1	Chromosome 2	Chromosome 3	Chromosome 4
M 16	3	11	1.22	1.32	11.32	12.57
			1.03—1.55	1.09—1.63	8.30—14.00	9.22—14.80
M 55	4	19	1.26	1.42	10.43	11.78
			1.04—1.45	1.09—2.33	7.86—14.33	9.33—15.20
M 79	1	4	1.33	1.50	7.25	10.18
			1.24—1.43	1.44—1.53	6.36— 8.25	7.00—13.57
M 81	3	11	1.33	1.41	10.63	11.94
			1.13—1.73	1.22—2.19	8.25—13.00	8.50—14.60
M 92	4	18	1.33	1.47	12.80	15.31
			1.20—1.54	1.27—1.64	9.12—22.16	9.50—23.00
Deviating individual M 16-4	—	5	1.62	2.81	9.28	11.22
			1.38—1.75	2.58—3.10	7.88—10.83	10.17—12.80

text be designated as the field type, i.e. *Leopoldia comosa* (L.) Parl. The other diploid type more or less restricted to phrygana vegetation, has four subtelocentric chromosomes of about equal length. This type will be designated as the phrygana type. It is possible to distinguish the two pairs of long chromosomes of the phrygana type from each other on the basis of their arm indexes.

FIELD TYPE, LEOPOLDIA COMOSA (L.) PARL.

In Fig. 3 A some populations representing the diploid field type are shown as idiograms. The general appearance of the studied chromosomes from different populations are almost the same. The subtelocentric chromosome pair has an arm index of 7—15 and a relative length of ca. 62. The submedian pair has an arm index of 1.2—1.5 and a relative length of ca. 38 (Table 2). No satellites have been observed on the four long chromosomes. In nearly every population representing this cytotype, one pair of the short (S) chromosomes has minute satellites (Fig. 2 A). In half of the populations studied the plants display a secondary constriction on the long arm of the subtelocentric chromosomes.

Fig. 2. Mitotic metaphase plates. — A: Diploid field type, *Leopoldia comosa* (L.) Parl. — B: Diploid phrygana type. — C: Normal tetraploid type. — Arrows indicate satellites.


A
0 5 10 μ
B
0 5 10 μ
C
0 5 10 μ

Normally, the constriction appears homozygotically, but in population M 55 (Fig. 3 A) some individuals were found in which the secondary constriction appeared in only one of the subtelocentric chromosomes. This constriction is the only structural alteration found in the subtelocentric chromosome pair of this cytotype. A more distinct structural dissimilarity was found in population M 16, where one individual was heterozygous in its submedian chromosome pair.

Morphologically the populations investigated are very similar, and belong to *Leopoldia comosa* (L.) PARL. s.str.

PHRYGANA TYPE

This second cytotype on the diploid level is characterized by two long, subtelocentric pairs of chromosomes (Figs. 2 B and 3 B). One pair has an arm index of 7.6—9.4 and a relative length of ca. 51, whereas the other pair has an arm index of 3.0—3.8 and a relative length of ca. 49 (Table 3). Satellites are always (except in M 50) attached to the long arm of the investigated chromosomes. No satellites were found on any of the short (S) chromosomes. In the material investigated, the satellites never exceeded two. The satellites could be attached to different chromosomes in different populations or also to different chromosomes in different individuals of the same population (M 8, Fig. 3 B). In the same individual, the size of putatively homologous satellites may be different. This may, however, be a result of the squash technique used. No structural hybridity, except the satellites, was found in the phrygana type.

A special karyotype is represented in population M 50 (Fig. 3 B). The four long chromosomes are all subtelocentric. One pair has an arm index of 3.65—3.94 and a relative length of 50.2, and the other pair has an arm index of 4.14—4.73 and a relative length of 49.8 (Table 3). The shorter pair of chromosomes has satellites on the short arm and an indistinct secondary constriction near the centromere on the long arm.

Population M 50 is morphologically, distinctly different from other populations of the phrygana type and resembles *Leopoldia longipes* (BOISS.) A. LOS.

Tetraploid populations

NORMAL KARYOTYPE

Most tetraploid *Leopoldia* populations in the Aegean area have constantly the same general karyotype (Figs. 2 C and 4). There are, how-

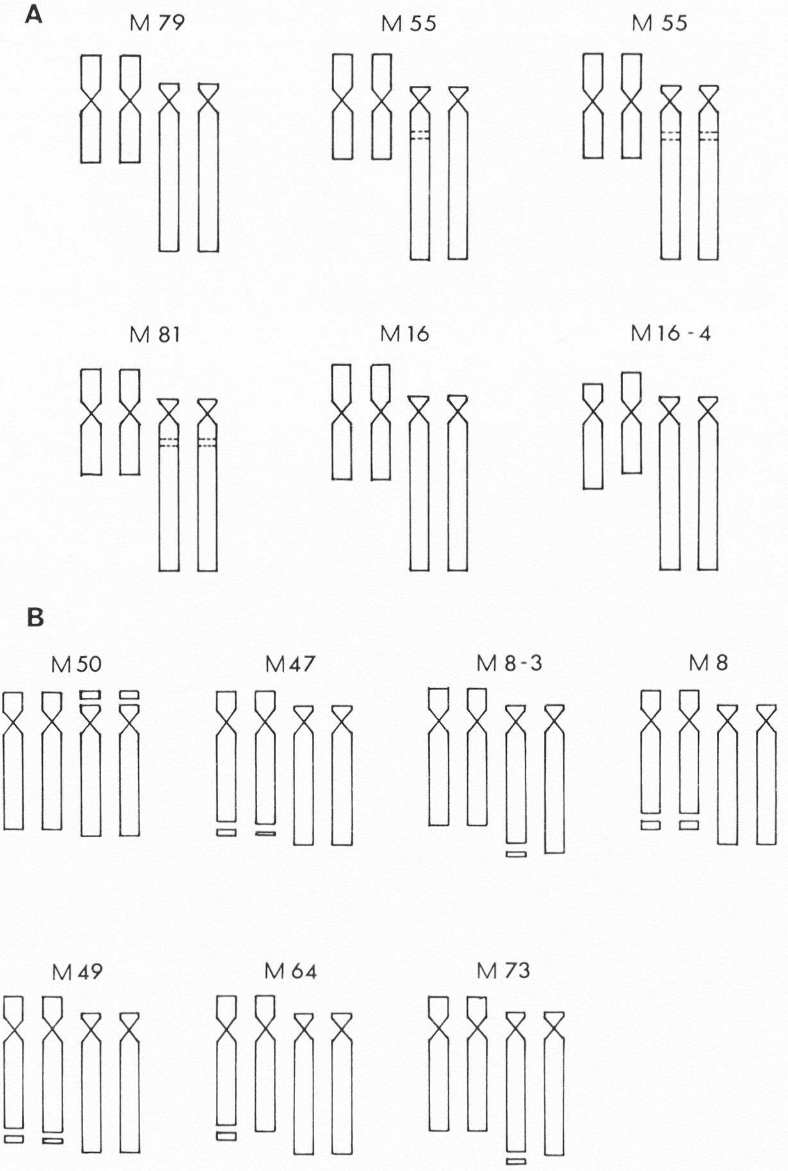


Fig. 3. Ideograms showing the four long chromosomes from different pouplations of diploid *Leopoldia*. — A: Diploid field type. — B: Diploid phrygana type.

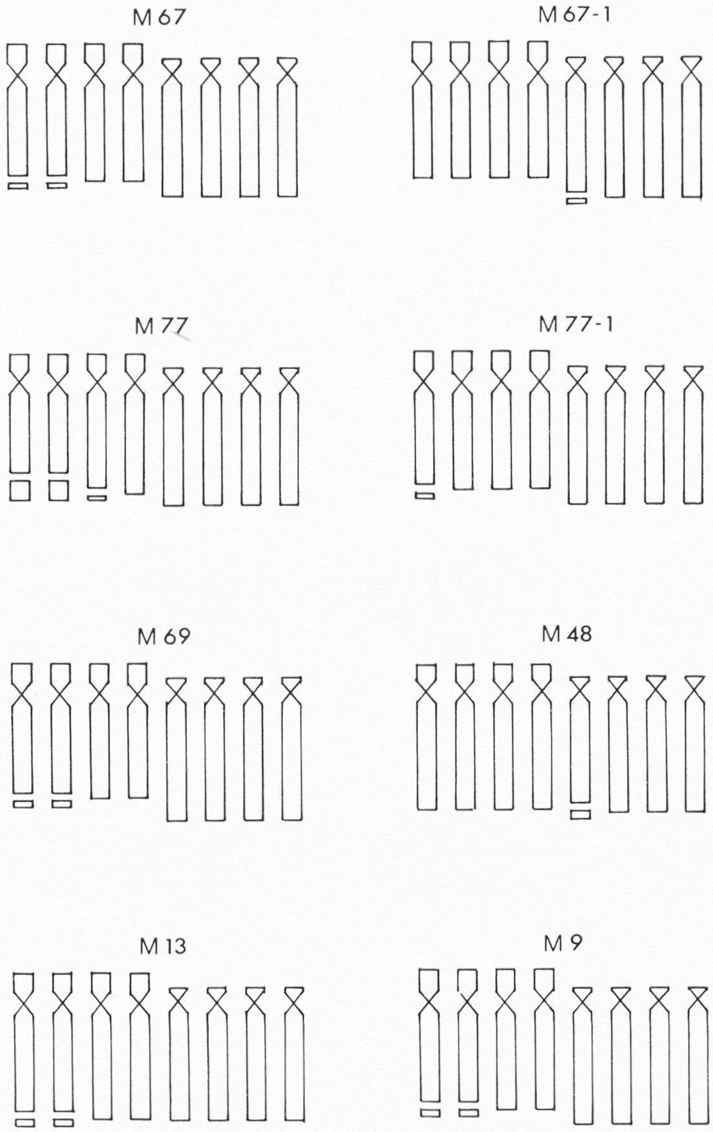


Fig. 4. Idiograms showing the eight long chromosomes from different populations of tetraploid *Leopoldia.*

Table 3. Diploid phrygana populations of *Leopoldia* PARL. Arm indexes for the four long chromosomes arranged with respect to increasing values. Mean value with min. and max. values.

Population	No. of plants	No. of plates	Chromosome			
			1	2	3	4
M 8	4	18	3.12 2.56—3.47	3.48 2.88—4.00	8.07 5.60—10.33	9.21 7.25—13.80
M 47	8	27	3.44 3.00—4.06	3.79 3.13—4.50	7.99 5.75— 9.83	9.03 6.14—10.86
M 49	6	23	3.24 2.70—4.07	3.62 3.06—4.19	7.61 4.80—10.83	9.37 6.50—12.80
M 64	3	19	3.05 2.47—3.53	3.38 2.88—3.81	8.00 5.75— 9.88	8.81 5.88—11.33
M 73	6	25	3.28 2.66—3.87	3.69 2.93—4.33	7.95 6.30— 9.50	8.99 6.45—10.85
Deviating population M 50 ..	1	7	3.65 3.32—4.00	3.94 3.48—4.38	4.14 3.75— 4.83	4.73 4.43— 5.27

ever, some exceptions, which will be discussed below. Normally, the karyotypes appear like a double set of the phrygana-type chromosomes.

The arm index for the group of chromosomes with the longest short arm is 2.7—5.2. The relative length for the same chromosomes is most often 25—27. (These values should be multiplied by 2 in order to obtain the corresponding diploid value.) The arm index for the other chromosome group is 5.5—11.2 and the relative length is 23—25 (Table 4).

In the same population, the satellites are often unequally distributed within the karyotype (M 67, Fig. 4). The number of satellites frequently varies within one population, but they never exceed four.

TWO DEVIATING POPULATIONS FROM SIRINA

In many individuals, representing several tetraploid populations, gross structural hybridity exists, as well as an increase or a decrease in the number of long chromosomes, which usually does not affect the total chromosome number. None of the individuals from the island of Sirina (Fig. 5) have the same chromosome complement as generally described for the tetraploid *Leopoldia* populations.

In Fig. 5 some of the chromosomes from the island of Sirina (M 66 and M 74) are marked *a, b, c* and *d*.

Chromosomes a. The arm index for these chromosomes varies between 1.6 and 2.0. The relative length is 23.6—24.4. As is obvious from

Table 4. Tetraploid populations of *Leopoldia* PARL. investigated except M 66 and M 74. Arm indexes for the eight long chromosomes arranged on the basis of increasing values. Mean value with min. and max. values.

Population	No. of plants	No. of plates	Chromosome 1	2	3	4	5	6	7	8
M 9	4	10	2.75 2.37—3.14	3.13 2.56—3.60	3.43 3.07—3.79	3.69 3.27—4.00	6.94 5.22—9.00	8.10 7.00—10.80	8.91 7.25—11.00	10.51 7.50—13.60
M 10	2	9	3.09 2.61—3.53	3.41 3.06—3.63	3.66 3.38—4.08	3.85 3.41—4.33	7.47 6.00—8.86	8.04 6.38— 9.43	8.70 7.00—10.33	10.26 8.00—12.00
M 13	4	10	3.32 2.73—3.69	3.50 3.21—3.81	3.72 3.31—4.09	4.04 3.43—4.42	6.61 5.63—7.86	7.39 5.75— 8.86	8.19 6.86—10.67	9.03 8.00—11.00
M 17	3	8	3.48 3.00—4.25	3.77 3.21—4.40	4.27 3.93—4.60	5.05 4.33—5.90	6.06 4.42—6.71	7.11 6.13— 8.13	7.91 6.86— 9.33	9.12 7.33— 9.86
M 25	1	4	3.07 2.82—3.18	3.31 3.22—3.47	3.50 3.35—3.79	3.87 3.64—3.87	6.37 5.45—7.13	7.54 6.71— 8.57	7.96 6.71— 9.83	9.63 9.00—11.00
M 32	3	6	1.82 1.40—2.17	2.86 2.39—3.06	3.15 2.88—3.44	3.38 3.20—3.64	6.83 5.67—8.43	7.40 6.00— 8.50	7.91 6.09— 8.50	9.06 6.90—11.00
M 42	3	7	1.52 1.04—1.82	2.90 2.44—3.19	3.23 2.63—3.39	3.89 3.26—4.33	7.23 5.70—9.13	8.64 6.25—11.50	9.66 7.85—12.00	10.41 8.25—12.00
M 44	1	4	3.25 3.12—3.37	3.49 3.35—3.62	3.83 3.69—4.00	4.27 3.84—4.58	6.87 6.50—7.57	7.45 6.62— 8.16	8.97 8.00—10.40	9.78 8.33—11.00
M 48	4	14	3.40 2.33—4.15	3.89 3.35—4.93	4.14 3.37—5.92	5.21 3.85—7.40	7.67 6.33—9.14	8.57 7.00—10.14	10.17 7.57—13.66	11.23 8.00—13.83
M 67	7	25	2.73 2.45—3.22	3.00 2.68—3.63	3.31 2.80—4.28	3.75 3.00—5.50	5.50 3.68—8.00	6.88 4.77— 8.12	7.60 5.50—10.00	8.62 5.71—11.00
M 69	7	18	2.81 2.44—3.35	3.04 2.62—3.65	3.31 2.78—3.88	3.69 3.17—4.31	7.19 5.13—9.86	7.99 6.29—10.14	8.86 7.13—10.67	10.05 8.33—13.25
M 77	4	8	3.15 2.82—3.44	3.47 3.07—3.93	3.78 3.28—4.21	4.15 3.35—4.94	6.96 5.60—8.22	7.61 6.50— 8.70	8.68 6.75— 9.83	9.82 7.71—12.17
Deviating individuals										
M 10-5 . .	—	3	1.62 1.31—2.04	3.42 3.11—3.85	3.55 3.24—3.92	3.83 3.38—4.50	7.17 7.00—7.25	7.89 7.38— 8.57	8.02 7.50— 8.57	9.57 8.38—10.33
M 17-3 . .	—	5	2.00 1.79—2.23	3.37 3.11—3.53	3.80 3.22—4.17	4.32 3.81—4.75	6.84 5.00—8.71	7.88 5.55— 9.33	8.64 6.25— 9.67	10.30 8.67—11.67
M 42-1 . .	—	2	3.48 3.42—3.53	3.66 3.63—3.69	3.74 3.73—3.75	3.97 3.93—4.00	7.33 7.22—7.44	8.08 7.44— 8.71	10.00 9.29—10.71	11.98 11.29—12.67
M 44-5 . .	—	6	1.72 1.52—1.86	1.92 1.83—2.03	3.25 3.04—3.68	3.74 3.50—4.35	6.38 5.33—7.25	6.60 5.70— 7.37	7.60 6.00— 9.50	9.70 7.66—11.25

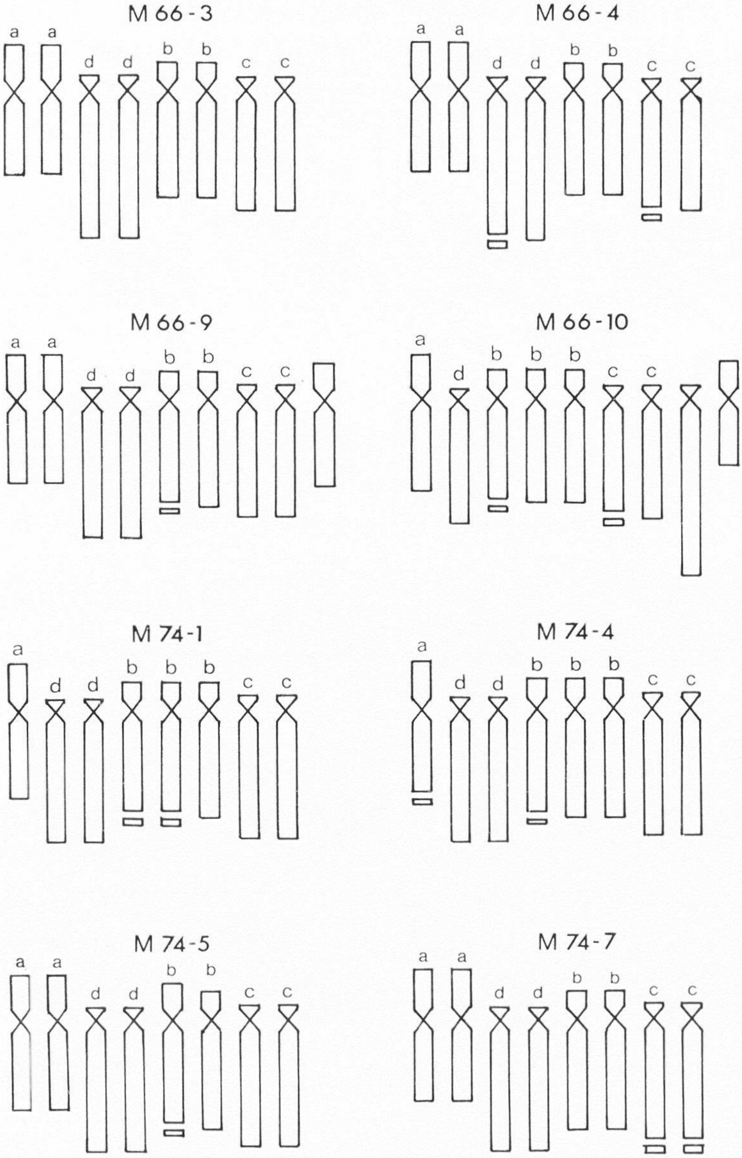


Fig. 5. Idiograms showing the long chromosomes and their variation within two populations of tetraploid *Leopoldia.*

Fig. 5, the *a* chromosomes exist either as a homologous pair or as a single chromosome in different individuals. They sometimes have a satellite (M 74-4).

Chromosomes b. The arm index is 2.8—3.7 and the relative length is 23.6—25.9. The *b* chromosomes correspond rather well with the subtelocentric chromosomes with the longest short arm of the diploid phrygana type (Fig. 3 B).

Chromosomes c. The arm index is 7.9—8.7 and the relative length is 23.3—25.4. This group of chromosomes corresponds to the long, subtelocentric chromosomes with the shortest short arm of the diploid phrygana type (Fig. 3 B).

Chromosomes d. In population M 66 the *d* chromosomes are easily detected in three individuals by their relative lengths (27.6—29.3), but in other specimens, the *d* chromosomes are rather difficult to recognize. The arm index varies between 9.6 and 11.6, which is most often markedly different from that of the *c* chromosomes. The relative lengths of the *d* chromosomes are more or less equal to those of the *c* chromosomes. There is a possibility that the *c* and *d* chromosomes sometimes have been intermixed.

Besides these four types of chromosomes others exist that are different from the normal chromosomes of tetraploid populations. There is an extra long chromosome in M 66-5, M 66-9 and M 66-10. These extra long chromosomes are not measured in Table 5.

In spite of the very pronounced structural hybridity in the M 66 and M 74 populations (Fig. 5), they seem to suffer very little in reproductive capacity. In the M 74 population, all individuals (15) except one (M 74-1) have 95—100 % stainable pollen. M 74-1 has ca. 88 % stainable pollen. In population M 66 only one individual (M 66-4) has been investigated for pollen fertility (99 % stainable pollen).

OTHER DEVIATING POPULATIONS

Structural hybridity on the tetraploid level is common throughout the investigated area. On the islands of Naxos (M 44), Serifos (M 10), Nikouria (M 17) and Rhodes (M 32), which are isolated from one another, populations of *Leopoldia* were found that to a varying extent have more or less the same structural hybridity (Fig. 6 A). They all possess one or two chromosomes that are more or less similar to those marked with *a* in Fig. 5 (Table 4).

Table 5. The tetraploid populations M 66 and M 77 of *Leopoldia* PARL. Arm indexes for the eight long chromosomes arranged according to increasing values. Mean value with min. and max. values.

Population and individual plants	No. of plates	Chromosome							
		1	2	3	4	5	6	7	8
M 66-3	3	1.54 1.43—1.61	1.75 1.52—2.00	3.26 3.00—3.77	3.56 3.07—3.85	7.71 6.86— 8.83	8.83 8.22— 9.57	9.44 8.00—10.33	11.57 8.38—14.00
M 66-4	4	1.60 1.43—1.77	1.77 1.62—1.90	3.54 3.33—3.69	3.94 3.33—4.28	8.10 7.38— 8.43	8.66 7.70—10.00	9.30 8.63— 9.67	9.73 8.30—11.86
M 66-5	4	1.78 1.57—1.92	3.28 2.82—3.83	3.57 3.26—3.87	4.08 3.76—4.36	7.52 5.58— 9.50	7.85 7.13— 8.71	9.24 8.25— 9.71	10.10 8.50—12.33
M 66-10	4	2.05 1.84—2.26	3.12 2.40—3.67	3.67 3.07—4.25	3.97 3.40—4.50	7.36 6.78— 8.43	9.13 8.00— 9.83	11.59 8.50—15.00	14.16 13.57—15.57
M 66-9	5	1.66 1.43—1.93	1.76 1.58—1.93	3.31 2.79—3.56	3.79 3.33—4.08	7.34 6.38— 8.86	8.54 6.38—10.14	9.60 7.89—13.60	9.64 8.00—10.75
M 74-1	8	1.71 1.48—1.92	3.15 2.61—3.60	3.41 3.11—3.73	3.82 3.47—4.08	7.68 5.90—11.00	8.66 6.88—11.60	9.72 7.86—12.00	11.60 10.33—13.20
M 74-4	2	1.64 1.54—1.74	3.00 2.94—3.05	3.40 3.33—3.47	4.05 3.53—4.57	8.25 8.25— 8.25	8.94 8.63— 9.25	10.57 10.14—11.00	11.57 10.19—13.00
M 74-5	3	1.86 1.47—1.81	1.85 1.56—2.05	2.76 2.59—2.93	3.70 3.54—3.80	7.15 6.38— 7.75	7.66 7.33— 8.33	8.44 7.33—10.00	11.05 8.80—13.75
M 74-6	6	1.94 1.68—2.37	3.03 2.50—3.46	3.22 2.75—3.58	3.84 3.28—4.22	7.85 6.85—10.00	9.13 7.33—10.40	9.90 8.00—11.60	12.23 10.66—14.25
M 74-7	4	1.51 1.34—1.60	1.62 1.51—1.72	3.49 3.27—3.76	3.69 3.36—4.21	7.26 5.33— 8.25	8.29 6.50— 9.57	10.32 6.85—13.00	11.87 8.66—16.00

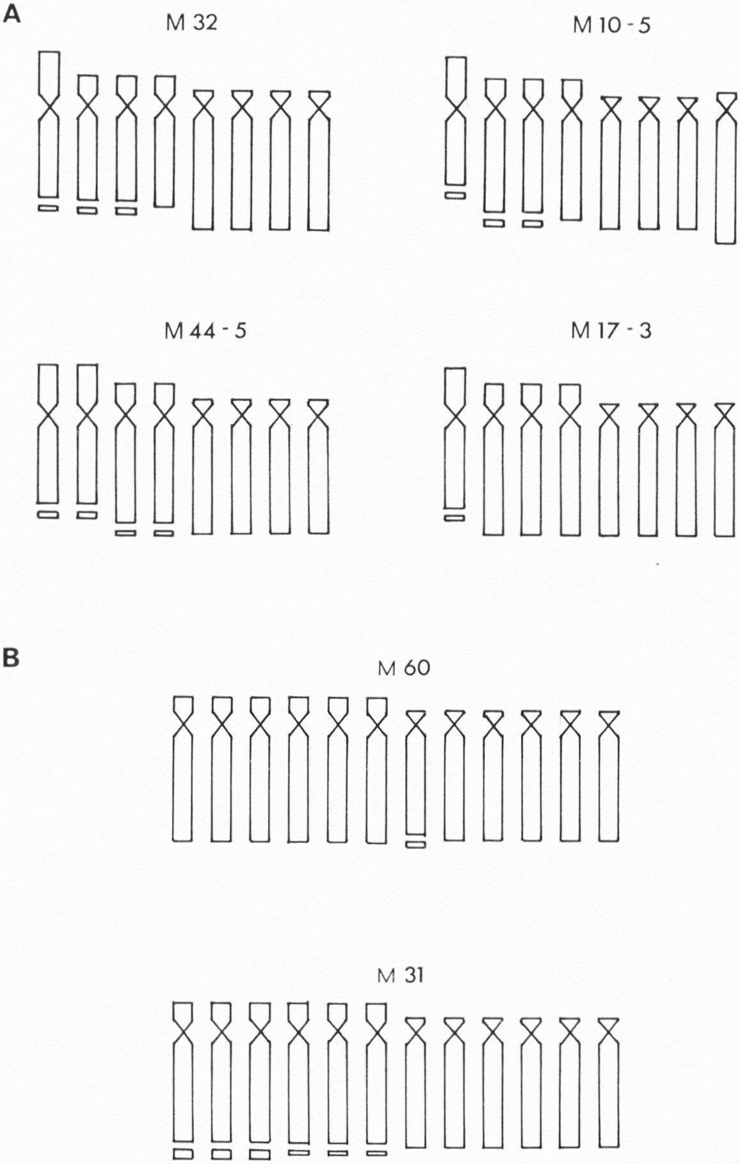


Fig. 6. A: Idiograms showing the eight long chromosomes from different populations of tetraploid *Leopoldia*. Note the existence of a more or less submetacentric chromosome with a satellite in all the populations. — B: Idiograms showing the twelve long chromosomes of two hexaploid populations of *Leopoldia*.

Table 6. Hexaploid populations of *Leopoldia* PARL. Arm indexes for the twelve long chromosomes arranged with respect to increasing values. Mean value with min. and max. values.

Population	No. of plants	No. of plates	Chromosome			
			1	2	3	4
M 31	2	2	3.32 3.30—3.33	3.61 3.50— 3.71	3.68 3.61— 3.75	3.88 3.61— 4.14
M 60	3	3	3.25 2.94—3.56	3.40 3.19— 3.60	3.85 3.35— 4.27	4.04 3.69— 4.36
			5	6	7	8
M 31	—	—	4.08 4.00—4.15	4.41 4.31— 4.50	6.47 6.44— 6.50	7.71 7.42— 8.00
M 60	—	—	4.27 3.92—4.57	5.31 3.93— 6.10	6.91 6.13— 8.29	7.41 6.56— 8.67
			9	10	11	12
M 31	—	—	8.67 8.50—8.88	9.17 9.00— 9.33	9.63 9.25—10.00	10.09 9.57—10.60
M 60	—	—	7.57 6.90—8.80	8.74 7.44—11.20	9.52 7.56—13.00	10.42 8.57—13.50

All populations of tetraploid *Leopoldia,* with few exceptions, grow in phrygana vegetation. In a few cases the tetraploid populations are more or less restricted to cliffs.

Hexaploid populations

The chromosome complement looks like the diploid, phrygana type complement duplicated three times (Fig. 6 B). Only two groups of large chromosomes have been possible to distinguish. Between different hexaploid populations, the variational range of arm index and relative length is rather narrow. One group of chromosomes has an arm index varying between 3.3 and 5.3 and a relative length varying between 17.4 and 17.8. The other chromosome group has an arm index of 6.5—10.4 and a relative length of 15.6—15.9 (Table 6).

The satellites are often, like in other *Leopoldia* populations, unequally distributed in different individuals. In one population (M 31) six satellites were found. In the other population (M 60) the number of satellites varied.

No structural hybridity, besides the unequal satellite distribution, was found on the hexaploid level.

Most hexaploid populations of *Leopoldia* are restricted to cliffs. Only four populations with this level of ploidy were found during 1967.

Two were from the island of Santorin and two, from the island of Folegandros.

DISCUSSION

Satellites

Normally, satellites of plant chromosomes are regarded as stable and are often used as chromosome morphological characters. In *Leopoldia* the varying distribution, form and number of satellites in the diploid phrygana type and in tetraploid and hexaploid populations may possibly indicate frequent, minor inversions and translocations in the distal chromosome segments.

In *Elymus rechingeri* (Run.) Run., Heneen and Runemark (1962) described differences in the satellite morphology of homologous satellite chromosomes. One of the satellites in a homologous pair could even be missing. They postulated that this probably was caused by a fusion of the satellite with the arm to which it was attached.

Leopoldia comosa (L.) Parl. (field type)

In the light of apparently frequent existence of structural hybridity in the field type, one can hardly assume that it confers any pronounced deleterious effect on the individual. It is amazing that the same or almost the same structural dissimilarity is found in both Italian (Garbari 1969) and Aegean material of *Leopoldia comosa* (L.) Parl. If the structural hybridity in the submetacentric chromosome pair is caused by an inversion (Sato 1942), this does not necessarily mean anything negative to the affected individual (cf. Stebbins 1950 p. 421).

In the Aegean material five of six investigated populations have, to a varying extent, developed accessory bulbs in cultivation. In other *Leopoldia* populations, accessory bulbs are rather rare. However, the correlation between development of accessory bulbs and sexual reproduction is not yet investigated nor is the correlation between accessory bulbs and structural hybridity.

Diploid phrygana type

The karyotype of these populations generally agrees with that found by Garbari (1969) in material determined to *Leopoldia tenuiflora*

(Tauch.) Heldr. No structural hybridity besides the unequal satellite distribution and morphology has been found.

Tetraploid populations

Morphologically, the tetraploid populations are often rather difficult to distinguish from the diploid phrygana populations. Stebbins (1950 p. 328) points out that in many polyploid, critical plant groups that are continuous in morphological characters the polyploid is a result of autopolyploidy or segmental allopolyploidy. In the present investigation it is too early to make any statement on the origin of the tetraploid populations.

The tetraploid populations of *Leopoldia* have a chromosome complement resembling phenotypically a duplicated set of diploid, phrygana -type chromosomes; however, some minor differences exist. The chromosome groups with the highest arm index values in tetraploid populations often have lower relative lengths than the chromosome groups with the lowest arm index values. In the diploid phrygana type the situation is often the contrary. A change in relative and absolute lengths may be a result of the tetraploid state with its new gene environment. The chromosome morphology has been shown to be controlled by genes by several workers (cf. Rees 1961). Segmental interchange may also be responsible for the differences between the two levels of ploidy.

Structural hybridity in population M 74 and M 66 from the island of Sirina

On the island of Sirina (Fig. 1) only cytologically heterogenous populations (e.g. M 66 and M 74) have been found. The two populations investigated grow near each other but on different biotopes — phrygana and cliffs. Populations of *Leopoldia* are growing on the three islets of Tria Nisia and the two islets of Adelphae (Fig. 1). The karyotypes of these populations are drawn in Fig. 7.

No diploid populations of the phrygana type were found on Sirina and the neighbouring islets. The basis for the discussion is the tetraploid karyotype found in M 42-1, Tria Nisia. From a population like M 92 (Fig. 7), unreduced pollen may have been produced. A cross between such pollen and normally reduced egg cells from a tetraploid individual like M 42-1 (Fig. 7) would give rise to a tetraploid offspring

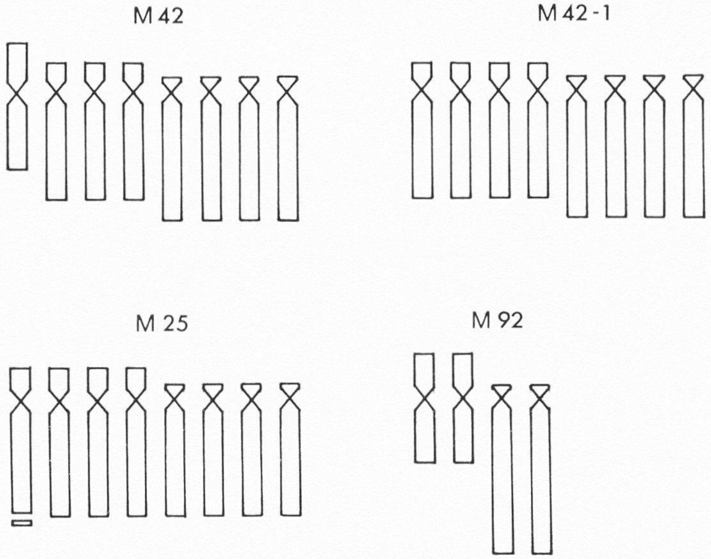


Fig. 7. Idiograms showing the long chromosomes from populations of *Leopoldia* adjacent to Sirina (see map, Fig. 1). M 42 and M 25 are tetraploid. M 92 is diploid.

with two submetacentric chromosomes of type *a,* two subtelocentric of type *b,* two of *c* and two of *d* (Fig. 8).

A backcross with the tetraploid hybrid to the "basic tetraploid" would result in individuals with one *a* and *d* chromosomes and three *b* and *c* chromosomes. The offspring of the backcrosses can theoretically give rise to several karyotypes (Fig. 8).

There is, of course, a second possibility for the evolution of the different karyotypes. If both the diploid field type and phrygana type once have existed together in the area, they may have produced a true allotetraploid. This allotetraploid may then have crossed with a "basic tetraploid" with several karyotypes in the F_2 offspring as a result. This second possibility seems less probable to the author since the diploid phrygana type is not known from the area. A direct cross between a normal tetraploid and a diploid field type resulting in the evolution of the different tetraploid karyotypes seems more tenable. Such a cross can run either directly from diploid to tetraploid as outlined above or over a partly sterile triploid hybrid generation (cf. LEWIS 1967).

Structural hybridity, found in different individuals, which can not be directly explained by different crosses, may be due to the fact that in

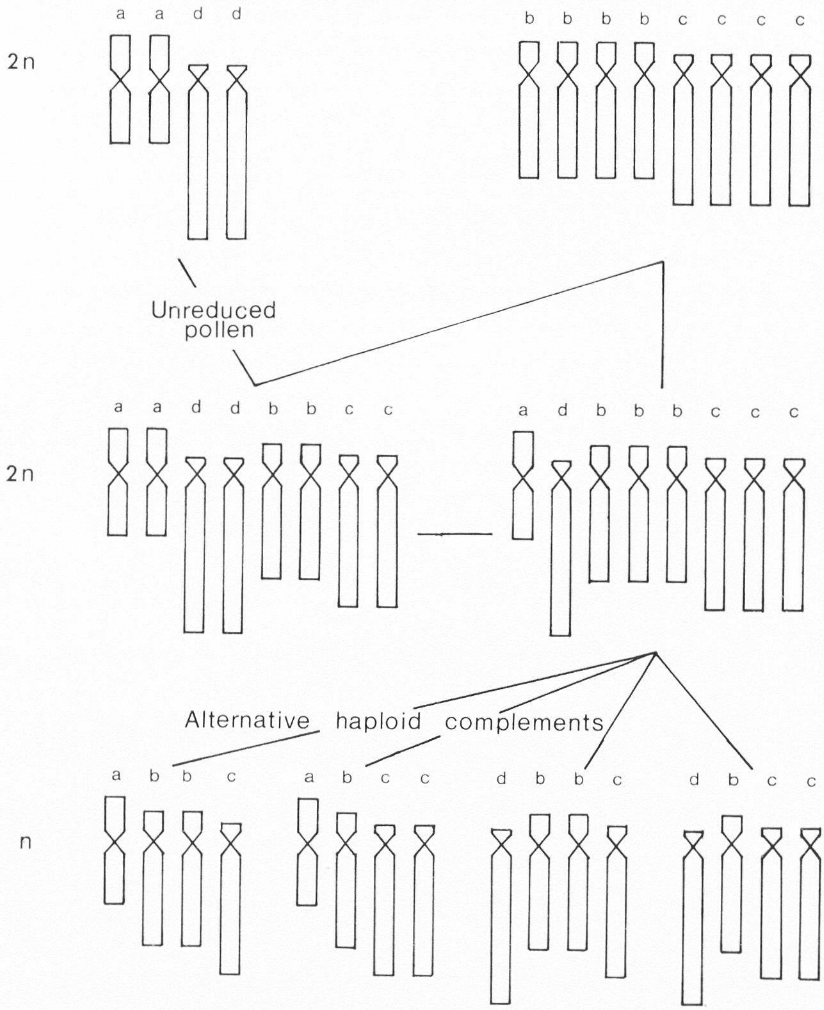


Fig. 8. A theoretical scheme for the evolution of structural hybridity in *Leopoldia* (see Fig. 5).

hybrids structural changes are much more likely than they are in the parents of the hybrid (cf. GILES 1942; MOAV, MOAV & ZOHARY 1968). The structural hybridity in the Sirina region must, judging from the population composition, be rather old.

It is known that polyploids often are able to tolerate structural hybridity and other disturbances better than diploids (SEARS 1944). To explain the surprisingly high pollen fertility of the M 74 and M 66 populations, meiosis must be studied carefully. It is possible that only one more or less undisturbed diploid set of chromosomes is enough for a tetraploid to have a normal seed set.

Structural hybridity on the islands of Naxos, Nikouria, Rhodes and Serifos

In population M 10 from one of three investigated individuals, in M 17 from one of four individuals, in M 32 from three of three individuals and in M 44 from one of two individuals, one or two chromosomes more or less similar to those marked with *a* in Fig. 5 have been observed (Fig. 6 A). This chromosome type is similar to one pair of chromosomes in the diploid field type; *Leopoldia comosa* (L.) PARL. The existence of such chromosomes in phytogeographically widely separated areas in the Aegean support the interpretation that the observed karyotypes are the results of independent cases of introgressive hybridization between the diploid field type and the normal tetraploid type in a way similar to that of the Sirina populations discussed above. Apparently, the "*Leopoldia comosa* chromosomes" can survive for a long period of time within tetraploid populations as "floating relicts".

Hexaploid populations

No gross structural hybridity was found on this level of ploidy. This may be due to the limited material of hexaploids investigated but may, of course, also be a reality. Once on the cliffs, where most populations were found, the hexaploid populations are, to a rather great extent, isolated from other populations and as a consequence of this, chromosomal interchange is precluded through crossing.

There are in some localities tetraploid *Leopoldia* populations growing at the base of cliffs on which hexaploids are established. In these localities, however, hybrid or introgressive forms have not been found.

APPENDIX

List of localities of the material investigated:

M 8 Milos: The small island of Ag. Georgios. The southernmost cape. Volcanic material. 17.4.1967. — **M 9** Milos: Western part. The valley N to the monastery. Phrygana, 10—20 m s.m. 18.6.1967. — **M 10** Serifos: The mountain N to the village of Serifos. Phrygana, ca. 300 m s.m. 21.6.1967. — **M 13** Paros: Ca. 1 km SE of the village of Naoussa. Phrygana, ca. 50 m s.m. 18.5.1967. — **M 16**

Naxos: Ca. 1 km S of the village of Apollona. In a field. 1.5.1967. — **M 17** Nikouria: (N of Amorgos). On the peak. Slope facing N cliffs, ca. 300 m s.m. 1.7.1967. — **M 25** The islets of Adelphae: The western islet. Phrygana, limestone. 11.5.1967. — **M 31** Folegandros: W of the bay on the SW side of the island. Phrygana. 16.6.1967. — **M 32** Rhodes: 1 km SW of the village of Siana. Cliffs, ca. 300 m s.m. 2.6.1967. — **M 42** The islets of Tria Nisia: The N islet. Phrygana, ca. 20 m s.m. 11.5.1967. — **M 44** Naxos: Close to the monastery E of the town of Naxos. Phrygana, ca. 100 m. s.m. 15.4.1967. — **M 47** Piperi: (NE of the island of Serifos). Phrygana, 0—160 m s.m. 27.4.1967. — **M 48** Anaphi: On the cliffs of Kalamos. The E peak, ca. 430 m s.m. 29.6.1967. — **M 49** Poliagos: SW of the highest peak. Phrygana. 19.4.1967. — **M 50** The islets of Unia Nisia: Phrygana on limestone. 6.5.1967. — **M 55** Poliagos: NW of the highest peak. In a field. 19.4.1967. — **M 60** Santorin: On Mount Prof. Elias. E of the peak. On cliffs, 450 m s.m. 28.6.1967. — **M 64** Milos: SSW of the peak of Mount Prof. Elias. Phrygana, 0—300 m s.m. 18.6.1967. — **M 66** Sirina: The NE part of the island. Phrygana, ca. 50 m s.m. 9.5.1967. — **M 67** Karpathos: SE of the village of Vurgunda. Cliffs, ca. 400 m s.m. 7.5.1967. — **M 69** Rhodes: S of the village of Salakos. In a field. 2.6.1967. — **M 73** Milos: The southernmost part of the habour bay. Slopes facing W. Phrygana, ca. 50 m s.m. 20.4.1967. — **M 74** Sirina: NE part of the island. Cliffs, ca. 100 m s.m. 9.5.1967. — **M 77** Serifos: Ca. 1 km SW of the village of Livadhion. Cliffs. 26.4.1967. — **M 79** Amorgos: Ca. 2 km N of the peak of Mount Orox Korax. In a field, ca. 200 m s.m. 2.7.1967. — **M 81** Folegandros: Ca. 0.5 km E of the habour village on the eastern part of the island. In a field, ca. 30 m s.m. 16.4.1967. — **M 92** The islets of Tria Nisia: The W island. Limestone, ca. 40 m s.m. 11.5.1967.

All collections have been made by Dr. HANS RUNEMARK and the author.

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Studies on Mire Vegetation in the Torneträsk Area, Northern Sweden

II. Winter Conditions of the Poor Mires

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ABSTRACT

In a mountain area of North Scandinavia investigations of the winter conditions of the poor mires (bogs and poor fens) were carried out during four years. In particular, the relationship to the mire vegetation was emphasized. As a whole the distributional pattern of snow is similar from year to year. The relative distribution varies more between different periods during winter than between different years. There is a strong correlation between a short period of snow cover and a thin cover of snow on one hand and the occurrence of permafrost in the hummock-sites or hummock-structures on the other. The relationship to other types of site/structure appears ambiguous. A depth ranging from 30 to 50 cm was found to be the average depth required to prevent more pronounced influence of air temperature. The great difference in the period of snow cover and snow depths between the western oceanic sites and the eastern less oceanic ones is allied to marked vegetational differences. Corresponding differences are also seen in the separate mires where, in addition, the long lasting covering of water in the depressions after snow thaw (in the eastern sites) probably increases the differences. There is an apparent relationship seen between the height of *Betula nana* shoots and the situation of the snow surface both in mire and terrestrial sites. The cover of *Andromeda polifolia* and *Empetrum hermaphroditum* are negatively correlated while cover of *Vaccinium myrtillus* is positively correlated to a deep snow cover. The regional and local phenological differences found were smaller than expected.

INTRODUCTION

Since the papers of Kihlman (1890) and Vestergren (1902) the importance of snow to Boreal and mountain vegetation has frequently been considered in investigations in Fennoscandia. However, reports of quantitative observations of natural or semi-natural sites are few (see e.g. Dahl 1956, Havas 1966 and Eurola 1968).

The present paper deals with investigations of mainly Subalpine mires, untouched or only slightly touched by man, in the Torneträsk area, Northern Sweden, during the winters of 1962—63, 1963—64, 1965—66 and 1966—67. Some phenological studies were carried out during 1969. The main intention has been to see to what extent some mire plant communities of the area (SONESSON 1967, 1970) are related to the environmental conditions prevailing during the cold season. In particular, the relationship with the period of snow cover, the snow depths and the various distributional patterns of snow has been emphasized.

The Torneträsk area is situated in the northern part of the mountain area occupying Western Scandinavia. It has a pronounced west—east extension, situated about 25 km from the Atlantic Ocean in the west and extending about 100 km to the east (Fig. 1). Climatically, a decisive oceanic—continental gradient is evident from west to east. There are great differences in the amount of precipitation and in the duration of snow cover between the western and the eastern parts. This is allied to differences in slope, topography and vegetation of the mires. The western mires are often gently sloping, having a lower relief, and are unfrozen or contain seasonal frost only. The eastern mires are horizontal, often having more accentuated relief and containing permafrost to a large extent. The mire plant communities, especially the dry-growing ones, are distinctly different usually being chionophilous in the western part while chionophobous in the eastern part.

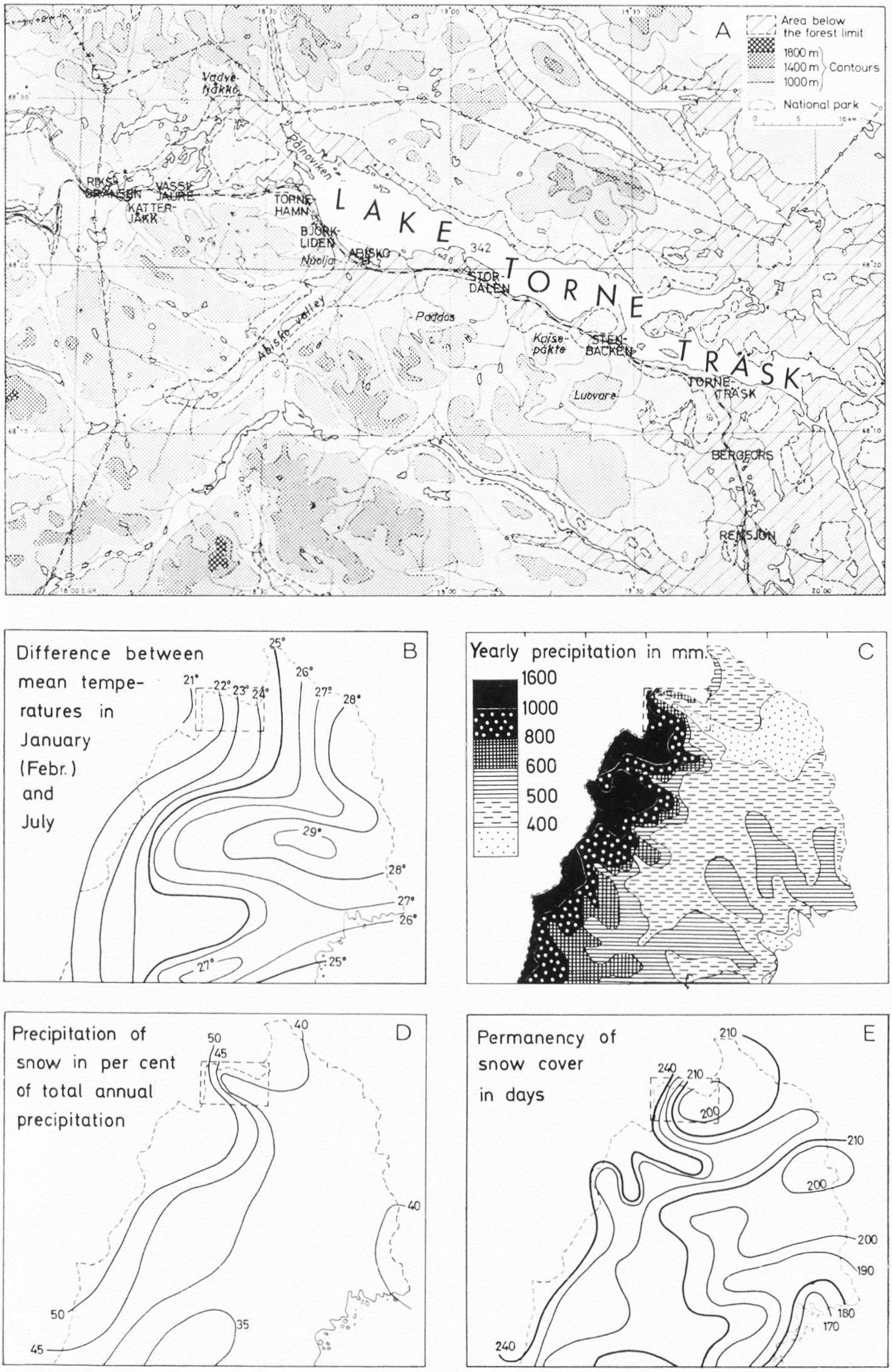
A full description of the investigation area, the mires and the mire vegetation is given in SONESSON 1967 and 1970. The reader is referred to these papers, where the terminology, nomenclature and basic environmental data are also given.

METHODS

Sites Investigated. Mires representative with respect to the vegetation were selected along a west—east transect about 70 km long at approximately the same altitude (350—600 m). Mires selected were in the vicinity of Riksgränsen (wB3=western Boreal no. 3, explanation in SONESSON 1970), Vassijaure (wB6), Abisko (eB28=eastern Boreal no. 28), the western and eastern part of Stordalen (eB34 and eB37 respectively) and at Torneträsk (eB39). See Fig. 1. Those west of the Tornehamn area represent the western ("oceanic") type, those east of that area represent the eastern ("continental") type.

At each site line transects from 5—35 m long were established for vegetational mapping. The transects were arranged to cross vegetational discontinuities either within the site or between mire and neighbouring terrestrial sites. The measurements of snow and the cover and height of plants (see below) were carried out along these transects. Details of some of the mires and transects are given in SONESSON op. cit.

Fig. 1. A. Adapted from MÅRTENSSON 1956. Låktatjåkka is situated about 2 km east of Vassijaure. — B, D—E after Atlas över Sverige. — C. Adapted from ÅNGSTRÖM 1958.


A
Area below the forest limit
1800 m
1400 m
1000 m
Contours
National park
0 5 10 km
18°00
18°30
19°00
19°30
20°00
68°30
68°20
68°10
18°00 E.GR
Vadvetjåkko
Pålnoviken
RIKSGRÄNSEN
VASSIJAURE
KATTERJÅKK
TORNEHAMN
BJÖRKLIDEN
ABISKO
Nuolja
Abisko valley
LAKE TORNETRÄSK
342
STORDALEN
Paddos
Kaisepakte
STENBACKEN
Luovare
TORNETRÄSK
BERGFORS
RENSJÖN
B
Difference between mean temperatures in January (Febr.) and July
21°
22°
23°
24°
25°
26°
27°
28°
29°
28°
27°
26°
27°
25°
C
Yearly precipitation in mm.
1600
1000
800
600
500
400
D
Precipitation of snow in per cent of total annual precipitation
50
45
40
40
50
45
35
E
Permanency of snow cover in days
210
240
210
200
210
200
200
190
180
170
240

A special series of measurements of snow cover over stands of two hummock communities (Fig. 7 B) was made during late winter in 1966 and 1967 at Katterjåkk (wB5), Vassijaure (wB6, 7), Låktatjåkka (wB13), western part of Stordalen (eB35) and at Torneträsk (eB39). The communities were: *Vaccinium myrtillus - Pleurozium* variant (of western distribution in the area, only rarely found in eastern mire margins) and *Cetraria nivalis - Dicranum elongatum* variant (of eastern distribution, rare in western sites). The randomly selected measuring plots were each marked with a wooden pole and measurements taken within areas approximately 2 500—40 000 m^2. The plots of the eastern sites were all situated in the vicinity of the mire margins, while those of the western sites were situated mainly in the mire expanses.

Snow Depths. Snow depths were measured at half metre intervals along the transects (cf. above). Measurements were made using a sharpened metal rod. Using this method it was also often possible to determine the depth of frozen peat. Precautions were taken so as not to disturb the stratigraphy of snow unnecessarily. Six transects are presented here to show the variation (Figs. 4—5). To facilitate comparisons parts of them of uniform length have been selected. The relative depths are given as percentages of the sum of all snow depths for each period and each transect (left columns). Transformed relative values are also given (right columns), which means that the calculation sum used has been the same for all the periods and transects under consideration. The whole material of snow depth measurements are used in Table 2.

During the measurements made in March 1963 at Riksgränsen it was impossible to find any poles, although they usually exceeded 2.5 m above the mire surface. It is for this reason that the depths are regarded as being greater than 250 cm in Figs. 7—9.

Apparent Density of Snow. The sampling was carried out according to a method described by ZINGG (1962—63). A common balance was used, however. This method means sampling and weighing continuously from the surface to the bottom with the aid of small metal cylinders (diameter 55 mm) within each layer of different snow observed in a section through the snow cover. During the second sampling period points other than those employed during the first were used. The standard deviation calulated from 97 duplicates (mean 100.3 g, interval 18—181 g) amounts to 8.9 g. All sampling plots were situated on the mire expanses.

Temperature. In connection with the observations of snow depths during late winter in 1963 the temperature of the surface of the mires was measured (Fig. 3 C) with aid of thermistors (average reading accuracy at least ±1°C). The thermistors were connected together in twos and attached to one end of wooden poles. In November and March the vertical thermal gradient in a few sections of the snow over lawn stands was studied, two of which are presented here (Fig. 6 B). The thermistors were also in this case inserted in couples or in threes in each level, but about 10 cm distant.

Thermograph recordings (Lambrecht Thermograph) were carried out at one point in Abisko in a hummock-site containing permafrost (eB28) over a stand belonging to the *Cetraria nivalis - Dicranum elongatum* variant (Fig. 6 A). The thermographs were calibrated before and after each period of recording and some corrections have been made on the figures according to this.

A few readings of the minimum temperature on the surface of some hummock-structures were taken during the winter 1962—63. The thermometers used were mounted in strong metallic frames. They were put directly on the moss layer in the autumn of 1962 in the following sites and vegetation: Riksgränsen (wB3): *Vaccinium myrtillus - Pleurozium* variant, Stordalen (eB37): *Cetraria nivalis - Dicranum elongatum* variant, Torneträsk (eB39): Ditto, Luovare (eA47 = eastern Alpine no. 47): Ditto.

Cover and Height of Plants. The measurements were carried out over the transects mentioned above during the period 19/7—28/8 1963. Because of a lack of time the entire transect could not be used in every case. In such instances smaller parts of them were selected at random. The cover was thoroughly estimated in per cent (0.25 m^2 squares at each half metre). The average height of the highest twigs in each square was measured vertically from the bottom layer/peat layer. The material from hummock (only mire expanse types) and lawn (to a minor extent also mire margin type) communities is shown in Figs. 8—9. Material from hummock mire expanse as well as hummock mire margin communities of one site (Vassijaure, wB6) is shown in Fig. 10. However, only the highest twig of *Betula nana* and *Vaccinium uliginosum* was measured for the material of Figs. 8, 9 A and 10. In *Betula nana* the height of the youngest greenish part of the twig (usually a few centimetres) was then subtracted.

During the summers of 1965 and 1967 the heights of *Betula nana* shoots were also measured in relation to the level of the "Olivacea-limit" (NORDHAGEN 1927—1928 pp. 98—102, 1943 p. 584), i.e. the level of the mean snow depth in winter indicated on trees (preferably birches) by the occurrence of *Parmelia olivacea*, a species which does not tolerate snow cover (operibus cit). Two series of such measurements were made. The first one in 1965 was carried out over places close to the margins of mires at Katterjåkk, Vassijaure, Abisko, Stordalen and Torneträsk (Fig. 9 B left). The second one in 1967 was made over terrestrial sites, mainly dry ones, in the same localities but with the addition of Låktatjåkka and Rensjön (Fig. 9 B right). All measuring plots were selected at random. At the plots the height of *Betula nana* shoots within a radius of 1 metre from a stem/stems with epiphytic *Parmelia olivacea* was measured. In 1967 the relation to the Olivacea-limit was determined with aid of a simple levelling instrument. The Olivacea-limit was supposed to be that level at which the specimens of the lichen present exceeded 2 cm in diameter. In this case no subtraction of the heights of the green ends of *Betula nana* was made.

Phenology. The following communities were studied: *Vaccinium myrtillus - Pleurozium* variant, *Cetraria nivalis - Dicranum elongatum* variant (see p. 484) and the *Cetraria delisei* variant (lawn community of an eastern distribution, usually found in depressions of the hummock-sites). Only mire expanse facies were taken into consideration (cf., however, below). The observations and sampling were carried out over the same plots during two periods, 30/5—5/6 and 24/6—29/6 1969. The sites selected are situated at

Abisko (eB28), Torneträsk (eB39), Vassijaure (wB6), Luovare (eA47), Katterjåkk (wB5) and Stordalen (eB37). One site was visited each day in this order during the periods. Observations of the stages of generative and vegetative development and measurements of the frost depths were made over the randomly selected plots. Samples of the young subaerial parts of the species studied were also collected for determination of the water content. Since the development of the buds in spring is mainly due to an increase in the water content (see the plant physiological manuals, e.g. SCHUMACHER 1962 pp. 262—263) such a determination would show the stage of development as well. In *Andromeda polifolia, Ledum palustre* and *Vaccinium vitis-idaea* the apical parts were collected down to an often obvious scar separating the older parts of the shoots. *Empetrum hermaphroditum* 1 (Fig. 11) designates the extreme end of the twig including the distal whort of floral buds. *E. h.* 2 means the next, more proximal part including whorl no. 2. In *Vaccinium myrtillus, V. uliginosum* and *Rubus chamaemorus* the whole shoot was collected. *Betula nana* 1 designates the buds and or the leaves only, *B. n.* 2 the youngest part of the twigs (easy to separate by the deviating colour) excluding the buds or leaves. In *Eriophorum vaginatum* the leaves were collected. The plant material was sampled in plastic bags and weighed within twelve hours of sampling. The dry matter was determined by drying at 105°C, the loss on ignition by ashing in a muffle furnace at approximately 550°C. Only material from hummock vegetation was used.

Special observations were made of one big hummock-structure in Torneträsk to get the phenological differences between plots facing towards south and those facing north. The plant community studied was a mire margin facies of the *Ledum - Sphagnum fuscum* variant.

Weather Conditions During Measuring Periods. In Table 1 is shown the precipitation and temperature prevailing during the measuring periods in relation to the normal values. Kiruna is situated approximately 50 km SE of Torneträsk. For evaluating the results of the phenological investigation the following temperature data are added (the normal monthly means within parenthesis):

	1969			
	April	May	June 1—15th	June 16—30th
Riksgränsen	—4.7 (—4.0)	0.4 (1.0)	4.2 (6.6)	13.8
Kiruna	—4.4 (—3.5)	1.0 (2.7)	6.9 (9.2)	14.8

RESULTS

Period of Snow Cover

REGIONAL CONDITIONS. Broadly speaking, over the whole Boreal zone of the Torneträsk area the snow fall normally begins in the first half of October (Atlas över Sverige). Sporadic snow falls may also

Table 1. Weather conditions near measuring sites in relation to normal conditions (official sources). The figures show the monthly means above (+) or below (—) the normal means (see SONESSON 1970 Fig. 3).

		J (July)	A	S	O	N	D	J	F	M	A	M	J (June)
1962—63													
Riksgränsen	mm	—29	—72	—8	+213	—7	+64	+34	+7	—30	+9	—23	—37
	(Period of snow cover 174 days, maximum depth 158 cm; all snow disappeared on June 5th)												
	°C	—2.7	—1.0	—0.6	+1.1	+0.7	—3.3	+0.8	—1.1	—1.9	+1.4	+4.6	—0.1
Abisko	(Period of snow cover 174 days, maximum depth 73 cm)												
Kiruna	mm	—41	—2	+19	—12	—8	—6	—6	0	—12	—12	—15	—15
	(Period of snow cover 205 days, maximum depth 73 cm; all snow disappeared on May 25th)												
	°C	—2.0	—2.3	—1.0	+1.9	+0.4	—3.9	+1.4	—0.7	—1.8	+1.9	+6.1	—0.8
1963—64													
Riksgränsen	mm	—6	—52	—6	+13	—22	+61	+207	+5	—29	—8	—4	—2
	(Period of snow cover 231 days, maximum depth 108 cm; all snow disappeared on July 25th)												
	°C	—2.9	+1.4	+2.1	+1.5	—1.0	+1.5	+6.5	—0.7	+1.7	—0.2	+1.3	—1.2
Abisko	(Period of snow cover 199 days, maximum depth 64 cm)												
Kiruna	mm	+38	0	+27	+4	+31	—5	—19	—7	—20.9	+21	—17	—25
	(Period of snow cover 210 days, maximum depth 88 cm; all snow disappeared on May 25th)												
	°C	—2.8	+0.6	+2.3	+1.4	—1.8	+1.5	+8.0	—1.4	+2.0	+0.5	+1.7	—0.9
1965—66													
Riksgränsen	mm	+2	—42	—66	+90	—16	—50	—21	—48	—12	—20	+5	—37
	(Period of snow cover 230 days, maximum depth 101 cm; all snow disappeared on June 25th)												
	°C	—2.7	—1.2	+1.5	+0.8	—3.2	—6.0	—5.0	—7.2	—4.4	—2.6	—0.9	+2.6
Abisko	(Period of snow cover 196 days, maximum depth 50 cm)												
Kiruna	mm	+5	+22	—9	+19	+1	+11	—9	+10	+18	—4	—2	—1
	(Period of snow cover 217 days, maximum depth 100 cm; all snow disappeared on June 5th)												
	°C	—3.7	—1.4	+1.1	+1.0	—4.4	—6.8	—5.7	—8.5	—4.6	—3.2	—1.3	+2.3
1966—67													
Riksgränsen	mm	+7	+65	—50	—3	—18	—58	+26	—16	—19	+2	—45	+22
	(Period of snow cover 255 days, maximum depth 110 cm; all snow disappeared on June 25th)												
	°C	—0.9	—2.0	—3.7	—2.3	+1.3	—1.7	—2.8	—0.1	+3.4	+0.5	+0.8	—0.7
Abisko	(Period of snow cover 223 days, maximum depth 72 cm)												
Kiruna	mm	—21	—40	+6	+29	—6	+56	+6	+4	+24	—1	—16	—41
	(Period of snow cover 234 days, maximum depth 98 cm; all snow disappeared on June 5th)												
	°C	0.0	—1.8	—3.4	—2.5	+1.2	—0.8	—4.5	+1.9	+3.4	+0.5	—0.1	—0.5
1968—69													
Riksgränsen	mm	+31	+28	—106	—21	+26	+31	—45	—43	—14	+3	—30	—25
	(Maximum snow depth 109 cm; all snow disappeared on June 25th)												
	°C	—3.6	—2.8	—0.8	—5.1	+1.2	+3.5	—3.6	—6.2	+0.1	—0.7	—0.6	+2.7
Kiruna	mm	—55	—31	—30	+18	—1	+9	0	—9	+2	—12	0	—57
	(Maximum snow depth 52 cm; all snow disappeared on June 15th)												
	°C	—2.7	—1.8	—1.4	—5.6	—0.4	+3.8	—3.2	—5.9	—0.8	—0.9	—1.7	+1.8

occur during late spring, summer (middle of June—middle or end of August) and early autumn. The thaw is usually complete by the second half of June in the western part and by the last half of May in the eastern part (see SONESSON 1970). There are, however, exceptions in protected places, especially in valleys which are sheltered by mountains from the winds bringing precipitation mainly westerly (see HOLDAR 1960 p. 231). The best known example is the Abisko valley, where one of the lowest mean annual precipitations in Sweden is recorded (1921—1950: 298 mm in average). The snow normally melts here during the first half of May (SANDBERG 1963 p. 888) except in the most sheltered places.

In May 1963 the mean air temperature was about 5 degrees higher than normal (Table 1). At Riksgränsen (18/5) there was still a thick layer of snow over the mires (average 100 cm). But at Vassijaure (20/5), however, the tops of the majority of the hummocks had emerged. The depths of snow at the mire margins amounted to 50—100 cm while those of the expanses between the hummocks amounted to 5—30 cm. Although the melting was very rapid no free water was observed in the depression of the hummock-sites (some seasonal frost was present) after digging up the cover of snow. At this time, however, all eastern mires were devoid of snow except in sheltered places in the marginal parts. A specially observed mire at Abisko (eB28) was practically free from snow during the very first days in May. Both at Abisko (14/5, 20/5) and Stordalen (15/5, 16/5) many depressions of the hummock-sites (containing permafrost) were covered with water. At Torneträsk (21/5), however, there was a water table visible in only a few such depressions.

LOCAL CONDITIONS. Relatively continuous observations and measurements were carried out at Abisko (eB28) in 1964 and 1966 along a transect from a bog-like hummock-site (with permafrost) to a neighbouring fen site (which has only seasonal frost).

1964 (see Fig. 2 B): The upper levels of the hummocks were free from snow and ice by the 4th of May. The remaining parts of the hummocks as well as the lawns were bare by the 13th, the mud-bottom by the 15th of May. The lawns were covered with free water more than one month after the melting of snow, but by the middle of June the water table was invisible except in the mud-bottom.

1966: The hummocks began to emerge on the 24th of April and were free from snow and ice by the 30th, the lawns and the mud-bottom by the 3rd of May. A temporary snow cover, 5—10 cm deep, lay over

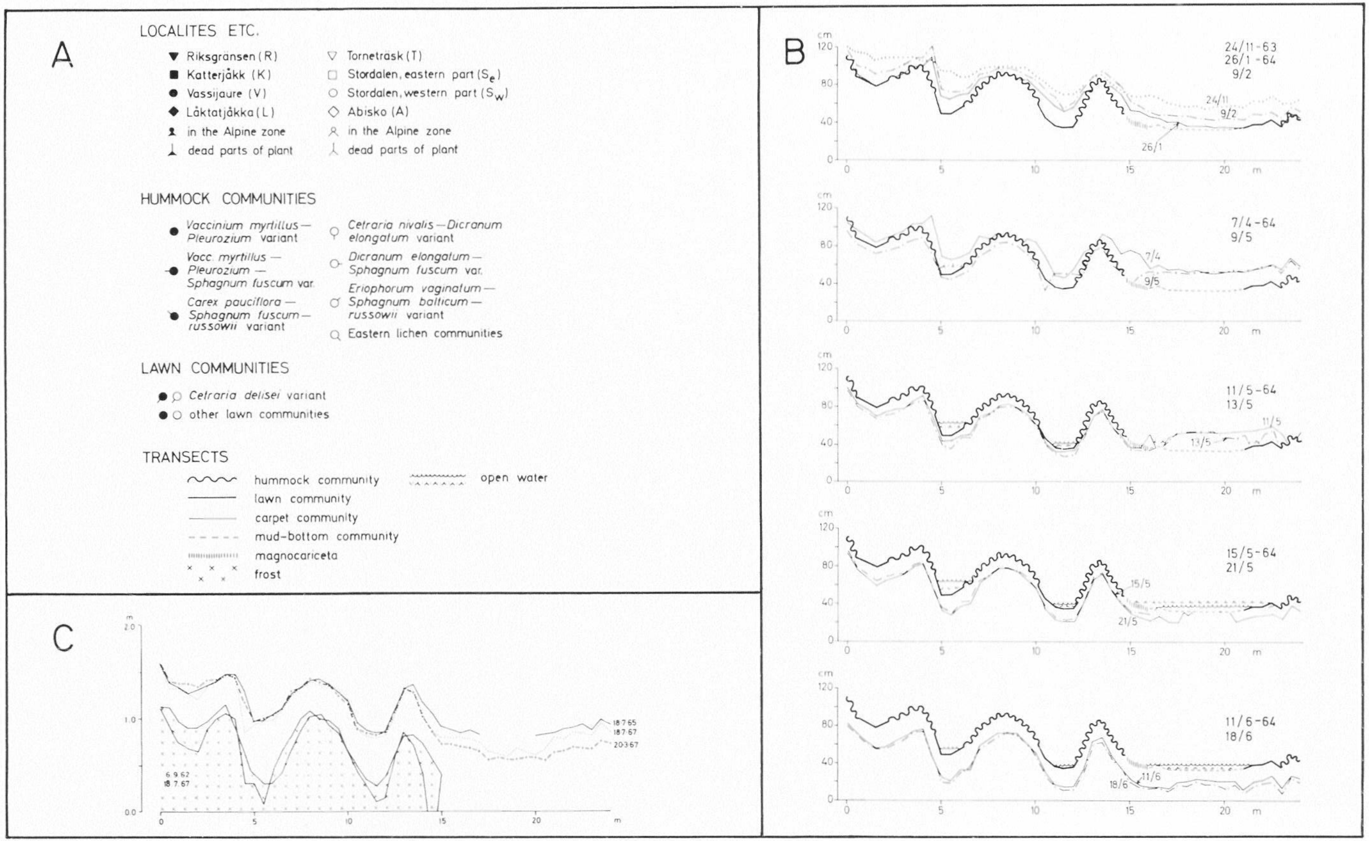


Fig. 2. A. Legend. — B. Snow depths and depths to frost table in mire at Abisko. Observation period early winter—early summer 1963—64. — C. Situation of the same mire surface during three occasions of levelling. The transect crosses the boundary between two mire sites, one of which contains permafrost. Vertical exaggeration 5: 1.

the lawns from 7/5 to 12/5. The lawns (and mud-bottom) were covered with water from the melting of the snow and were still covered on the 25th of May when the observations ended.

The difference in time of snow cover in late spring between the upper levels of the hummocks and the lawns and the mud-bottom of the depressions amounted to approximately ten days in Abisko. A similar lag was also observed at Vassijaure in 1963. There on the 20th of May the upper parts of the hummocks were visible above the snow (cf. SONESSON 1970 Fig. 6). After careful consideration of the weather during May this year the hummocks were estimated to have been free from snow at most two days before the time of observation. By the 26th all snow had melted from the mires except in sheltered places at the margins; that means that in this year the thaw here was at least three weeks later than in Abisko (cf. above p. 488).

Distribution of Snow

REGIONAL CONDITIONS. The results given above (p. 488) show great differences in the period of snow between the western and eastern mires during most winters (see also Fig. 1). In Table 2 the mean snow depths observed during various periods are seen (the mean depth of at least 200 cm in Riksgränsen in March 1963 may be added, see p. 484). During the period of snow fall in early winter there may not be any consistent distributional differences either in depths or qualities of snow (Table 2; Fig. 3 A). In late winter, however, the western sites are covered with approximately four to five times as much snow as the eastern ones. The snow of the eastern mires usually has a higher apparent density (Fig. 3 A—B).

LOCAL CONDITIONS (Figs. 4—5). The relative distribution of snow varies more between different periods in winter than between different years. There is a tendency of a more even distribution during the period of snow fall and also during early winter, i.e., the differences in the absolute snow depths between the hummocks and the depressions are then less than during late winter. The variation in the relative values is often very great during these periods due to the low absolute snow depths.

In late winter the upper levels of hummocks typical to western mires are usually covered with more than 70 cm snow, while those of the eastern mires are covered with a layer less than about 30 cm (Fig. 7).

Table 2. Calculated water equivalent (as mm precipitation) for different mean snow depths over mires investigated (using regression equations of the values shown in Fig. 3 A).

	Vassijaure	Abisko	Stordalen	Torneträsk
1963				
March				
Mean depth cm	137	38	45	41
Precipitation equivalent mm	530	120	140	130
November				
Mean depth cm	30	23	31	22
Precipitation equivalent mm	80	60	80	60
1964				
January/February				
Mean depth cm	98	14	20	19
Precipitation equivalent mm	340	40	60	60
March/April				
Mean depth cm	104	15	19	28
Precipitation equivalent mm	400	50	60	90
1966				
March				
Mean depth cm	—	29	33	53
Precipitation equivalent mm	—	90	100	160
November				
Mean depth cm	—	29	—	20
Precipitation equivalent mm	—	80	—	50
1967				
March				
Mean depth cm	—	43	32	46
Precipitation equivalent mm	—	130	100	140

Those hummocks in the western part with a vegetation of an eastern type (Fig. 7 B) were found to be covered with snow less than 50 cm thick. The western lawns (explanation in Sonesson 1970) have a snow layer of more than 80 cm on the basis of data available while the eastern ones 0—60 (—approx. 100) cm. The eastern carpets and mud bottoms have a layer of 0—60 (—approx. 100) cm. The western carpets are probably covered with snow equal to or exceeding that of the lawns (80 cm). However, no measurements were actually made.

Temperature

REGIONAL CONDITIONS. The minimum temperatures of the upper parts of the hummock-structures observed during the winter of 1962—63 were —2.0°C in Riksgränsen (date of reading: 18/5), —4.1°C in Stordalen (16/5; ±0.0°C 19/7), —17.0°C in Torneträsk (21/5; ±0.0°C 22/7) and —15.5°C on Mt Luovare (28/8).

Sometimes during late winter of 1963 the temperature of the surface of the hummocks in the eastern sites was found to exceed zero by 0.5—1.0 degrees during sunny days, although the current air temperature was several degrees below zero. The moss layer, however, was firmly frozen below a level of about one centimetre from the surface.

There is an obvious correlation between the temperatures of the mire surfaces in late winter and the depths of snow over the sites (Figs. 3 C, 6 B). The range is wide, however; the widest being measured between about 15 and 60 cm depths. The temperatures over sites with a slight snow cover is of course related to a large extent to the current mean air temperatures.

LOCAL CONDITIONS. The thermograph recordings made in 1963 in a stand of the *Cetraria nivalis - Dicranum elongatum* variant on a hummock-structure in Abisko gave the following results (Fig. 6 A):

March: A snow cover of 7—10 cm during this period of measurements had a moderating effect on the temperature of the surface of the stand. The range of temperatures was thus about 7 degrees while that of the air was about 30 degrees. The precipitation during March 22nd and the morning of the 23rd resulted in a 3 cm thick topmost layer of loose snow. The low air temperature of ca. —23°C then corresponded to a temperature on the mire surface of ca. —13°C. However, after the 25th, when practically all newly fallen snow had blown away, approximately the same air temperature answered to a surface temperature of ca. —16°C.

May: During the first two days the temperature just below the surface (in the moss layer) exceeded or approximately corresponded to that of the air, but after the heavy rain on the 16th it was on average 2—3 degrees lower than that of the air. The range of the readings at the surface was 17 degrees, and that of the air ca. 21 degrees. About 10 cm below surface (frost level at 20 cm) the amplitude was +5—0°C. Even when the temperatures of the upper rods were below zero, that of the 10 cm deep was close to or well above zero.

July: On the whole, the temperature at the surface equalled or exceeded that of the air. The smallest difference in temperature between these rods was measured after the rains of the 22nd and 26th and during the nights and mornings. The range of temperatures of the surface was about 18 degrees, of the air about 15 degrees and at 10 cm depth below the surface about 5 degrees (frost level at 30 cm).

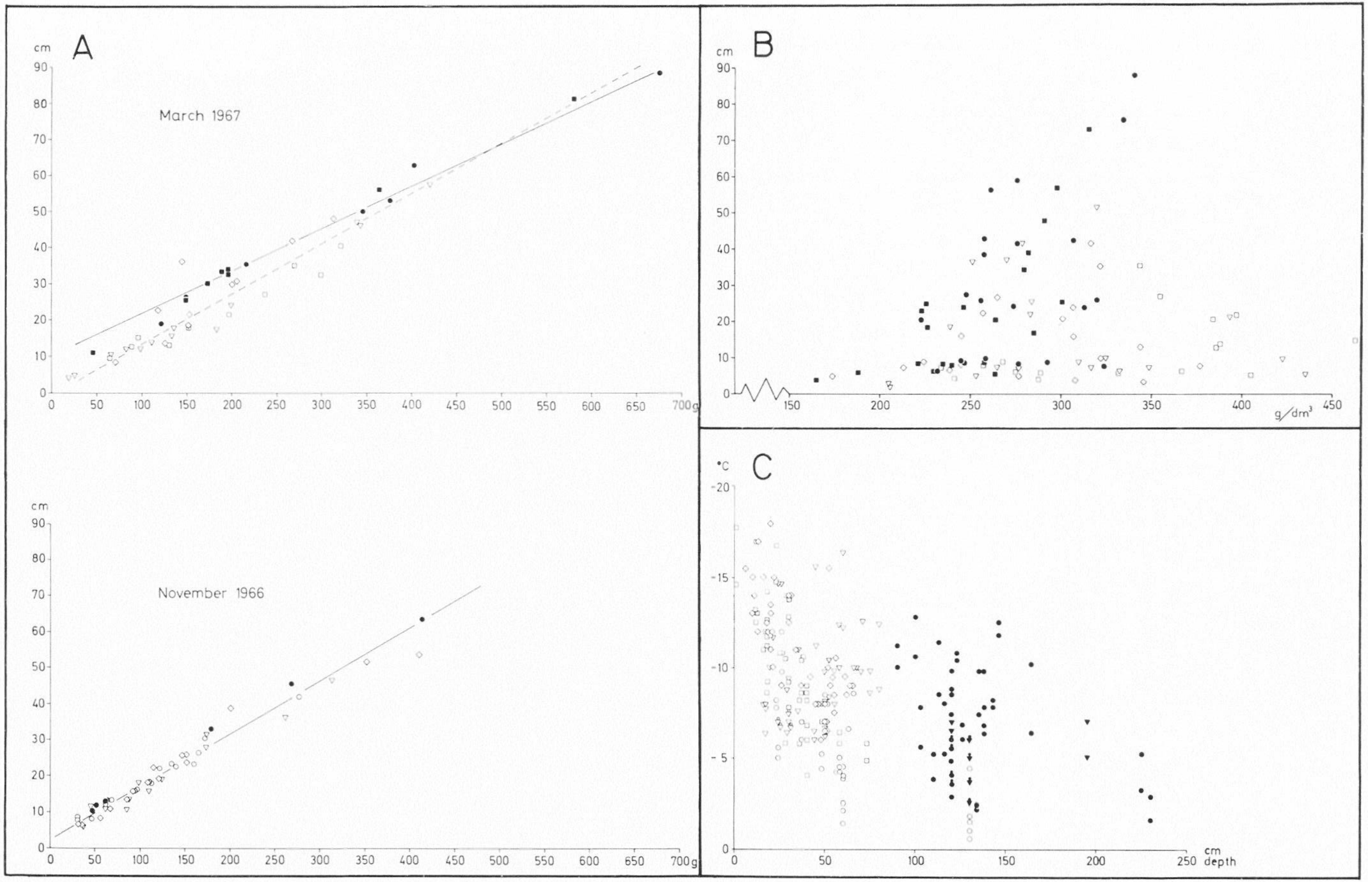


Fig. 3. A. Height and weight of snow pillars (diameter 55 mm) during early and late winter 1966—67. Calculated regression lines shown for all the November values but for the western and eastern March values separately. — B. Depth and apparent density of snow in March 1967. — C. Snow depths and temperatures of mire surface in March 1963. See legend in Fig. 2 A.

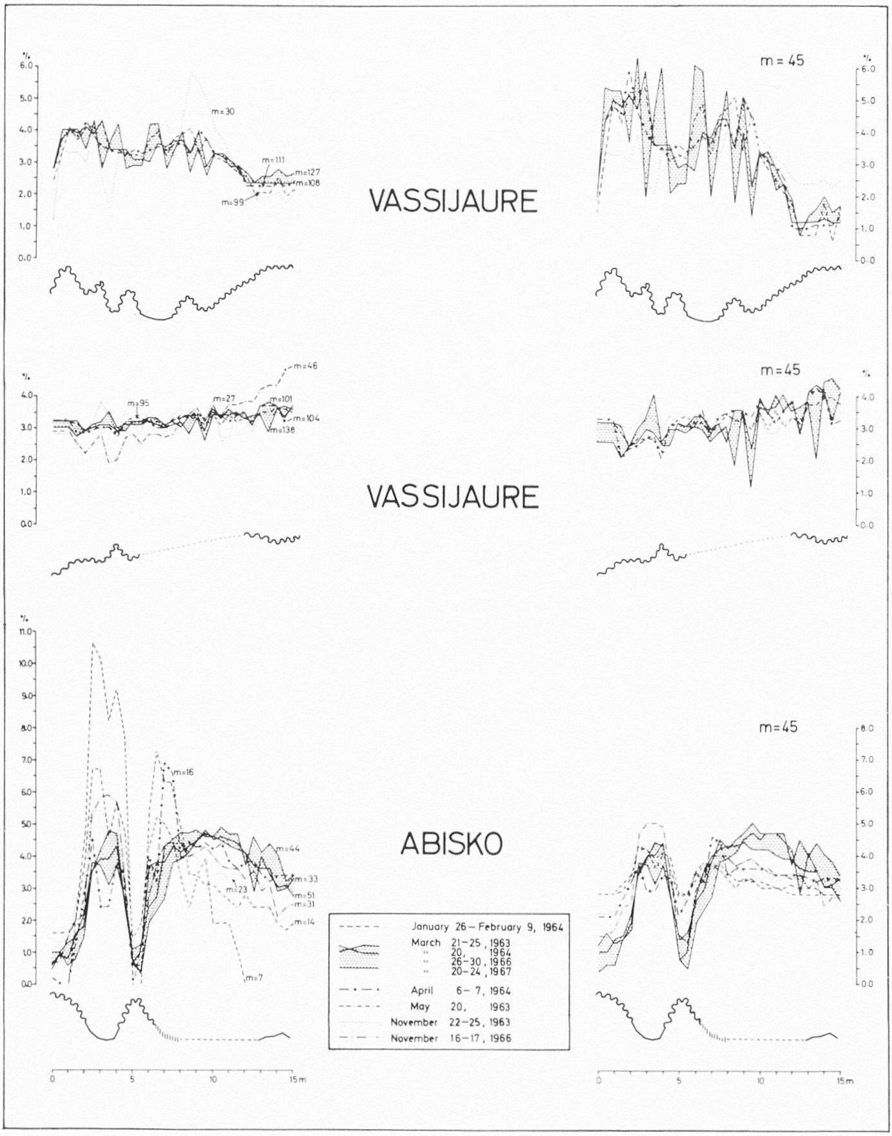
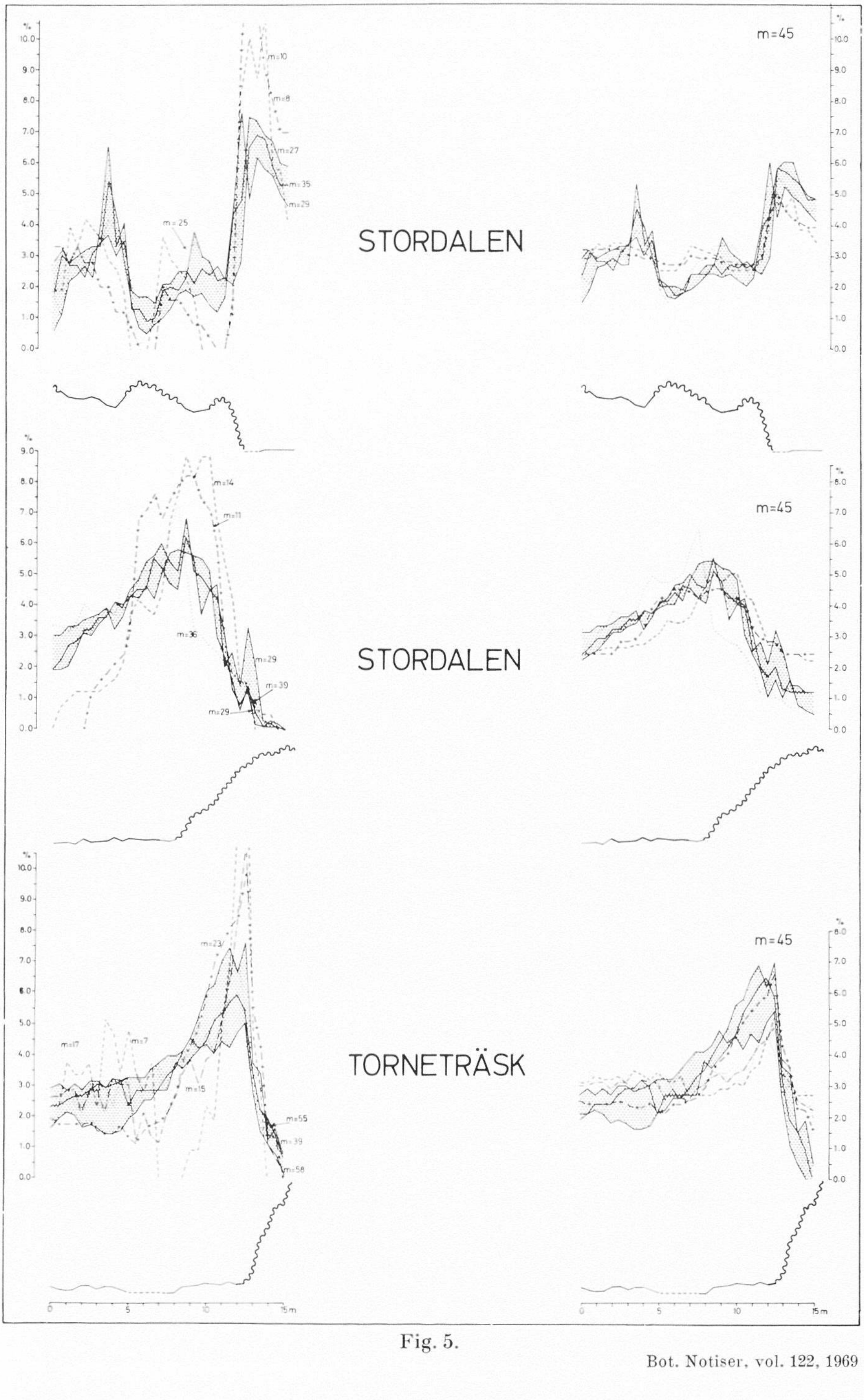


Fig. 4.

Figs. 4—5. Relative snow depths over some transects. Depths given as percentages of the sum of all snow depths for each period and each transect are shown in left columns (m = mean depth). Transformed relative values are given in right columns, i.e. the same calculation sum was used for all periods and transects. The March curves are specially marked. See pp. 482—484, and legend in Fig. 2 A.


STORDALEN
STORDALEN
TORNETRÄSK
%
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
m=10
m=8
m=27
m=35
m=29
m=25
m=45
m=14
m=11
m=36
m=29
m=39
m=29
m=45
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5
10
15m

Fig. 5.

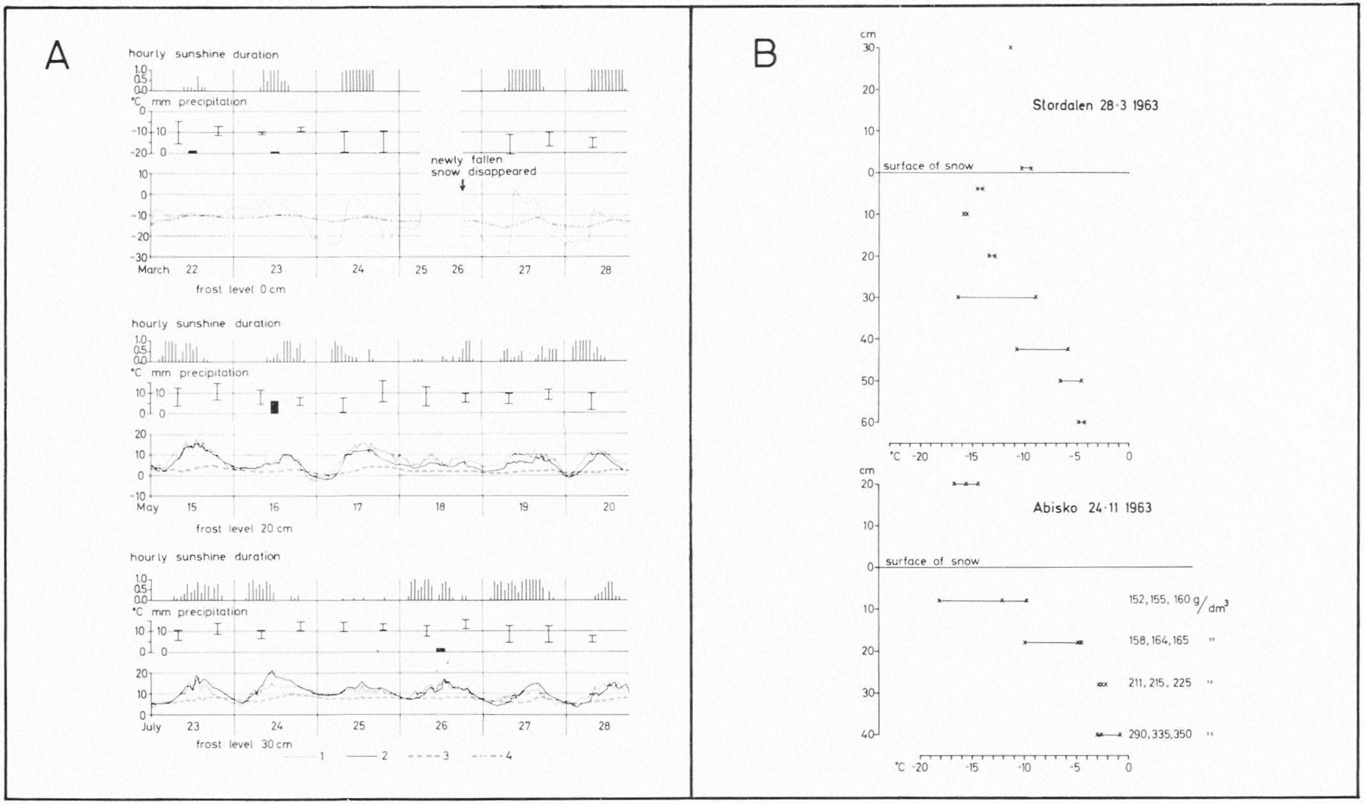

Fig. 6. A. Temperature recordings in a chionophobous hummock community at Abisko. 1. Air temperature (25 cm above snow or mire surface), 2. Temperature in the moss/lichen layer immediately below surface, 3. Temperature at a level 10 cm below mire surface, 4. Temperature on the surface under the snow cover (7 cm on the 21st of March, 10 cm on the 24th). The duration of sunshine during each hour of the day, the maximum and minimum temperatures and the daily precipitation at the Abisko Scientific Station (1 km distant from the site) are also shown. — B. Temperature at different levels of snow cover over mires at Abisko and Stordalen. Apparent density of snow shown for the Abisko site. See pp. 484—485.

Distribution of Snow Depths in Late Winter in Relation to Plant Communities (Fig. 7)

The smallest snow depths were measured over the easterly stands on the higher level of the hummock-structures (see SONESSON 1970). Consequently over the eastern lichen communities and the *Cetraria nivalis* - *Dicranum elongatum* variant the most frequent snow depths were within the range 0—15 cm also during the abnormal year of 1966 (Table 1, see SONESSON op. cit.), while there was a tendency to greater median depths seen in the material from the *Dicranum elongatum* - *Sphagnum fuscum* variant. Over the *Eriophorum vaginatum* - *Sphagnum balticum-russowii* variant (lower level) a median snow depth of about 50 cm or slightly more was measured. The median depths of the eastern lawn, carpet and mud-bottom communities varied between about 20 and 40 cm, but the differences between the measurements of the three years were great in these communities.

Over the stands of the western *Vaccinium myrtillus* - *Pleurozium* variant, *V. myrtillus* - *Pleurozium* - *Sphagnum fuscum* variant and *Carex pauciflora* - *S. fuscum*—*russowii* variant great depths were measured in comparison with their eastern equivalents (above). Especially deep snow covered the mire margin facies. Over the few stands in eastern mires the depths were less but still much deeper than over corresponding levels in the eastern hummock communities (cf. also Fig. 7 B). A similar difference is also obvious concerning the western and eastern stands of the lawn and carpet communities.

The difference in depths between the mire margin and expanse communities is seen in the greater medians and extremes of depths in the mire margin communities.

Height and Cover of Plants in Relation to Snow Depths in Late Winter

HEIGHT (Figs. 8—9). With the exception of *Betula nana* there is no correlation apparent between the height of the shoots and the depth of the snow. The average maximum heights of the shoots measured were: for *Andromeda polifolia* 5 cm (range 1—12 cm), for *Empetrum hermaphroditum* 5 cm (range 1—12 cm), for *Vaccinium myrtillus* 8 cm (range 3—15 cm), for *V. uliginosum* 8 cm (range 1—14 cm) and for *Rubus chamaemorus* 5 cm (range 1—10 cm).

The shoot height of *Betula nana* are positively correlated to the in-

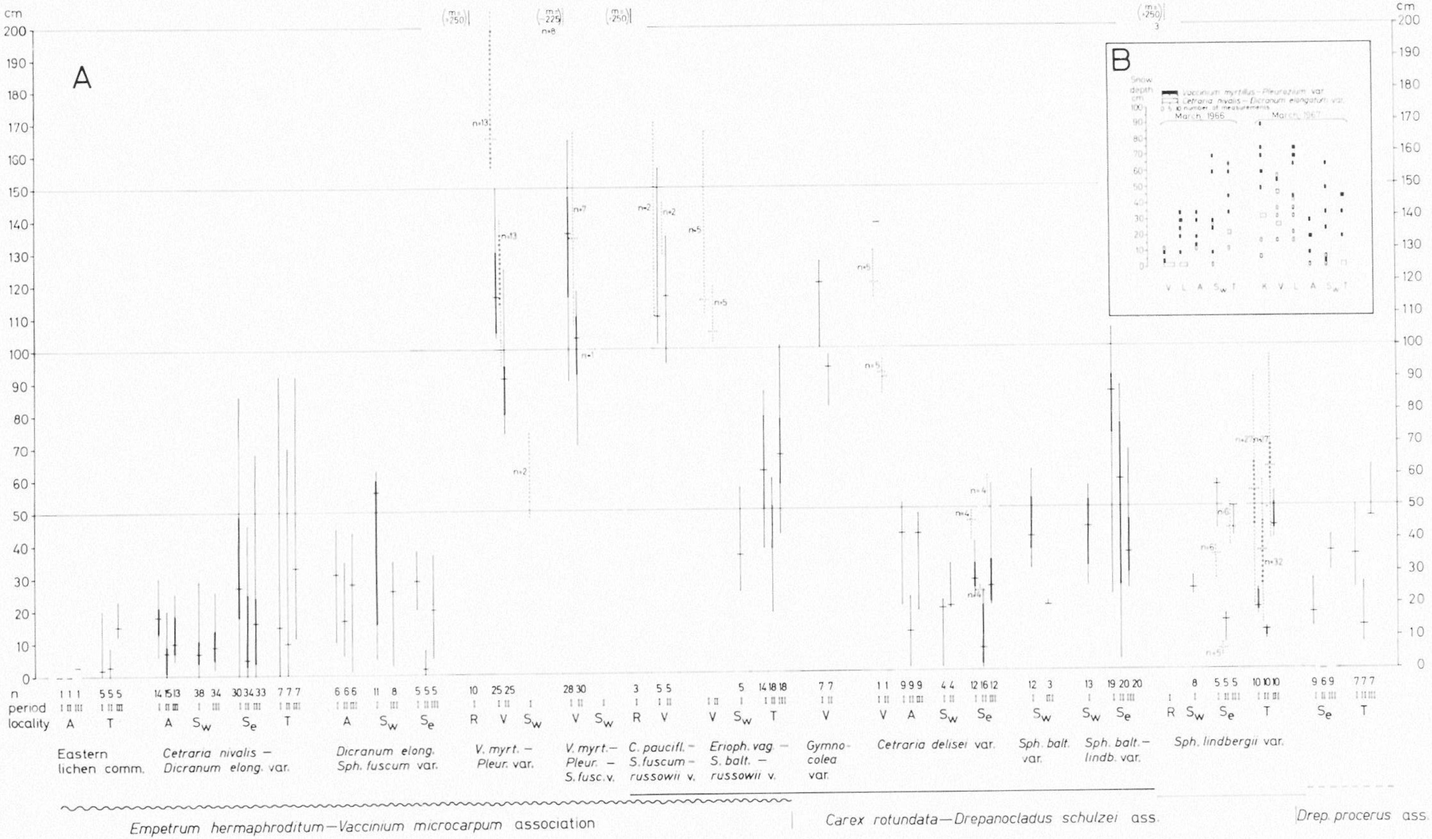

Fig. 7. A. Distribution of snow depths over some mire plant communities during late winter of three years: I. 20—28th May 1963, II. 20th March—7th April 1964, III. 20—30th March 1966. The same plots were measured on each occasion. Median, interquartile range and total range indicated. Dotted lines indicate mire margin facies. — B. Snow depths over two hummock communities during late winter in 1966 and 1967. The same plots were measured on each occasion (see p. 484). Legend in Fig. 2 A.

creasing depths over the eastern hummock vegetation of the mire expanses. This tendency is not seen in the material from the western part nor in that of the lawns (all localities).

The heights of *Betula nana* are also correlated to the level of the Olivacea-limit (definition, see p. 485) both in mire margin communities/wet-growing terrestrial communities near the mires (Fig. 9 B left) and in relatively dry-growing terrestrial communities (Fig. 9 B right). But shoots exceeding 75 cm in height are rare. *Betula nana* was found to be absent or very rarely occurring only (as low, solitary shoots) on places where the Olivacea-limit exceeded 200 cm in height.

COVER (Figs. 8—10). *Andromeda polifolia* decreases as the snow depth increases in all communities under consideration. This is also the case with *Empetrum hermaphroditum* in hummock vegetation both of the margin type and the expanse type. In the lawns, however, there is no apparent correlation. No conclusive evidence of correlation is apparent for *Betula nana* in any of the communities studied. This is also the case for *Vaccinium uliginosum* except in the mire margin type of the hummock vegetation (Fig. 10). However, for *Rubus chamaemorus* the relation is uncertain. The highest covers related to relatively low snow depths are referable to one locality and one community only (Torneträsk: the *Eriophorum vaginatum - Sphagnum balticum-russowii* var.).

Phenology

When evaluating the results it is important to consider the order of sampling days especially during the second period because of the prevalent warm weather immediately before and during that period (see pp. 485—486 and Table 1).

During the first period (30/5—5/6) highest water content values obtained and those specimens best developed morphologically were recorded from the eastern sites (Fig. 11 A, C—D). The highest values for water content were, however, noted in Katterjåkk, although the westernmost locality and not the latest studied. Any corresponding morphological development was not apparent. The relatively low values recorded from Torneträsk may be due to the early sampling.

During the second period (24/6—29/6) similar results were obtained from all the sites, even from the Alpine mire. The small differences are most likely to be due to the different times of sampling and to the sampling and measuring errors.

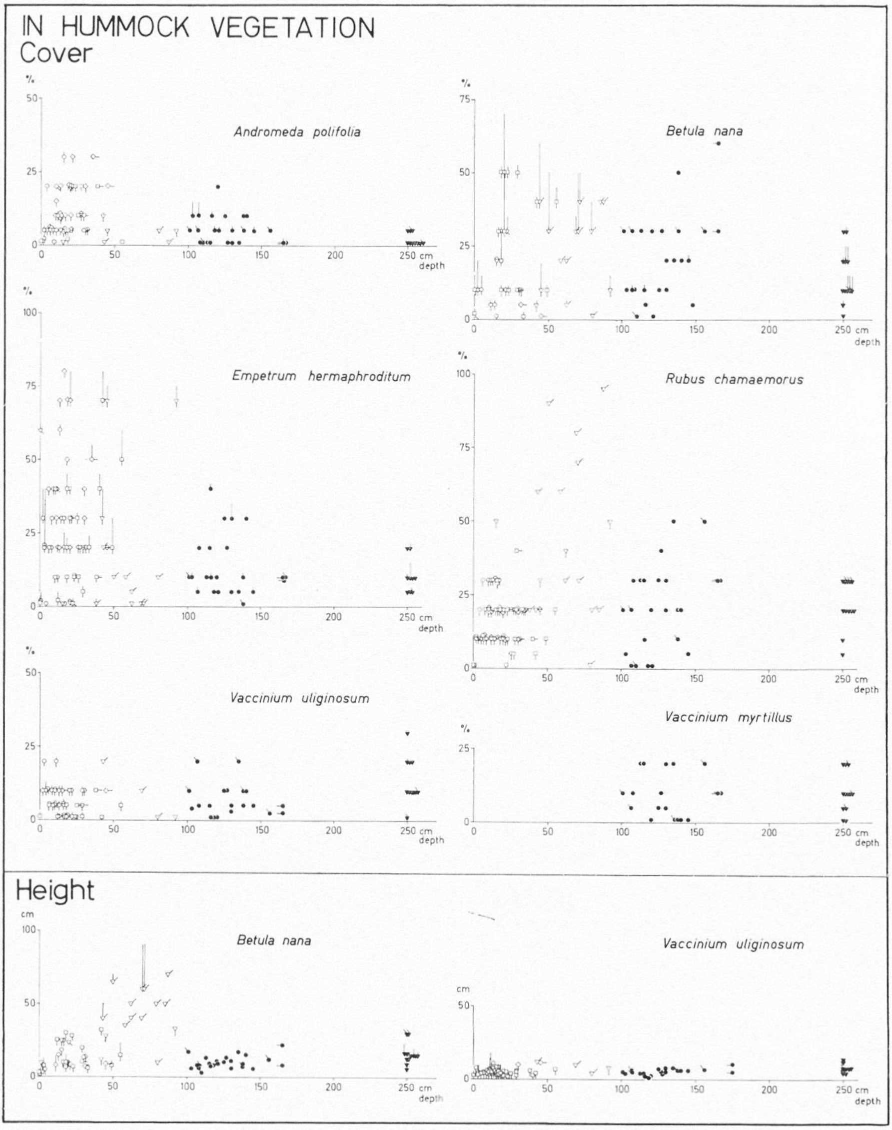

Fig. 8. Cover and height of plants in hummock vegetation (mire expanse type) in relation to snow depths in late winter (March 1963).

Fig. 9. A. Cover and height of plants in lawn vegetation (mire expanse and mire margin types) in relation to snow depths in late winter (March 1963). — B. Range of heights of *Betula nana* shoots in relation to the level of the Olivacea-limit in 1965 (left), range and mean heights of *Betula nana* shoots in relation to the Olivacea-limit in 1967 (right). Further explanations on p. 485, legend in Fig. 2 A.

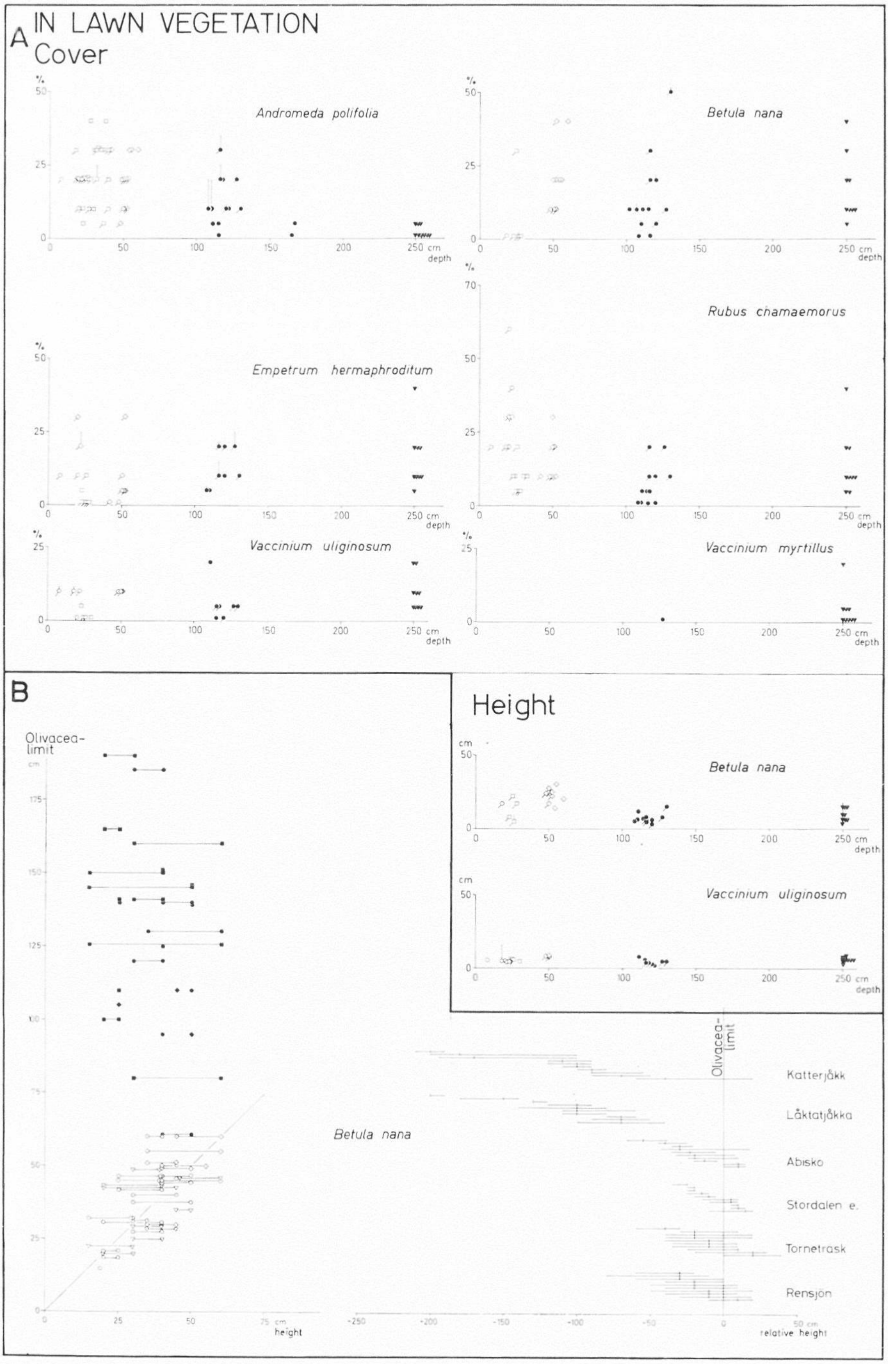
A IN LAWN VEGETATION
Cover
Andromeda polifolia
Betula nana
Rubus chamaemorus
Empetrum hermaphroditum
Vaccinium uliginosum
Vaccinium myrtillus
%
cm depth
B
Height
Betula nana
Vaccinium uliginosum
Olivacea-limit
cm
height
Betula nana
Olivacea-limit
Katterjåkk
Låktatjåkka
Abisko
Stordalen e.
Torneträsk
Rensjön
relative height

Fig. 9.

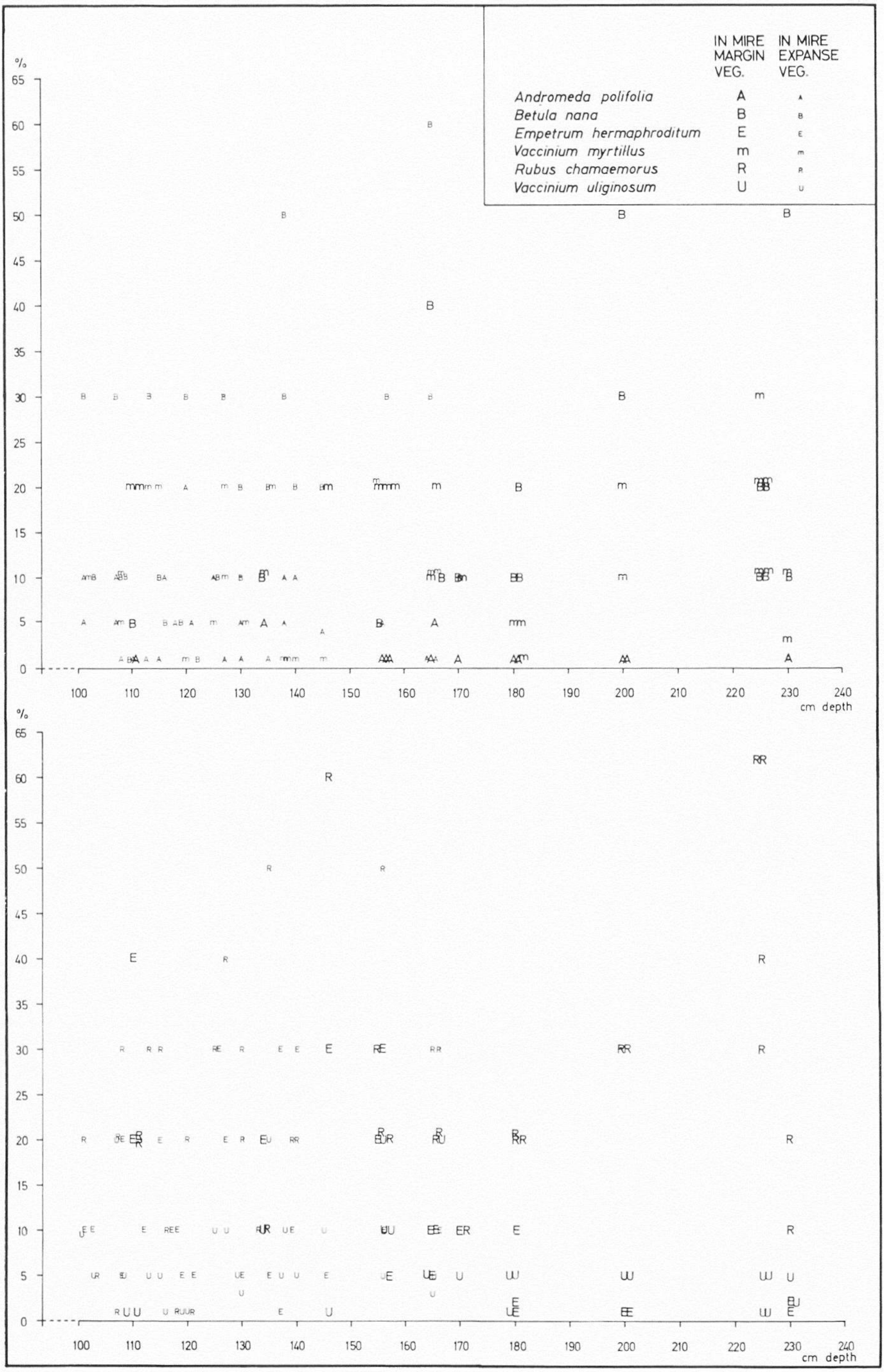

Fig. 10. Cover of plants in hummock vegetation in relation to snow depths over one site at Vassijaure in late winter (March 1963).

Any certain differences between the hummock and lawn communities (all lawn plots situated in depressions) during the two periods are not obvious (Fig. 11 C). The differences are more related to the regional situation of the sampling plots than to the local situation.

Specimens more developed morphologically were found on the south facing plots in comparison with those of the north facing ones (Fig. 11 D). The differences in water content found between the two sides are slight and may well depend on measuring errors and the restricted amount of material.

The differences in the development are related to the water content and not to any differing contents of organic substance of the plants (Fig. 11 B). *Rubus chamaemorus* is, however, an exception in having a considerably increased content of organic matter in the westernmost site studied at the time of the second measuring period. There is, however, a slight tendency of a larger range in the values of loss on ignition during the first period than during the second one.

An obvious vegetative development without any corresponding generative one was, of course, observed in many cases, but with *Empetrum hermaphroditum* the reverse situation was also noted.

On the whole, the vegetative development is related to frost depth (cf. EUROLA 1968 p. 94) although the relationship appears far from being unambiguous. This particularly applies to the water content of plants.

DISCUSSION AND CONCLUSIONS

Period of Snow Cover, Distribution, Temperature

There are great differences in the duration of the snow cover of the western and the eastern mires. The time lag between the melting from the hummocks and depressions in spring was found to be approximately the same, but the eastern hummocks are uncovered for much longer period during spring. They are also exposed frequently during the whole snow season, and the tops of these hummocks may often be covered for only a short time after falls of snow, mainly as a result of the wind blowing the snow free of the hummocks. The thin layer of dense snow or ice often found on the tops, would afford a poor insulation and soon disappears with increasing solar radiation or temporary periods of milder weather.

The one to two week lag between the melting of snow from depressions and even ground was also reported by FRIES (1913 p. 188) in the Subalpine belt of Torne Lappmark.

The result of the measurements of the relative distribution of snow is in accordance with that which could be expected. During the period of snow fall in autumn and early winter, the distribution is more even than during late winter. The alterations caused by wind and mild weather are of course most obvious during late winter.

The difference in snow densities between the western and the eastern sites and between the two periods of measurements reflect the differences in wind speed and frequency of high wind. In addition, the western mires would be better insulated from the winds due to their smaller areas protected by the surrounding forest (SONESSON 1970) affording more sheltered conditions than eastern mires in general (cf. SIRÉN 1936 p. 2).

There is a strong correlation between a short period of snow cover and or a thin cover of snow on one hand and the occurrence of perennial frost in the hummock-sites on the other (cf. SONESSON 1970, see also FRIES 1913 inter alia pp. 194—196). Thus, those structures of the eastern sites which normally have the slightest snow cover are frozen deep into the mineral ground throughout the year, while those of the western sites usually are unfrozen or contain only a thin layer of frost which may persist throughout the summer (SONESSON op. cit.).

The relation between the snow cover and the mire lawns appears ambiguous. The lawns of the eastern hummock-sites are usually perennially frozen (for exceptions, see SONESSON op. cit.), while those outside the sites often contain thin lenses of seasonal frost, sometimes persisting during the summers and autumns. However, the cover of snow is about the same over both types of lawns. In the sites/structures separating the hummock-sites or the hummock and terrestrial sites there are often mire margin species which may indicate moving water (see e.g. DAHL 1956 pp. 212—216, PERSSON 1961 p. 131), e.g. *Polytrichum commune* coll. and *Scapania* spp. However, these species may also be found in the lawns of the hummock-sites containing permafrost (SONESSON 1970).

There is no apparent correlation between the period of snow or snow depths with occurrence of frost in carpets and mud-bottoms. All carpets investigated were unfrozen during summer, and probably are normally only superficially frozen during winter (SONESSON 1970). This seems to be in contradiction to the results of EUROLA (1968) who found a distinct correlation between the snow depths and depths of frost in

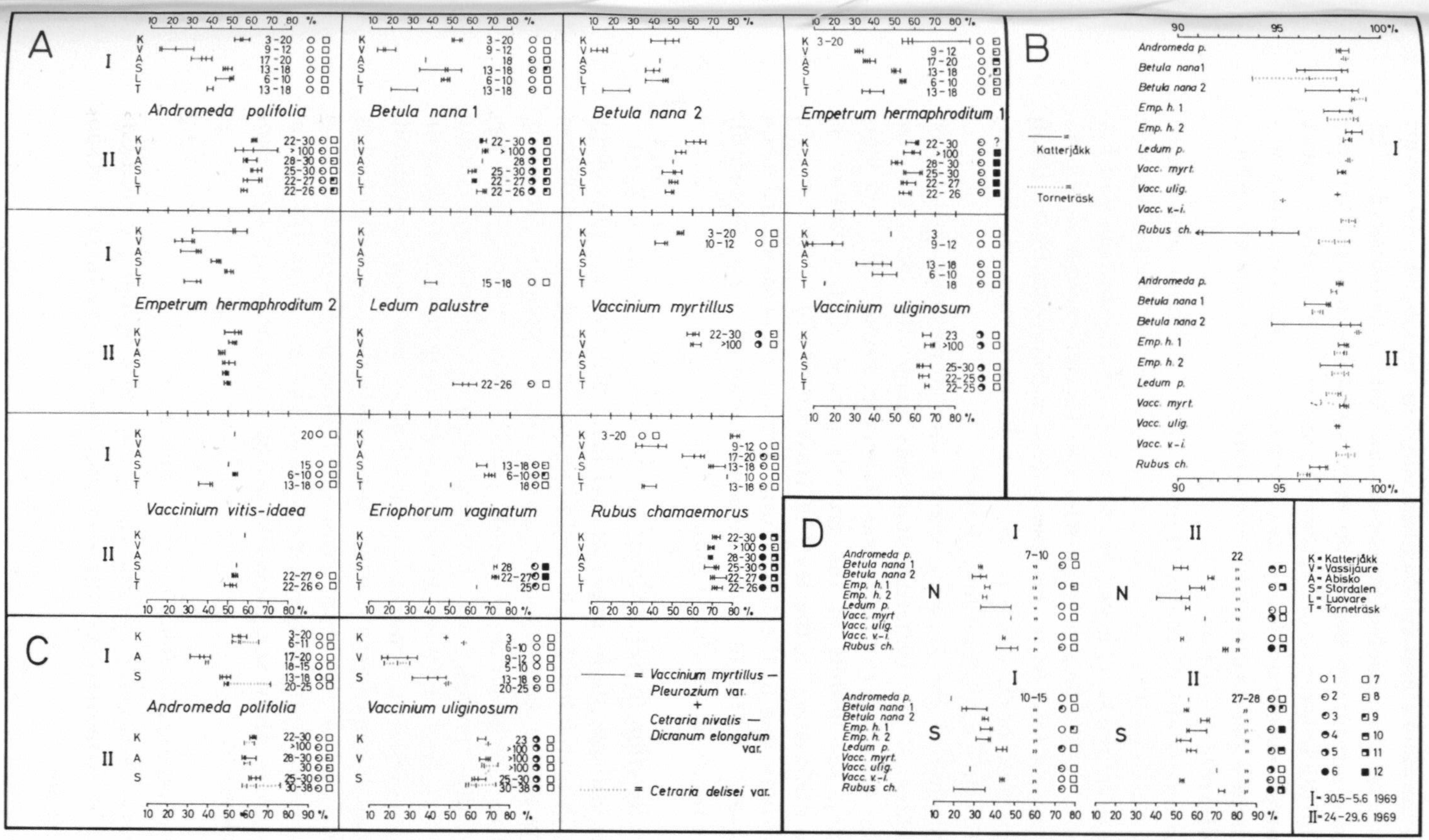

Fig. 11. A. Phenological development of some species in hummock vegetation (mire expanse type) during two periods in late spring—early summer 1969. Water content given as per cent fresh weight. Depths as centimetre to frost table shown. Each site was studied for one day — in the following order: Abisko (A), Torneträsk (T), Vassijaure (V), Luovare (L), Katterjåkk (K), Stordalen (S). Vegetative development: 1. No development observed, 2. Buds swollen/apparent increase in size of shoots, 3. A few leaves half-way developed, 4. Many leaves fully developed, 5. Most leaves fully developed, 6. All leaves fully developed. Generative development: 7. No development observed, 8. A few reproductive organs developed, 9. Many reproductive organs developed, 10. Most reproductive organs developed, 11. Many reproductive organs wilted/some (unripe) fruits observed, 12. Most reproductive organs wilted/many (unripe) fruits observed. — B. Loss on ignition in per cent dry weight. — C. Phenological development of two species in hummock and lawn vegetation (mire expanse type). — D. Phenological development of some species in hummock vegetation of the mire margin type in stands facing north and south respectively. Further explanations on pp. 485—486.

peat both in hummocks and in "Schlenken" (op. cit. p. 90). However, the equivalence between such depressions and the carpet-structures of my investigation area may be slight. The mud-bottoms studied were covered with a thick layer of ice under the snow. During the summer no frost occurred except in many mud-bottoms of the eastern hummock-sites where a permafrost table was normally situated 40—70 cm below the surface of the peat.

The higher temperatures of the mire surface in winter are related to early snow falls as well as to certain depths of snow. The snow cover of the eastern hummocks is insufficient to prevent the influence of the air temperature. A 30—50 cm layer seems to be the average depth required. This agrees well with the results received by e.g. DAHL (1956 p. 271) and by SANDBERG (1958 p. 55). But the data vary greatly possibly due to the differences in snow density.

At the beginning of the growing season the temperature just below the moss surface of the eastern hummocks generally seemed to be lower than the air temperature. It was, however, higher than air temperature during the middle of the growth period. This condition is related to the differences in the level of frost table and to the varying thermal diffusivity due to the fluctuating wetness of peat (cf. EUROLA 1968 pp. 85—86). Different wind velocities may also be important, but they have not been measured here.

Phenology in Relation to Snow Cover

The results indicate slight regional and local differences; phenology seems to be little related to chionophilous-chionophobous conditions (cf. SØRENSEN 1941 p. 68). After the snow thaw temperature obviously determines the development of many plants (see EUROLA 1968 pp. 93—94). Broadly speaking the low temperatures prevailing during May and the first half of June 1969 were inadequate to initiate growth. Only plants in sites with a warmer local climate were more advanced. Since the mean temperatures during April—July are normally higher in the eastern part of the area investigated than in the western part there may be greater phenological differences in a west—east direction during other years. However, a counteracting ecotypic adaptation cannot be excluded.

Vegetational Gradients in Relation to Snow Cover

The difference between chionophobous and chionophilous conditions in the sense of NORDHAGEN (1927—1928, 1943), GJAEREVOLL (1956, 1965), Dahl (1956) and Bringer (1965) seems to be mainly related to differences in the length of the period of snow cover. Differences are therefore not necessarily always dependent on the snow depths in late winter; however, since the snow normally falls at the same time in autumn over the whole Boreal part of the investigation area (p. 486) and there are small differences in precipitation and temperature during spring (April—June, see Sonesson 1970 Fig. 3), the different snow depths in late winter also seem to well answer to the differences in periods of snow cover.

From the observations on occurrence of plants in relation to the snow a tentative arrangement of some of them can be made along the gradient chionophobous—chionophilous:

	Chionophobous—Chionophilous			
Alectoria nigricans	×	—	—	—
Dicranum elongatum	×	(×)	—	—
Cetraria cucullata	×	(×)	—	—
Cetraria nivalis	×	(×)	—	—
Andromeda polifolia	×	×	(×)	—
Empetrum hermaphroditum	×	×	(×)	—
Vaccinium uliginosum	×	×	×	(×)
Rubus chamaemorus	×	×	×	×
Betula nana	—	(×)	×	×
Vaccinium myrtillus	—	—	×	×
Pleurozium schreberi	—	—	×	×

It is difficult to ascertain the direct reason for the differences in cover and height of the plants related to the snow depths. Different depths also mean different physical and chemical conditions to the plants (cf. Geiger 1961). The measurements were carried out during the middle—late part of the growth period (see Sonesson op. cit.). Any unequalities in the phenological development which would have influenced the results are then less probable.

Considering *Empetrum hermaphroditum,* shoots with dead parts were most frequent in the eastern sites. This indicates an influence of desiccation and or abrasion of wind and drifting snow during winter—early spring as in *Betula nana* (cf. Vestergren 1902 pp. 247—248), because the hummocks of these mires emerge much earlier than those of the western mires. However, a more direct influence of low temperatures cannot be excluded.

Desiccation (and or abrasion and low temperatures) also seems to be serious to *Pleurozium schreberi.* Thus in March 1966 when there was an abnormal distribution of snow (p. 497) the tops of the hummocks in the western Boreal sites at Katterjåkk and Vassijaure were not covered with snow, where the depths normally during that season are great. Many of the tops with an apparently fresh moss layer were marked on that occasion and were again studied in the summer of 1967. On all higher hummocks *Pleurozium* was found to differ markedly in colour. It had adopted a light greyish colour never before seen by me in these mires. Many of the specimens had shrunk considerably in size and were also crumbled.

Even to chionophilous plants an excessive cover of snow seems to be related to a decrease of the cover and height of the subaerial parts. Thus *Betula nana* is absent or very sparse over sites where the Olivacea-limit exceeds 2 metres in height (p. 499) (cf. e.g. Vestergren 1902 p. 246, Fries 1913 pp. 209—211, Nordhagen 1943 p. 87).

In the mires of the Scandes (i.e. the mountainous western part of Scandinavia, cf. Sonesson 1967 p. 274) *Calluna vulgaris - Empetrum hermaphroditum* and *Calluna - Betula nana* seem to be vicarious (Sjörs 1950 p. 182 and Dahl 1956 p. 246 respectively). This is due to different distributions parallelled by the gradient oceanic—continental climate (Dahl op. cit., cf. Sonesson op. cit.). It also seems to be related to different distributions along the gradient chionophobous—chionophilous as well. In relatively continental areas at least *Empetrum* occurs in a higher quantity over chionophobous sites, while *Betula nana* or *Calluna,* if present cf. Sonesson op. cit.), is quantitatively more important over the chionophilous areas (see e.g. Fries 1913 p. 207, Du Rietz 1925 b pp. 38—39, 1950 p. 12, Sandberg 1958 p. 50, Bringer 1965 p. 258). Although this difference is only slight, it is apparent concerning *Betula nana* in the table material of Boreal hummock vegetation in the Torneträsk area too:

	Vacc. myrt. - Pleur. var.	*Cetr. niv. - Dicr. elong.* var.	*Vacc. myrt. - Pleur. - S. fusc.* var.	*Dicr. elong.- S. fusc.* var.	*Carex pauc. - S. fusc. - russ.* var.	*Erioph. vag. - S. balt.- russ.* var.
	w	e	w	e	w	e
Empetrum hermaphroditum	95^{24}	96^{26}	93^{27}	100^{33}	71^{10}	56^{5}
Betula nana	89^{10}	26^{9}	82^{23}	65^{13}	91^{14}	56^{14}
Number of stands: squares	5:19	6:30	8:27	7:25	5:21	4:16

Communities with approximately the same relative level in the western (w) and the eastern mires (e) (see Sonesson 1970) are put together in this table. Characteristic degrees of cover are given as per cent. It must be emphasized however, that this material was not sampled at random.

Calluna vulgaris may also be more directly dependent on temperature (concerning Fennoscandian literature see FRIES 1913 p. 341 and RUUHIJÄRVI 1960 p. 148) and nutrients (EUROLA 1962 p. 160) in oceanic areas besides the sheltering of snow during winter (cf. NORDHAGEN 1927—1928 p. 218, EUROLA 1968 p. 96). The taxonomy of *Calluna* is also under discussion (cf. SONESSON 1967 and literature cited there).

The results of the investigation of distribution of snow over different plant communities show that the communities of the mire margins as well as those of the westerly distribution types are, on the whole, covered with deeper snow in late winter than the communities of the expanses and those of an easterly type of distribution.

There is a correlation between the snow depths in late winter and the gradient chionophobous—chionophilous vegetation (SONESSON 1970) with regard to the hummock communities of the higher levels in the sites (see Fig. 7). The stands dominated by *Pleurozium schreberi* in the eastern sites were all located at the mire margins while those in the western sites were mainly located at the expanses. Thus these differences, to a great extent, also reflect the differences along the gradient mire margin—mire expanse as well as the gradient west—east (cf. SONESSON 1967).

Some of the chionophilous communities, at least those of an easterly distribution, are better related to a long covering of snow and water than directly to the depth of snow. A large portion of the annual precipitation is liberated as water in spring (Table 2, cf. Fig. 1). The wetness of the peat then seems to be only temporary increased in the western sites but can be prolonged in the depressions in the eastern sites, especially on perennially frozen ground.

There is no correlation apparent between the carpet and mud-bottom communities and the snow depths in late winter.

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Mrs. Mimmi Varga has drawn most of the figures. The English text was corrected by Miss A. Rosemary K. Wands.

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Comprehensive Key to the Species of Aspalathus (Leguminosae)

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INTRODUCTION

The genus *Aspalathus* L. (incl. *Borbonia* L.) has been revised in the series "Revision of the Genus Aspalathus" published in Opera Botanica 4, 6 (2), 8 (1), 10 (1), 11 (1), 21 and 22 and Botaniska Notiser 121: 165—208. In this revision the species have been assembled in a great number of groups, within which there has been obvious resemblance in morphological characters between the species. Some groups are relatively large, others consist of a single species. Keys have been provided previously for the species of all the groups with more than one species, and keys have also been given for the species with flat (trifoliolate and simple) leaves in Opera Botanica 4 and 22. However, no comprehensive key has been given for all the species. As the desire for such a key has been pointed out to me by several South African botanists, it is presented here.

The key has been constructed so as to include as completely as possible the forms of each species. Too aberrant or peripheral specimens in the variation may fall outside the key, however. The authors' names have not been inserted in the key but are given in an alphabetic list for the species at the end. This list has been considered necessary because of the richness in current synonyms and homonyms. An index to all the *Aspalathus* species, with indication of where descriptions, illustrations and maps have been published, was given in the last part of the revision, Opera Botanica 22: 119—126.

In order to use the key, fresh material is of course desirable, although seldom available. When determining dried material, especially with small and/or fragile details, flowers should be boiled up in water quickly (for 5—30 seconds depending on the material) in order to retain the original size and shape. (In fact, practically all the information on size has been obtained from dried material quickly boiled.) "Brachyblast" in the key is synonymous with short-shoot.

KEY 1

1 A. Leaves simple .... 2 A
1 B. Leaves trifoliolate .... 9 A
2 A. Leaves distinctly flat .... 3 A
2 B. Leaves linear, subterete or only slightly flattened .... 7 A

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3 A. Stigma elongate, forwardly directed, fig. 4 J (subgenus *Rafnioides*) .... *A. nudiflora*

3 B. Stigma subcapitate, not or only slightly forwardly directed, fig. 4 L—M .... 4 A

4 A. Leaves silvery-sericeous on both sides *and* carina sericeous ...... 5 A

4 B. Leaves not closely sericeous, or if so always with glabrous carina (former genus *Borbonia*) .... **Key 19**

5 A. Flowers in a several—numerous flowered apical spike, fig. 1 A .. 6 A

5 B. Flowers solitary on lateral brachyblasts, thus distributed on long distances of the branches .... *A. caledonensis*

6 A. Calyx lobes deltoid, only 0.5—1.5 mm long .... *A. altissima*

6 B. Calyx lobes narrowly triangular, 2.5 mm long or more .... *A. sericea*

7 A. Stigma elongate, forwardly directed (subgenus *Rafnioides*) .... *A. nudiflora*

7 B. Stigma subcapitate, not or only slightly forwardly directed (subgenus *Nortieria*) .... 8 A

8 A. Treelike plant with pendulous branches; carina blades 6.5—7 mm long .... *A. pendula*

8 B. Low or rather high shrub; branches usually not pendulous; carina blades 6 mm long or less .... *A. linearis*

9 A. Bracteoles (and bracts) trifoliolate, fig. 3 D (subgenus *Triplobractea*) .... **Key 2**

9 B. Bracteoles simple; bracts trifoliolate or simple .... 10 A

10 A. Petals white, violet, or purplish, entirely without yellow colour; bracts trifoliolate, trilobate, or simple (often of all these shapes in the same inflorescence acropetally, fig. 3 A—C) and when simple apparently corresponding to 3 folioles (flowers 2—several in groups, heads, or spikes on the branch tips; ovary always 2-ovulate; style delicate; pod small, less than 7 mm long, one-seeded; leaves not silvery-sericeous: subgenus *Purpureipetala*) .... **Key 3**

10 B. Petals usually partly or entirely yellow, but often with red or purplish shades, seldom entirely of different colour and *if so* the flowers solitary on lateral short-shoots *or* the pods more than 8 mm long *or* the leaves silvery-sericeous; bracts trifoliolate or simple .... 11 A

11 A. Bracts trifoliolate, at least on the lower (peripheral) flowers in the inflorescence .... **Key 4**

11 B. Bracts simple (or seldom absent) .... 12 A

12 A. Leaflets distinctly flat, of variable shape .... 13 A

12 B. Leaflets ericoid or pinoid and subterete or angular (sometimes slightly sulcate or depressed, but not flat) .... 19 A

13 A. Flowers, solitary or in sparse racemes, on peduncles which emerge as it seems laterally and opposite a leaf, fig. 1 C (in reality the inflorescence terminal and the branch system sympodial) .... **Key 5**

13 B. Flowers not on peduncles which seemingly emerge laterally and opposite a leaf .... 14 A

14 A. Calyx tube glabrous on most parts of the outer side (except, sometimes, on the base) .... **Key 6**

14 B. Calyx tube pubescent on most of the outer side .... 15 A

15 A. Flowers extremely small, directly on the branches below leafy branch ends (by concrescence of axillary short-shoot); leaflets flat but with involute margins and densely woolly upper side, fig. 2 B (subgenus *Ecklonella*) .... *A. diffusa*

15 B. Flowers not in such a position, when small-flowered not having flat leaves with involute margins and woolly upper side .... 16 A

16 A. Flowers in spikes, heads, racemes, or umbels (flowers usually 3 or more together) on branch or branchlet tips .... 17 A

16 B. Flowers solitary or binary on branch or branchlet tips or on lateral short-shoots .... 18 A

17 A. Inflorescence compact, headlike or umbel-like, not ovate or more elongate .... **Key 7**

17 B. Inflorescence more or less elongate, a spike or raceme .... **Key 8**

18 A. Flowers solitary or in pairs on the tips of well developed branchlets (or branches) .... **Key 9**

18 B. Flowers solitary (or binary) on lateral short-shoots (i.e. in the centre of lateral leaf clusters) .... **Key 10**

19 A. Flowers solitary or binary on lateral short-shoots (i.e. situated in the centre of lateral leaf clusters), the appearance of the branch ends being often "pseudospicate", fig. 1 B .... 20 A

19 B. Flowers solitary or 2—several on the tips of branchlets with one—many distinct internodes (the latter occasionally peduncle-like and ± leafless), fig. 1 E .... 24 A

20 A. All petals glabrous (the very base of the vexillum back sometimes excepted) .... **Key 11**

20 B. Petals (at least the apex or midrib of the vexillum back) with some pubescence .... 21 A

21 A. Carina entirely glabrous .... 22 A

21 B. Carina ± pubescent .... **Key 12**

22 A. Leaflets also when fully developed (not only in the juvenile stage) covered with close, grey-sericeous pubescence .... **Key 13**

22 B. Leaflets when fully developed green, either glabrous or sparsely and often spreadingly pubescent or puberulous .... 23 A

23 A. Leaflets sharply spine-tipped .... **Key 14**

23 B. Leaflets not sharply spine-tipped, varying from obtuse to acuminate or mucronate .... **Key 15**

24 A. Petals entirely glabrous (except for some pubescence on the vexillum base and some ciliation on petal margins) .... **Key 16**

24 B. Petals not entirely glabrous, at least the apex or midrib (and the base) of the vexillum pubescent .... 25 A

25 A. Carina glabrous .... **Key 17**

25 B. Carina ± pubescent .... **Key 18**

KEY 2

1 A. Very robust and large-flowered; carina blades more than 15 mm long (corolla sometimes bright yellow, sometimes cream-coloured) .... *A. grandiflora*

1 B. Not so robust or large-flowered; carina blades 13 mm long or less (corolla always bright or light yellow) .... 2 A

2 A. Upper calyx lobes broadly triangular, calyx closely sericeous or lanate .... 3 A

2 B. Upper calyx lobes narrowly triangular (like the lower) or linear-triangular, with ± subulate apices; calyx sparingly long-sericeous or, at least the lobes, almost glabrous .... *A. galeata*

3 A. Longest leaflets usually 6—12 mm long; vexillum blade usually more than 13.5 mm broad; pod more than 11 mm long and 7 mm broad; shrublets about 1 m tall or more .... *A. densifolia*

3 B. Longest leaflets usually less than 5 mm long; vexillum blade usually less than 13.5 mm broad; pod less than 11 mm long and less than 7 mm broad; shrublets less than 1 m tall .... *A. triquetra*

KEY 3

1 A. Carina glabrous; upper two calyx lobes separated from each other by a relatively deep split, fig. 1 F (flowers always cream-coloured) .... *A. forbesii*

1 B. Carina more or less hairy; split between upper lobes not or only slightly deeper than those between the other lobes .... 2 A

2 A. Inflorescence with a relatively large number of ovate, imbricate bracts or bractlike leaves, the lowest without flowers in their axils .... *A. globulosa*

2 B. Inflorescence base not subtended by numerous close leaves, or if so (*A. globosa*) these not ovate, but mainly trifoliolate or trilobate .... 3 A

3 A. Ala blades more than 10 mm long, with apical parts glabrous; carina beaklike .... *A. rosea*

3 B. Ala blades less than 10 mm long, ± hairy also on apical parts (seldom, as in forms of *A. submissa* and *nigra*, partly glabrous); carina not beaklike .... 4 A

4 A. Calyx lobes, bracts, and bracteoles filiform and slender .... 5 A

4 B. Calyx lobes shortly linear, triangular, ovate, or obtusely semicircular; bracts and bracteoles not filiform and slender .... 6 A

5 A. Ala blades usually less than 5 mm long and less than 2 mm broad; calyx lobes very slender; leaflets usually incurved; inflorescence globose .... *A. cerrhantha*

5 B. Ala blades more than 5 mm long and 2 mm broad; calyx lobes not so slender although linear—subfiliform; leaflets usually straight; inflorescence elongate, ovate, or globose .... *A. cephalotes*

6 A. Corolla densely woolly—villous; shrubs up to more than one metre high .... 7 A

6 B. Corolla sericeous or partly tomentose; shrubs less than one metre high .... 8 A

7 A. Inflorescence globose, subtended by a number of close imbricate leaves which are trifoliolate or variously trilobate; calyx lobes less than 2.5 mm long .... *A. globosa*

7 B. Inflorescence elongate, not subtended by close leaves; calyx lobes 5—6 mm long (similar in habit to *A. cephalotes*) .... *A. barbigera*

8 A. Bracts more than 5 mm long and bracteoles more than 4 mm long; calyx lobes generally more than 3 mm long .... *A. cephalotes*

8 B. Bracts less than 3.5 mm long and bracteoles less than 4 mm long; calyx lobes generally less than 3 mm long .... 9 A

9 A. Bracts in the upper part of the inflorescence always simple (but lowest ones trifoliolate or trilobate), fig. 3 A—C; ala blades usually 2 mm broad or more; calyx lobes triangular or semicircular (subacute or obtuse) .... *A. nigra*

9 B. Bracts usually trifoliolate throughout; ala blades usually less than 2 mm broad; calyx lobes generally broadly lanceolate or narrowly ovate, acute—acuminate, often subglabrous .... *A. submissa*

KEY 4

1 A. Leaves (on long-shoots) supplemented at the base by a very sharp, woody spine usually 3—7 mm long, fig. 3 G .... *A. aculeata*

1 B. Leaves not supplemented at the base by a spine .... 2 A

2 A. Bracts of peripheral (lower) flowers in the inflorescence with a stalk or petiole 1—4 mm long, fig. 3 H .... *A. chenopoda*

2 B. Bracts not with stalklike basal portion, fig. 3 E—F .... 3 A

3 A. Leaflets of vegetative leaves mostly less than 4 mm long, obtuse (plant similar to *A. ciliaris,* but smaller in all parts) .... *A. millefolia*

3 B. Leaflets of vegetative leaves mostly (4—) 5 mm long or more .... 4 A

4 A. Calyx lobes narrowly linear or acicular, usually about 0.5 mm broad or less for most of their length .... 5 A

4 B. Calyx lobes from linear to lanceolate or almost ovate, at least the upper lobes much more than 0.5 mm at about the middle of the length . . . 8 A

5 A. Carina blades partly with minutely sericeous pubescence and less than 6.5 mm long (calyx lobes usually partly purplish) .... *A. pigmentosa*

5 B. Carina blades glabrous, more than 6.5 mm long (calyx lobes usually not purplish) .... 6 A

6 A. Carina blades more than 9.5 mm long; leaves usually rigid and spiny; petals becoming ± ferruginous—reddish .... *A. rubiginosa*

6 B. Carina blades less than 9.5 mm long; leaves not spiny .... 7 A

7 A. Flowers in close heads; petals constantly yellow .... *A. araneosa*

Fig. 1. *Aspalathus:* A—E: branches; F—I: calyx or part of calyx. — A: *A. sericea* × 1.6 — B: *A. ericifolia* (ssp. *minuta*) × 2. — C: *A. comptonii* × 2.4 — D: *A. alpestris* × 2. — E: *A. concava* × 2. — F: *A. forbesii* × 4. — G: *A. glabrata* × 4. — H: *A. recurva* × 4. — I: *A. cymbiformis* × 4.

The illustrations of details on this and the following plates are also found, though often on different scale, in parts of "Revision of the genus Aspalathus" and in "Studies on Aspalathus and some related genera in South Africa", to which the reader is referred for further information.

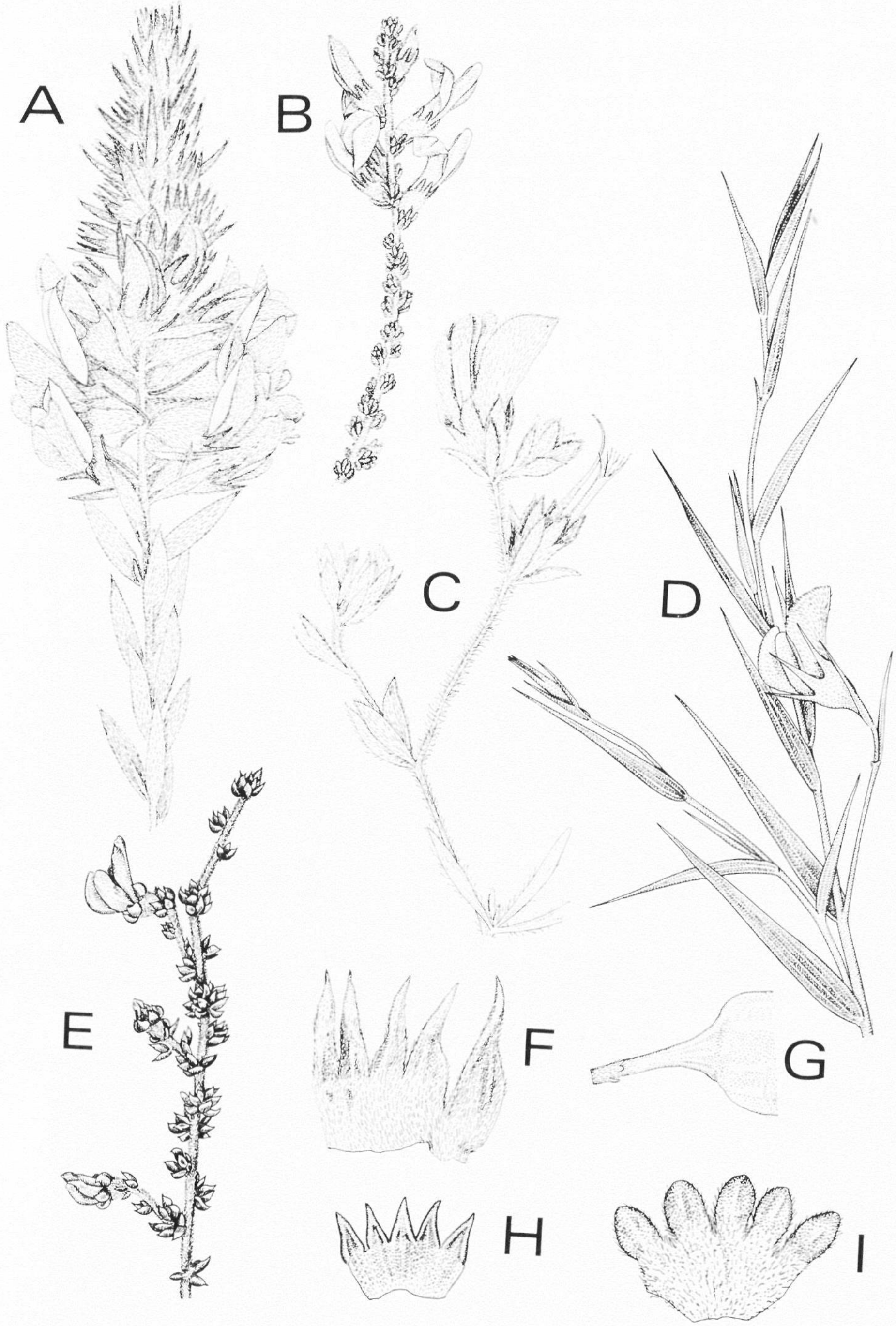

Fig. 1.

7 B. Flowers solitary or in pairs; petals usually turning ferruginous .... *A. spicata*
8 A. Carina at least partly sericeous .... *A. ciliaris*
8 B. Carina glabrous .... 9 A
9 A. Ala blades usually more than 7 mm long; vexillum cusp less than 1 mm long .... *A. ciliaris*
9 B. Ala blades usually ca. 7 mm long or less; vexillum cusp about 1 mm long or more .... *A. spicata*

KEY 5

1 A. Carina blades sericeous .... 2 A
1 B. Carina blades glabrous .... 3 A
2 A. Calyx lobes ca. 3 mm long; bracteoles 4—5 mm long; leaf pubescence rather sparse and lowest leaves glabrescent, light-green, fig. 1 C .... *A. comptonii*
2 B. Calyx lobes 1.5—2.5 mm long; bracteoles 1.5—3 mm long; pubescence closely silvery-sericeous, lowest leaves usually not glabrous and light-green .... *A. bodkinii*
3 A. Leaflets (the largest) less than 1 cm long .... 4 A
3 B. Leaflets more than 1 cm long .... 5 A
4 A. Carina blades connate to their tips .... *A. bracteata*
4 B. Carina blades connate to a ± distinct little lobe 1—2 mm below their tips, fig. 4 F (alpine plant) .... *A. patens*
5 A. Leaflets usually more than 1.5 mm broad .... 6 A
5 B. Leaflets less than 1.5 mm broad .... *A. bracteata*
6 A. Ala blades ca. 4.5 mm broad; calyx lobes 7—9 mm long; leaflets attenuately acuminate .... *A. latifolia*
6 B. Ala blades 2.5—3 mm broad; calyx lobes usually less than 6 mm long; leaflets linear, lanceolate or falcate, not attenuately pointed .... *A. lanata*

KEY 6

1 A. Flowers several together in terminal heads or headlike spikes .... 2 A
1 B. Flowers solitary on branchlet tips or solitary or in pairs on axillary brachyblasts .... 6 A
2 A. Vexillum back and carina partly puberulous .... *A. myrtillifolia*
2 B. Vexillum back (except the base) and carina glabrous .... 3 A
3 A. Ala blades with several (5—7) rows of lunulate folds on upper part near base .... 4 A
3 B. Ala blades with one (—2) row(s) of irregular transverse folds on upper half, fig. 3 W .... 5 A
4 A. Largest bracts not more than 8.5×2.5 mm .... *A. fusca*
4 B. Largest bracts generally more than 11 mm long and more than 6 mm wide .... *A. vacciniifolia*
5 A. Branches glabrous (except at the very nodes), sulcate ...... *A. callosa*

5 B. Branches puberulous, subterete (more small-flowered than A. *callosa*) .... *A. tylodes*
6 A. Leaflets ending in spines .... *A. abietina*
6 B. Leaflets non-spiny .... 7 A
7 A. Vexillum back partly short-sericeous; leaflets glaucous, spathulate .... *A. sulphurea*
7 B. Vexillum back glabrous; leaflets green, linear, sulcate on lower and upper sides, fig. 2 C .... *A. mundiana*

KEY 7

1 A. Leaflets 3—6 cm long, narrowly linear; flowers large, with petals almost glabrous; vexillum blade ca. 20 mm long .... *A. stokoei*
1 B. Leaflets shorter; flowers not as above .... 2 A
2 A. Lowest calyx lobe distinctly larger than the others, fig. 2 I .... 3 A
2 B. Lowest calyx lobe of about the same size as the others (although often slightly longer) .... 7 A
3 A. Carina glabrous .... 4 A
3 B. Carina ± pubescent .... 6 A
4 A. Largest bracts usually more than 8×4 mm large .... 5 A
4 B. Largest bracts usually less than 7×3 mm large .... *A. rupestris*
5 A. Shrublets stiff and erect; also upper leaves with axillary brachyblasts .... *A. fasciculata*
5 B. Shrublets weaker and ± decumbent; upper leaves linear, not with axillary brachyblasts .... *A. suaveolens*
6 A. Leaflets glabrous, shiny; ovary with 4—5 ovules .... *A. venosa*
6 B. Leaflets pubescent on both sides; ovary with 2 ovules; fig. 2 I .... *A. polycephala*
7 A. Calyx lobes spine-tipped .... 8 A
7 B. Calyx lobes not spine-tipped .... 10 A
8 A. Bracts about 3—4 mm long; flowers 6—8 mm long .... *A. corniculata*
8 B. Bracts more than 10 mm long; flowers 10—14 mm long incl. calyx lobes .... 9 A
9 A. Vexillum blade more than 8 mm broad; pod and ovary completely pubescent .... *A. acidota*
9 B. Vexillum blade less than 7 mm long; pod and ovary hairy only on upper edge .... *A. borboniifolia*
10 A. Ala and carina claws adnate at the base to the staminal sheath (leaflets less than 1 mm broad but the larger ones 10—20 mm long) .. *A. confusa*
10 B. Ala and carina claws free from the staminal sheath (leaves proportionally not so narrow) .... 11 A
11 A. Leaflets green, glabrous or sparingly (—densely) and ± spreadingly pubescent (not sericeous), usually carnose or coriaceous .... 12 A
11 B. Leaflets grey, closely silvery-sericeous, tomentose, or lanate, ± flexible .... 28 A
12 A. Bracts large, obdeltoid—rhombic, up to more than 6 mm broad, the lowest as broad as long, hairy on the base, otherwise glabrous, fig. 3 O .... *A. truncata*

12 B. Bracts much longer than broad or when suborbicular much less than 6 mm long .... 13 A

13 A. Leaf base produced into a single or ternate, woody cusp or spur .... *A. tridentata*

13 B. Leaf base without cusp or spur .... 14 A

14 A. Ovary with 2 ovules .... 15 A

14 B. Ovary with at least 3 or 4 (sometimes up to 8) ovules .... 23 A

15 A. Calyx lobes broadly triangular, about 1 mm long or less, lowest bract almost as broad as long .... *A. psoraleoides*

15 B. Calyx lobes narrowly triangular, bracts much longer than broad .. 16 A

16 A. Pedicels considerably longer than the calyx tube; gracile shrublet .... *A. taylorii*

16 B. Pedicels much shorter than the calyx tube; habit variable .... 17 A

17 A. Ala blades glabrous .... 18 A

17 B. Ala blades ± pubescent, at least on lower parts .... 19 A

18 A. Shrublets procumbent or decumbent; at least the upper leaves with leaflets more than 5 mm long .... *A. esterhuyseniae*

18 B. Shrublets ascending—erect, all leaflets about 3 mm long or less .... *A. pumila*

19 A. Bracts lanceolate—ovate .... *A. quinquefolia*

19 B. Bracts either narrowly linear-subulate or very small (less than 2 mm) .... 20 A

20 A. Leaflets broadly lanceolate, ovate or rhombic (broadest near the middle), ending as a spinelet, fig. 2 D .... *A. marginata*

20 B. Leaflets linear or oblanceolate, obtuse—acute or mucronulate .... 21 A

21 A. Flowers very small; vexillum and ala blades ca. 5 mm long or less .... *A. inops*

21 B. Flowers larger: vexillum more than 6 mm long and ala blades more than 5.5 mm long .... 22 A

22 A. Ala blades usually more than 8 mm long; leaflets of upper leaves usually about 3 mm broad or more .... *A. aspalathoides*

22 B. Ala blades usually 7.5 mm long or less; leaflets of upper leaves usually 2.5 mm broad or less .... *A. stenophylla*

23 A. Leaflets circular or very broadly rhombic-ovate .... *A. orbiculata*

23 B. Leaflets linear—oblanceolate or sometimes obovate .... 24 A

24 A. Bracts (and bracteoles) subfiliform or narrowly linear .... 25 A

24 B. Bracts (and bracteoles) lanceolate, oblanceolate or obovate .... 26 A

25 A. Leaflets carnose, quite glabrous when fully developed; pedicels slender, usually ca. 4 mm long or more .... *A. securifolia*

25 B. Leaflets less carnose (often ± puberulous when grown out); pedicels usually 2—3 mm long .... *A. cytisoides*

26 A. Ovary with 6 ovules .... *A. tridentata*

26 B. Ovary with 3—4 (—5) ovules .... 27 A

27 A. Leaves thick and coriaceous-carnose; bracts oblong-spathulate .... *A. securifolia*

27 B. Leaflets not carnose but often slightly coriaceous: bracts lanceolate .... *A. rugosa*

28 A. Leaflets completely grey-tomentose .... 29 A

28 B. Leaflets sericeous or lanate .... 30 A

29 A. Prostrate, alpine shrublet; calyx white-villous, with oblong lobes .... *A. incana*
29 B. Erect or ascending shrublet or shrub; calyx shortly villous, with narrowly triangular, tapering lobes .... *A. cytisoides*
30 A. Flowers less than 8 mm long; shrublets prostrate .... *A. argyrella*
30 B. Flowers 9 mm long or more; shrublets decumbent—erect .... 31 A
31 A. Ovary with 2 ovules .... 32 A
31 B. Ovary with 3 or more ovules .... 35 A
32 A. Shrubs erect and large, more than 50 cm tall .... 33 A
32 B. Shrubs smaller .... 34 A
33 A. Shrubs covered with long hairs; bracts linear, more than 1 cm long .... *A. dunsdoniana*
33 B. Shrubs more shortly sericeous; bracts broadly lanceolate or ovate, less than 1 cm long .... *A. quinquefolia*
34 A. Shrublets fine and slender, decumbent, usually with only 2—3 (—4) flowers on each branch tip; vexillum blade ovate, acute, 4—5 mm broad .... *A. villosa*
34 B. Shrublets not so slender, decumbent—erect, usually with 5—10 flowers in each head; vexillum blade elliptic, rounded-obtuse—retuse, usually 5 mm broad or more .... *A. quinquefolia*
35 A. Leaves on lower parts of the branches green and almost glabrous .... 36 A
35 B. Leaves also on lower parts of the branches closely sericeous .... 38 A
36 A. Bracts close, forming a starlike involucre below the flower head .... *A. tridentata*
36 B. Bracts not forming a close involucre .... 37 A
37 A. Leaves weak and flexible, without apical mucro .... *A. radiata*
37 B. Leaves ± rigid, mucronate or mucronulate .... *A. cytisoides*
38 A. Calyx lobes 10—13 mm long, lanceolate .... *A. bidouwensis*
38 B. Calyx lobes less than 7 mm long .... 39 A
39 A. Leaflets small, usually ca. 3 mm long or less (closely massed on lateral brachyblasts; shrublets knotty) .... *A. ramulosa*
39 B. Leaflets larger .... 40 A
40 A. Calyx lobes broadly and shortly triangular, 0.5—1.5 mm long .... *A. altissima*
40 B. Calyx lobes narrowly triangular, more than 2 mm long .... 41 A
41 A. Shrub with relatively thick branches; upper leaves closely situated and partly surrounding the floral heads .... *A. salicifolia*
41 B. Shrub with relatively slender, often straight branches; upper leaves not surrounding the base of the floral heads (which are instead subtended by the involucre-like assembly of the bracts) .... *A. tridentata*

KEY 8

1 A. Ovary 2-ovuled .... *A. quinquefolia*
1 B. Ovary 4 —several-ovuled .... 2 A
2 A. Ovary 4-ovuled .... 3 A

2 B. Ovary 5—7-ovuled . . . . *A. heterophylla*
3 A. Inflorescence a close, multiflorous spike . . . . 4 A
3 B. Inflorescence a raceme (i.e. pedicels distinct) . . . . 5 A
4 A. Calyx lobes broadly triangular, 0.5—1.5 mm long . . . . *A. altissima*
4 B. Calyx lobes narrowly triangular or linear—triangular . . . . *A. radiata*
5 A. Bracts and usually also bracteoles lanceolate or narrowly lanceolate . . . . *A. rugosa*
5 B. Bracts and bracteoles narrowly linear or subfiliform . . . . *A. cytisoides*

KEY 9

1 A. Lowest calyx lobe considerably larger and wider than the others, fig. 2 I (leaves grey-pubescent) . . . . *A. polycephala*
1 B. Lowest calyx lobe not or only slightly larger than the others . . . . . . 2 A
2 A. Calyx very closely villous and leaflets white-tomentose and oblanceolate, ca. 3 mm broad or more . . . . *A. incana*
2 B. Calyx lobes either not closely villous or *if so* the leaflets either narrower than 3 mm or not white-tomentose . . . . 3 A
3 A. Carina blades glabrous . . . . 4 A
3 B. Carina blades pubescent . . . . 6 A
4 A. Leaflets about 4 mm long or less; pod (ovary) entirely glabrous . . . . *A. acicularis*
4 B. Leaflets (when distinctly flat) at least 6 mm long; pod ± pubescent . . . . 5 A
5 A. Leaves, calyx, and vexillum with long, white-tomentose or villous pubescence . . . . *A. karrooënsis*
5 B. Leaves shortly puberulous or glabrous . . . . *A. leucophylla*
6 A. Leaves closely silvery-sericeous . . . . 7 A
6 B. Leaves glabrous or sparsely puberulous, green . . . . 9 A
7 A. Shrublets erect; flowers solitary on the tips of straight, rigid, and spreading branchlets . . . . *A. singuliflora*
7 B. Shrublets decumbent—prostrate; flowers solitary or few on weak branchlet tips . . . . 8 A
8 A. Shrublets closely matlike; vexillum with rounded-obtuse apex . . . . *A. bodkinii*
8 B. Shrublets decumbent or procumbent, not matlike; vexillum apex ± acute . . . . *A. villosa*
9 A. Calyx lobes ending as somewhat recurved spinelets; ovules 4—5 . . . . *A. corniculata*

Fig. 2. *Aspalathus:* A, B and D: leaflets; C and F: leaves; E: part of branch with leaf and axillary short-shoot; G—K and M—O: flowers; L: ala and carina petals with claws attached at the base to the staminal sheath. — A: *A. burchelliana* × 4. — B: *A. diffusa* × 4. — C: *A. mundiana* × 4. — D: *A. marginata* × 4. — E: *A. calcarata* × 4. — F: *A. perforata* × 2. — G: *A. dasyantha* × 3.6. — H: *A. rectistyla* × 4. — I: *A. polycephala* × 4. — J: *A. sanguinea* (ssp. *sanguinea*) × 4. — K: *A. asparagoides* (ssp. *asparagoides*) × 4. — L: *A. aculeata* × 4. — M: *A. variegata* × 4. — N: *A. leiantha* × 4. — O: *A. monosperma* × 4.

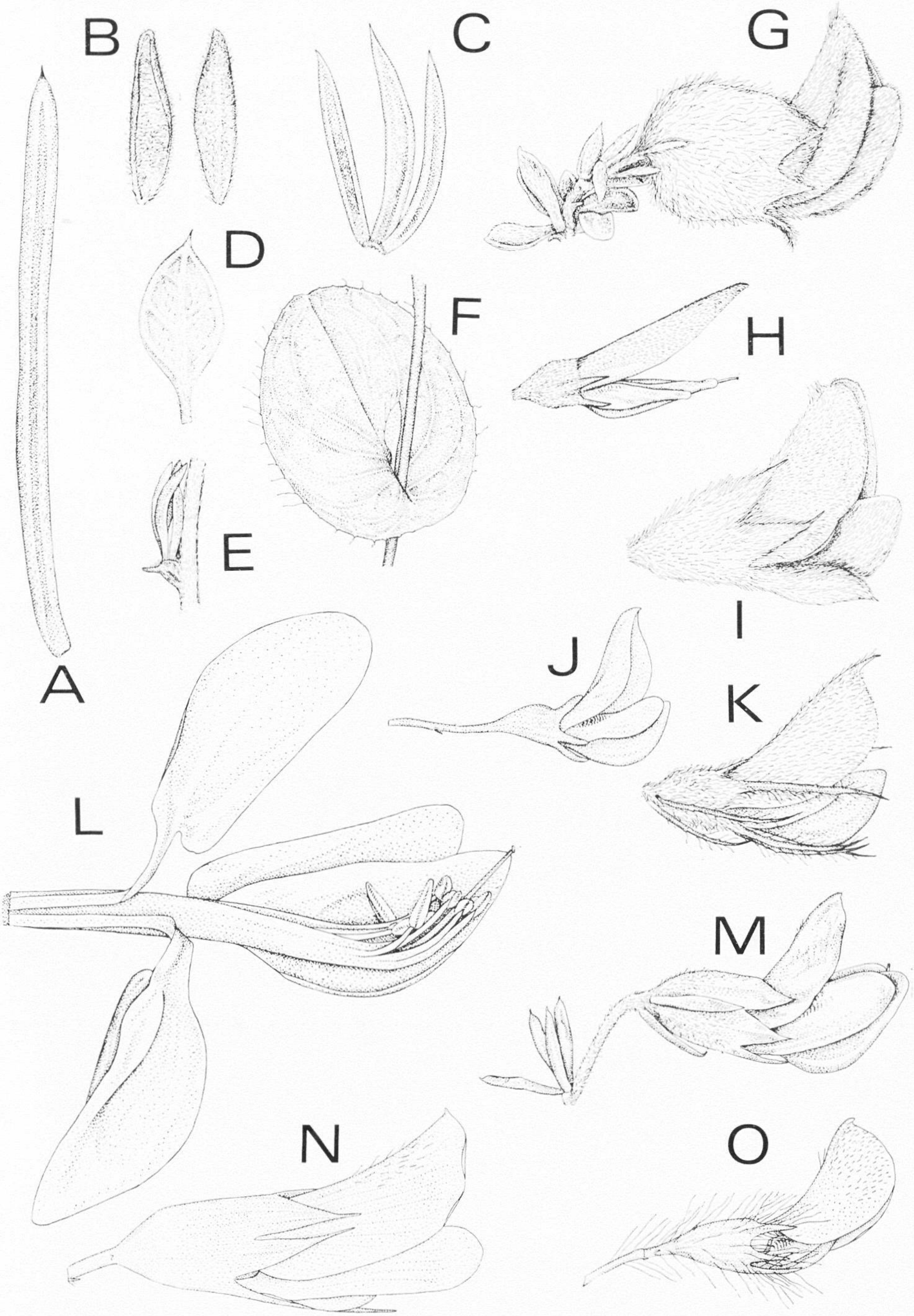

Fig. 2.

9 B. Calyx lobes not spine-tipped; ovules 2 .... 10 A
10 A. Ala blades glabrous .... 11 A
10 B. Ala blades at least slightly pubescent on lower parts .... 12 A
11 A. Shrublets decumbent; at least upper leaves with leaflets more than 5 mm long .... *A. esterhuyseniae*
11 B. Shrublets ascending—erect; all leaflets about 3 mm long or less .... *A. pumila*
12 A. Leaflets broadly lanceolate, ovate or rhombic (broadest near the middle), ending as a spinelet .... *A. marginata*
12 B. Leaflets linear or oblanceolate, acute—mucronulate .... 13 A
13 A. Flowers very small; vexillum and ala blades ca. 5 mm long or less .... *A. inops*
13 B. Flowers larger; vexillum more than 6 mm long and ala blades more than 5.5 mm long .... *A. stenophylla*

KEY 10

1 A. Branches with numerous lateral branchlet thorns .... *A. spinosa*
1 B. Branches not with lateral branchlet thorns (but branches sometimes thornlike) .... 2 A
2 A. Leaves green and glabrous, glabrescent or sparsely pubescent, sometimes ciliated on the margins .... 3 A
2 B. Leaves closely silvery-sericeous .... 8 A
3 A. Carina beaklike; flowers seemingly emerging in leaf axils on long parts of the branches (brachyblasts consisting of a small-bracteate flower only) .... *A. vulpina*
3 B. Carina not beaklike; brachyblasts leafy .... 4 A
4 A. Carina glabrous or almost glabrous .... 5 A
4 B. Carina pubescent .... 6 A
5 A. Ovary and pod glabrous .... *A. acicularis* (ssp. *planifolia*)
5 B. Ovary and pod at least partly short-sericeous .... *A. tuberculata*
6 A. Calyx with long, villous pubescence, fig. 2 G; ovules 4—5 .... *A. dasyantha*
6 B. Calyx with short, sericeous pubescence; ovules 2 .... 7 A
7 A. Leaflets oblong, quite flat, usually 3—5×1—2 mm large .... *A. oblongifolia*
7 B. Leaflets linear, flattened or slightly canaliculate, usually 8—22×0.8—1.2 mm large, fig. 2 A .... *A. burchelliana*
8 A. Ovary with 4—5 ovules; leaf bases usually with a woody, distinct spur .... *A. ternata*
8 B. Ovary with 2 ovules; leaf base without woody spur .... 9 A
9 A. Flowers about 10 mm long; calyx lobes almost quadrate, obtuse—retuse .... *A. quadrata*
9 B. Flowers about 13—16 mm long; calyx lobes ovate or narrowly triangular, usually acute .... 10 A
10 A. Bracteoles ovate; decumbent, slender shrublet with few-flowered branches .... *A. intervallaris*

10 B. Bracteoles lanceolate or linear; erect, straight, not or little branched shrubs with numerous-flowered branches .... 11 A

11 A. Leaves greenishly short-sericeous, often glabrescent; calyx lobes ovate .... *A. oblongifolia*

11 B. Leaves silvery-sericeous; calyx lobes tapering, narrowly triangular .... *A. caledonensis*

KEY 11

1 A. Lateral branchlets not ending in sharp thorns (but the branches sometimes thorny) .... 4 A

1 B. Lateral branchlets ending in sharp, woody thorns of almost uniform length .... 2 A

2 A. Leaves glabrous or sparsely and very shortly puberulous; calyx glabrous or short-puberulous .... 3 A

2 B. Leaves entirely or partly short-sericeous; calyx short-villous .... *A. acanthophylla*

3 A. Pedicel entirely short-pubescent; carina blades generally less than 6 mm long .... *A. spinosa*

3 B. Pedicel (incl. the narrow calyx base?) glabrous except on the base, fig. 1 G; carina blades more than 6 mm long .... *A. glabrata*

4 A. Leaflets sharply and straightly spine-tipped .... 5 A

4 B. Leaflets not spine-tipped, but often mucronate or mucronulate .... 7 A

5 A. Bracts about 2 mm broad or more .... *A. aciphylla*

5 B. Bracts less than 2 mm broad .... 6 A

6 A. Ala blades less than 3 mm broad; floriferous brachyblasts concentrated to the branch ends .... *A. spiculata*

6 B. Ala blades more than 3 mm broad; floriferous brachyblasts scattered .... *A. collina*

7 A. Pedicel glabrous, often relatively long, fig. 2 J .... 8 A

7 B. Pedicel if distinct ± pubescent (often minutely puberulous), generally short .... 11 A

8 A. Leaflet apices recurved, finely apiculate—mucronulate .... *A. recurvispina*

8 B. Leaflet apices not recurved, obtuse—acuminate .... 9 A

9 A. Leaflets usually less than 2.5 mm long; calyx lobes 0.4 mm long or less, carnose, obtusely triangular .... *A. obtusifolia*

9 B. Leaflets usually more than 2.5 mm long; calyx lobes 0.5 mm long or more, linear or triangular-linear .... 10 A

10 A. Ala blades less 3.5 mm long and less than 1.2 mm broad; ala claws ca. 2.5 mm long or more .... *A. zeyheri*

10 B. Ala blades more than 3.5 mm long and ca. 1.5 mm broad or more; ala claws 1.7 mm long or less, fig. 2 J .... *A. sanguinea*

11 A. Bracteoles more than 4 mm broad .... *A. capensis*

11 B. Bracteoles less than 1.5 mm broad .... 12 A

12 A. Flowers pale rose or pink (mauve) .... 13 A

12 B. Flowers yellow, orange, ferruginous or dark red .... 14 A

13 A. Calyx lobes deltoid, acute; bracts broadly linear or spathulate .... *A. costulata*

13 B. Calyx lobes linear or subulate; bracts linear-subulate ... *A. pallidiflora*

14 A. Shrublets prostrate or procumbent (calyx with glabrous longitudinally ridged tube and subulate—acicular lobes; pedicel not developed; pods flat, ovate) .... 15 A

14 B. Shrublets usually ascending—erect, seldom decumbent (in cases where the calyx is glabrous the lobes usually short or/and the pedicel distinct) .... 16 A

15 A. Leaflets very slender, only ca. 0.2 mm thick (but 2—5 mm long); pod glabrous, glossy, fig. 4 P .... *A. hypnoides*

15 B. Leaflets less slender, 0.3 mm thick or more; pod puberulous, not glossy .... *A. crassisepala*

16 A. Calyx lobes with conspicuously thickened green margins, fig. 1 H .... 17 A

16 B. Calyx lobes not with thickened margins .... 18 A

17 A. Carina blades 5.3 mm long or less; ovary glabrous or pubescent on basal upper parts only .... *A. wurmbeana*

17 B. Carina blades 5.5 mm long or more; ovary usually ciliated along the whole of the upper side .... *A. recurva*

18 A. Carina beaklike, 8 mm long or more .... *A. arenaria*

18 B. Carina blades lunate or angled, often slightly upcurved but not beaklike, 7 mm long or less .... 19 A

19 A. Calyx lobes ovoid and subterete, ca. 2 mm long and 1.5 mm thick .... *A. odontoloba*

19 B. Calyx lobes smaller and/or less thick and carnose .... 20 A

20 A. Leaflets with a profound longitudinal groove at least on the lower side, fig. 2 C .... *A. mundiana*

20 B. Leaflets terete or depressed, without distinct grooves .... 21 A

21 A. Branches very strong and thornlike .... *A. lactea* (ssp. *breviloba*)

21 B. Branches not thornlike .... 22 A

22 A. Calyx tube glabrous .... 23 A

22 B. Calyx tube puberulous or sparsely—closely villous .... 25 A

23 A. Vexillum claw almost non-existent (calyx lobes only ca. 0.5 mm long) .... *A. obliqua*

23 B. Vexillum claw distinct .... 24 A

24 A. Pods 10 mm long or more; ala blades 5 mm long or more (petals often carnose, stiff, mainly bright yellow) .... *A. pinguis*

24 B. Pods 9 mm long or less; ala blades usually 4.7 mm long or less (petals bright yellow or usually rubescent, hardly carnose) .... *A. lactea* (ssp. *adelphea*)

25 A. Vexillum apex very strongly incurved, fig. 3 S .... *A. smithii*

25 B. Vexillum apex only slightly incurved .... 26 A

26 A. Ala and carina claws proportionally very short, ca. 1 mm long, fig. 4 C (pods almost glabrous) .... 17 A

26 B. Ala and carina claws 1.3 mm long or more (pods villous or in *A. lactea* almost glabrous) .... 27 A

27 A. Calyx lobes triangular, short .... 28 A
27 B. Calyx lobes shortly subulate .... 29 A
28 A. Most leaflets 1—3 mm long (flowers bright yellow) .... *A. steudeliana*
28 B. Most leaflets 4—8 mm long (flowers usually ferruginous—rubescent) .... *A. lactea* (certain forms)
29 A. Ala blades with several rows of lunulate folds on upper basal parts; petals usually rubescent .... *A. lactea* (certain forms)
29 B. Ala blades with one row of folds on upper basal parts; petals yellow (vexillum tapering, pointed) .... *A. acutiflora*

KEY 12

1 A. Calyx (outer side), pedicel, and ovary glabrous (leaflets spiny) .... *A. rigidifolia*
1 B. Calyx, pedicel, and ovary (and pod) more or less pubescent .... 2 A
2 A. Ala and carina claws adnate at the base to the staminal sheath (such as in fig. 2 L) *and* leaflets spine-tipped (rather large shrubs) .... *A. spicata* (ssp. *neglecta*)
2 B. Ala and carina claws free from the staminal sheath or when adnate to this then the leaves not spine-tipped .... 3 A
3 A. Ala blades with one (—2) row(s) of rather irregular folds on upper parts and usually firmly attached to the lateral bulges of the carina, fig. 3 U—V (flowers small, with linear—subulate calyx lobes) .... 4 A
3 B. Ala blades with 3—several rows of small lunulate folds on upper basal parts and *not* attached to the carina .... 10 A
4 A. Bracts and bracteoles lacking .... *A. parviflora*
4 B. Bracts present but often small; bracteoles present or lacking .... 5 A
5 A. Bracts similar to and of almost the same size as the vegetative leaflets .... 6 A
5 B. Bracts much smaller and especially narrower than the vegetative leaflets .... 8 A
6 A. Ala blades pubescent on the lower apical parts, fig. 3 U; calyx closely long- and white-pubescent .... 7 A
6 B. Ala blades usually glabrous (seldom slightly puberulous near the apex); calyx rather sparingly villous .... *A. ericifolia*
7 A. Bracteoles similar to the bracts but narrower .... *A. varians*
7 B. Bracteoles lacking (or very small) .... *A. muraltioides*
8 A. Petals light—bright yellow .... 9 A
8 B. Petals pale, cream-coloured, with carina partly purple *or* all petals entirely pale-yellow .... *A. hispida*
9 A. Bracteoles generally lacking; foliage long-pubescent .... *A. muraltioides*
9 B. Bracteoles present; foliage with sparse and rather short pubescence .. .. *A. ericifolia*
10 A. Ala blades glabrous .... 11 A
10 B. Ala blades with at least some pubescence on the lower parts ..... 14 A
11 A. Leaflets usually 8—22 mm long and 0.8—1.2 mm broad, often slightly depressed or canaliculate, mucronate .... *A. burchelliana*

11 B. Leaflets much shorter or narrower .... 12 A

12 A. Calyx lobes triangular; bracts ca. 1 mm long or less .... *A. spinescens*

12 B. Calyx lobes filiform, linear-lanceolate, oblong, or rostrate (and incurved); bracts 2 mm long or more .... 13 A

13 A. Vexillum cusp more than 0.5 mm long, fig. 2 K; calyx lobes long and slender .... *A. asparagoides*

13 B. Vexillum cusp lacking or indistinct; calyx lobes rather broad and with distinct midveins .... *A. opaca*

14 A. Leaflets usually less than 3 mm long, obtuse—acute; ala blades pubescent on most parts of the outer side (flowers normally on the branchlet tips) .... *A. vermiculata*

14 B. Leaflets usually more than 3 mm long, pointed; ala blades pubescent on about half or less of the outer side .... 15 A

15 A. Flowers medium-sized or large: ala and carina blades more than 5.5 mm long .... 16 A

15 B. Flowers rather small: ala and carina blades usually less than 5 mm long .... 21 A

16 A. Carina blades slightly beaklike; calyx lobes short and spinelike (less than 2 mm long) .... *A. fourcadei*

16 B. Carina blades lunate; calyx lobes usually more than 2 mm long or when shorter not spinelike .... 17 A

17 A. Leaflets glabrous, sharply spine-tipped .... *A. teres*

17 B. Leaflets glabrous or pubescent, when glabrous not spine-tipped or pungent .... 18 A

18 A. Calyx lobes triangular or subulate, less than 4 mm long .... 19 A

18 B. Calyx lobes linear-acicular, more than 4 mm long .... *A. setacea*

19 A. Pods smoothly sericeous; calyx smoothly and closely puberulous; calyx lobes narrowly triangular and almost glabrous .... *A. setacea*

19 B. Pods rather woolly—villous; calyx variously villous or woolly; calyx lobes subulate or triangular, when triangular pubescent .... 20 A

20 A. Ratio blade/claw of carina less than 1.5 .... *A. setacea*

20 B. Ratio blade/claw of carina more than 1.7 .... *A. chortophila*

21 A. Calyx lobes more than 3.5 mm long (linear—subfiliform or acicular) .... 22 A

21 B. Calyx lobes less than 3.5 mm long, triangular or subulate ...... 23 A

Fig. 3. *Aspalathus*: A—K and O: bracts; L—N: bracts fused with the pedicel; P—Q: short and long anther of the same flower; R: vexillum base; S—T: vexillum petals; U: ala petal adherent in its basal part of the blade to the lateral bulge of the carina, V; W—Z': ala petals. — A—C: *A. nigra*, bract from lower, middle and upper levels of the inflorescence × 4. — D: *A. triquetra* × 4. — E—F: *A. ciliaris*, different forms, × 4. — G: *A. aculeata* × 4. — H: *A. chenopoda* × 4. — I: *A. asparagoides* (ssp. *asparagoides*) × 4. — J: *A. salteri* × 4. — K: *A. prostrata* × 4. — L: *A. excelsa* × 4. — M: *A. carnosa* × 4. — N: *A. variegata* × 4. — O: *A. truncata* × 4. — P—Q: *A. macrocarpa* × 8. — R: *A. macrantha* × 4. — S: *A. smithii* × 4. — T: *A. pinea* × 4. — U—V: *A. varians* × 4. — W: *A. callosa* × 4. — X: *A. arida* (ssp. *erecta*) × 4. — Y: *A. juniperina* (ssp. *grandis*) × 4. — Z: *A. chrysantha* × 4. — Z': *A. pachyloba* (ssp. *pachyloba*) × 4.

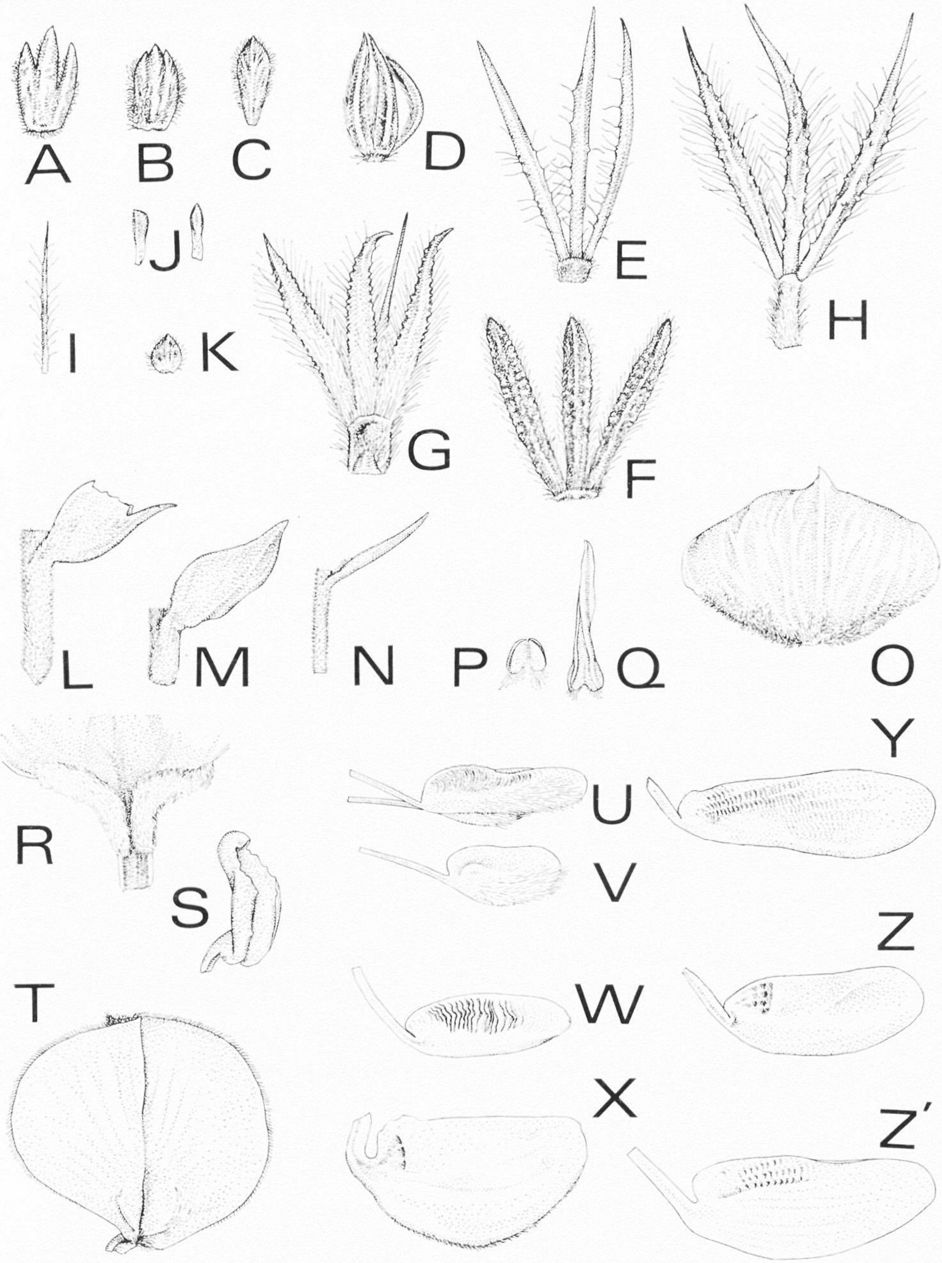

Fig. 3.

22 A. Leaves green, usually sparsely pubescent; ala blades less than 5 mm long .... *A. alopecurus*
22 B. Leaves grey-pubescent; ala blades more than 5 mm long .... *A. setacea*
23 A. Leaves glabrous .... 24 A
23 B. Leaves sparsely or closely pubescent, short .... 25 A
24 A. Ala and carina blades ca. 4 mm long or less .... *A. cliffortiifolia*
24 B. Ala and carina blades ca. 5 and 4.5 mm long or more respectively .... *A. setacea*
25 A. Calyx lobes subulate, subterete; carina blades less than 5 mm long .... *A. intermedia*
25 B. Calyx lobes ± triangular or linear-triangular, rather flat; carina blades more than 5.5 mm long .... *A. setacea*

KEY 13

1 A. Leaf bases on the long-shoots produced into a distinct, woody spur, fig. 2 E .... 2 A
1 B. Leaf bases not produced into a spur .... 4 A
2 A. Flowers small, less than 1 cm long (incl. pedicel) .... *A. calcarata*
2 B. Flowers larger, at least 1.5 cm long (incl. pedicel) .... 3 A
3 A. Branches ending in sharp thorns .... *A. rostrata*
3 B. Branches not ending in thorns (pod: fig. 4 N) .... *A. pinea*
4 A. Ala blades 6.5 mm long or more (relatively large-flowered species) .. 5 A
4 B. Ala blades 6.5 mm long or less (relatively small-flowered species) .... 13 A
5 A. Leaflets ± S-curved, with slightly recurved apex (floriferous brachyblasts usually concentrated to the apical 2—5 cm) .... *A. joubertiana*
5 B. Leaflets straight or slightly incurved, their apices not recurved .... 6 A
6 A. Flowers very large; vexillum blade ca. 16 mm broad or more and ala blades ca. 5.5 mm broad or more .... *A. lamarckiana*
6 B. Flowers not so large; vexillum blade ca. 14.5 mm broad or less and ala blades ca. 4.2 mm broad or less .... 7 A
7 A. Carina beaklike, fig. 4 A .... 8 A
7 B. Carina lunate (such as in fig. 4 B) .... 9 A
8 A. Most parts of vexillum back glabrous .... *A. joubertiana*
8 B. Most parts of vexillum back pubescent .... *A. laricifolia*
9 A. Leaflets rigid and quite sharp (pod: fig. 4 S) .... *A. hystrix*
9 B. Leaflets rather weak, but sometimes with apical mucro .... 10 A
10 A. Most leaflets less than 1 cm long .... 11 A
10 B. Most leaflets more than 1 cm long .... 12 A
11 A. Shrublets ca. 50 cm tall or less; carina blades usually 6—8.5 mm long .... *A. laricifolia*
11 B. Shrublets ca. 1 m tall or more; carina blades usually ca. 11 mm long .... *A. bowieana*
12 A. Calyx closely villous—velutionus; lobes with a short, mucronate apex (vexillum puberulous on apical-marginal parts of inside) .. *A. bowieana*
12 B. Calyx long-sericeous (or lanate), lobes attenuating into weak apices (vexillum glabrous on apical-marginal parts of inside) .. *A. argyrophanes*

13 A. Leaflets more than 15 mm long .... 14 A
13 B. Leaflets less than 15 mm long .... 17 A
14 A. Calyx lobes very short, only ca. 0.5 mm long or less; ovary and pod long-woolly; leaflets up to more than 3.5 cm long .... *A. longifolia*
14 B. Calyx lobes narrowly triangular, 0.7—2.8 mm long; ovary and pod sericeous or villous; leaflets seldom more than 3.5 mm long .... 15 A
15 A. Leaves (at least the older ones) glabrous on apical parts; pedicel ca. 1 mm long or less .... *A. glabrescens*
15 B. Leaves entirely silvery-pubescent; pedicel usually 1.5 mm long or more .... 16 A
16 A. Vexillum blade more than 6.5 mm long; ala blades more than 5.5 mm long .... *A. florifera*
16 B. Vexillum blade less than 5.5 mm long; ala blades less than 5 mm long .... *A. cinerascens*
17 A. Leaflets succulent, mostly 0.8—2 mm long only, with short hairs (seemingly basewardly directed) usually leaving the very leaflet apex naked .... *A. leucophylla*
17 B. Leaflets non-succulent, usually more than 2 mm long .... 18 A
18 A. Bract ca. 1.2 mm long or more (vexillum blade pubescent on practically all of the back side) .... 19 A
18 B. Bract ca. 1.0 mm long or less (vexillum blade usually glabrous at least on the basal parts of the back side) .... 20 A
19 A. Shrublet low, rather much-branched; young branches short-villous (or glabrescent) .... 20 A
19 B. Shrub or shrublet erect, sparingly branched; young branches white-woolly .... *A. gerrardii*
20 A. Calyx rather sparsely pubescent; pod closely white-lanate .... *A. intricata*
20 B. Calyx closely silvery-pubescent; pod shortly pubescent .... *A. frankenioides*
21 A. Vexillum short-sericeous or puberulous on apical parts; only with little pubescence at the base of the front side .... 22 A
21 B. Vexillum villous on the very apex of the back and extensively pubescent on basal parts of front side .... *A. candicans*
22 A. Carina blades at least 4.8 mm long and 2.7 mm broad; vexillum puberulous on more than 2/3 of the back .... *A. candidula*
22 B. Carina blades at most 4.5 mm long or less and 2.1 mm broad or less; vexillum puberulous on 1/3—1/2 of the back .... 23 A
23 A. Shrublets prostrate; ala blades ca. 3 mm long or less .... *A. incompta*
23 B. Shrublets ascending (seldom decumbent); ala blades at least 4.2 mm long .... *A. pycnantha*

KEY 14

1 A. Pedicel glabrous, often long in relation to the floral size .... *A. rigidifolia*
1 B. Pedicel, when distinct, pubescent .... 2 A

2 A. Ala and carina claws adnate at the base to the staminal sheath .... *A. spicata*
2 B. Ala and carina claws free from the staminal sheath .... 3 A
3 A. Calyx tube glabrous or minutely puberulous .... 4 A
3 B. Calyx tube closely pubescent .... 7 A
4 A. Bracts and bracteoles acicular; vexillum back finely sericeous only on the midrib (hairy also on the base) .... 5 A
4 B. Bracts and bracteoles oblong or lanceolate, when lanceolate with acicular apex; vexillum back variably pubescent, often only on apical or apical—central parts .... 6 A
5 A. Branch ends closely white-pubescent; carina tapering, beaklike (flowers normally in groups on the branch ends) .... *A. astroites*
5 B. Branch ends subglabrous—white-puberulous; carina angled, rather obtuse (flowers normally on lateral short-shoots) .... *A. abietina*
6 A. Bracts and bracteoles less than 1.3 mm long; petals becoming ± blackish when dried .... *A. pachyloba* (ssp. *rugulicarpa*)
6 B. Bracts and bracteoles more than 1.5 mm long; petals usually persistently yellow (or partly reddish) when dried .... *A. collina*
7 A. Ovary pubescent only on the upper part of the base; pod subglabrous .... *A. collina*
7 B. Ovary and pod entirely and closely pubescent (such as in fig. 4 S) .... 8 A
8 A. Leaflets straight (or slightly incurved); carina not beaklike ...... 9 A
8 B. Leaflets S-curved or recurved; carina rather beaklike (vexillum back sometimes pubescent only on the apex) .... *A. joubertiana*
9 A. Calyx lobes 8—11 mm long .... *A. acanthes*
9 B. Calyx lobes ca. 7 mm long or less .... 10 A
10 A. Shrubs not or very little branched ("rodlike"); flowers evenly distributed on long parts of the branches .... 11 A
10 B. Shrubs more richly branched; flowers scattered .... 12 A
11 A. Calyx shortly velutinous, with ovate lobes ...... *A. sceptrum-aureum*
11 B. Calyx white-woolly, lobes narrowly triangular ...... *A. verbasciformis*
12 A. Flowers large; ala blades 13—17 mm long, carina blades 13—16 mm long .... *A. spectabilis*
12 B. Flowers smaller: ala and carina blades less than 11 mm long .... *A. hirta*

KEY 15

1 A. Branches with relatively short, often recurved lateral thorns .... *A. spinosa*
1 B. Branches without short lateral thorns .... 2 A
2 A. Leaf-bases produced into a short woody spur or spine .... 3 A
2 B. Leaf-bases without spur or spine .... 8 A
3 A. Flowers small, less than 1 cm long (incl. pedicel); ala blades ca. 2.5 mm long or less .... *A. calcarata*

3 B. Flowers larger, considerably more than 1 cm long; ala blades at least 6 mm long (carina distinctly beaklike) .... 4 A

4 A. Shrubs ± decumbent; calyx lobes with green, somewhat thickened margins (pistil in fig. 4 K) .... *A. rycroftii*

4 B. Shrubs erect; calyx lobes not with thickened margins .... 5 A

5 A. Base of vexillum inside with glabrous semicircular callosities, fig. 3 T; anthers without basal pubescence .... 6 A

5 B. Base of vexillum inside without glabrous semicircular callosities; anthers with ± distinct basal pubescence, fig. 3 P—Q (carina tapering) .... 7 A

6 A. Ovary 3—7-ovuled; pod broadly lanceolate, sometimes upwardly beaked .... *A. uniflora*

6 B. Ovary with more than 14 ovules; pod long, broadly linear, fig. 4 N .... *A. pinea*

7 A. Shrubs not thorny .... *A. macrocarpa*

7 B. Shrubs sharply thorny .... *A. rostrata*

8 A. Ovary with 16—20 ovules; pods long and linear .... *A. filicaulis*

8 B. Ovary with less than 6 ovules; pods obliquely ovate or lanceolate .. 9 A

9 A. Ovary (and pod) completely glabrous, fig. 4 O and R .... 10 A

9 B. Ovary pubescent at least on upper parts .... 13 A

10 A. Calyx sparsely villous on outer side; flowers small ...... *A. granulata*

10 B. Calyx tube glabrous on outer side; flowers medium-sized or large .. 11 A

11 A. Ala blades with only 3—5 minute wrinkles on the base, fig. 3 X .... *A. arida*

11 B. Ala blades with numerous wrinkles in 4—7 rows .... 12 A

12 A. Calyx lobes overlapping at the base; flowers strongly compressed, with persistently bright-yellow petals .... *A. citrina*

12 B. Calyx lobes not overlapping at the base; flowers not particularly compressed; petals usually turning blackish when dried .... *A. pachyloba*

13 A. Margins of calyx lobes conspicuously thickened, carnose .... *A. marginalis*

13 B. Margins of calyx lobes not particularly thickened; calyx lobes carnose or non-carnose .... 14 A

14 A. Bracts, bracteoles and pedicel not developed (carina with blades shorter than claws, the latter partly attached to the staminal sheath) .... *A. parviflora*

14 B. At least the bract normally present (carina with blades longer than claws, exception: *A. incurvifolia*) .... 15 A

15 A. Style not or very slightly upcurved; carina extended (vexillum narrow, acute, dark-yellow), fig. 2 H .... *A. rectistyla*

15 B. Style upcurved; carina not particularly extended .... 16 A

16 A. Shrublets prostrate, closely branched; bracts and bracteoles flat, ovate, 1.3—2×0.8—1.2 mm large, fig. 3 K .... *A. prostrata*

16 B. Shrublets or shrubs from procumbent or decumbent to erect, not prostrate (exception: forms of *A. salteri*); bracts and bracteoles either not flat or, if so, not ovate .... 17 A

17 A. Pedicel as long as the calyx tube (calyx tube closely puberulous; branches thorny) .... *A. ferox*

17 B. Pedicel much shorter than the calyx tube .... 18 A

18 A. Ovary pubescent on the upper parts of the base only; pod hard, rugose, black when ripe (leaves succulent) .... *A. pachyloba*

18 B. Ovary pubescent at least on the upper half; pod pubescent on most parts .... 19 A

19 A. Vexillum pubescent on about half or less of the back .... 20 A

19 B. Vexillum pubescent on 2/3—all of the back .... 25 A

20 A. Vexillum narrow, with pointed apex; pubescence limited to the very apex .... *A. acutiflora*

20 B. Vexillum broadly ovate, with obtuse or subacute apex, and pubescent on a variable portion of the back .... 21 A

21 A. Leaves and branches weak, puberulous in the juvenile stage; pod short-sericeous, 6.5 mm long or more .... 22 A

21 B. Leaves rather firm; branches firm or coarse; pod either shorter than 5.5 mm or when more than 6.5 mm closely villous or sericeous ... 23 A

22 A. Calyx lobes 1.3—2 mm long ...... *A. leucophylla* (ssp. *septentrionalis*)

22 B. Calyx lobes 1 mm long or less .... *A. lactea* (ssp. *lactea*)

23 A. Pods 6.5 mm long or more, closely villous or sericeous; calyx tube 3.5—4 mm long .... *A. incurvifolia*

23 B. Pods than 5.5 mm long, short-sericeous; calyx tube less than 2.5 mm long .... 24 A

24 A. Vexillum blade (6.5—) 7—8 mm long, puberulous on the apical half of the back .... *A. aciloba*

24 B. Vexillum blade (4.5—) 5—6.2 mm long, puberulous on the apical parts only .... *A. calcarea*

25 A. Calyx lobes broadly oblong or lanceolate, ovate, or spathulate, upper ones more than 1.2 mm broad near the middle .... 26 A

25 B. Calyx lobes tapering, linear, subulate or triangular or (and) narrower than 1.2 mm near the middle .... 29 A

26 A. Calyx lobes triangular (2—4 mm long), with pointed, carnose (subterete) and often slightly incurved apex, fig. 3 J (shrublets decumbent—procumbent, or prostrate) .... *A. salteri*

26 B. Calyx lobes oblong-lanceolate or narrowly ovate—spathulate, not teretely carnose at the apex .... 27 A

27 A. Carina blades usually more than 8 mm long; calyx lobes 6 mm long or more .... *A. linguiloba*

27 B. Carina blades less than 7.5 mm long; calyx lobes 6 mm long or less 28 A

28 A. Petals cream-coloured; leaflets subcarnose, slightly incurved, subglabrous or finely, sparsely and adpressedly puberulous, foliage dull-green .... *A. pallescens*

28 B. Petals light—bright yellow; leaflets hardly carnose, with scattered short, ± spreading hairs (calyx lobes frequently spathulate and convex, fig. 1 I) .... *A. cymbiformis*

29 A. Pod entirely woolly (flowers medium-sized—large; calyx lobes triangular) .... *A. laricifolia*

29 B. Pod shortly or only partly sericeous .... 30 A

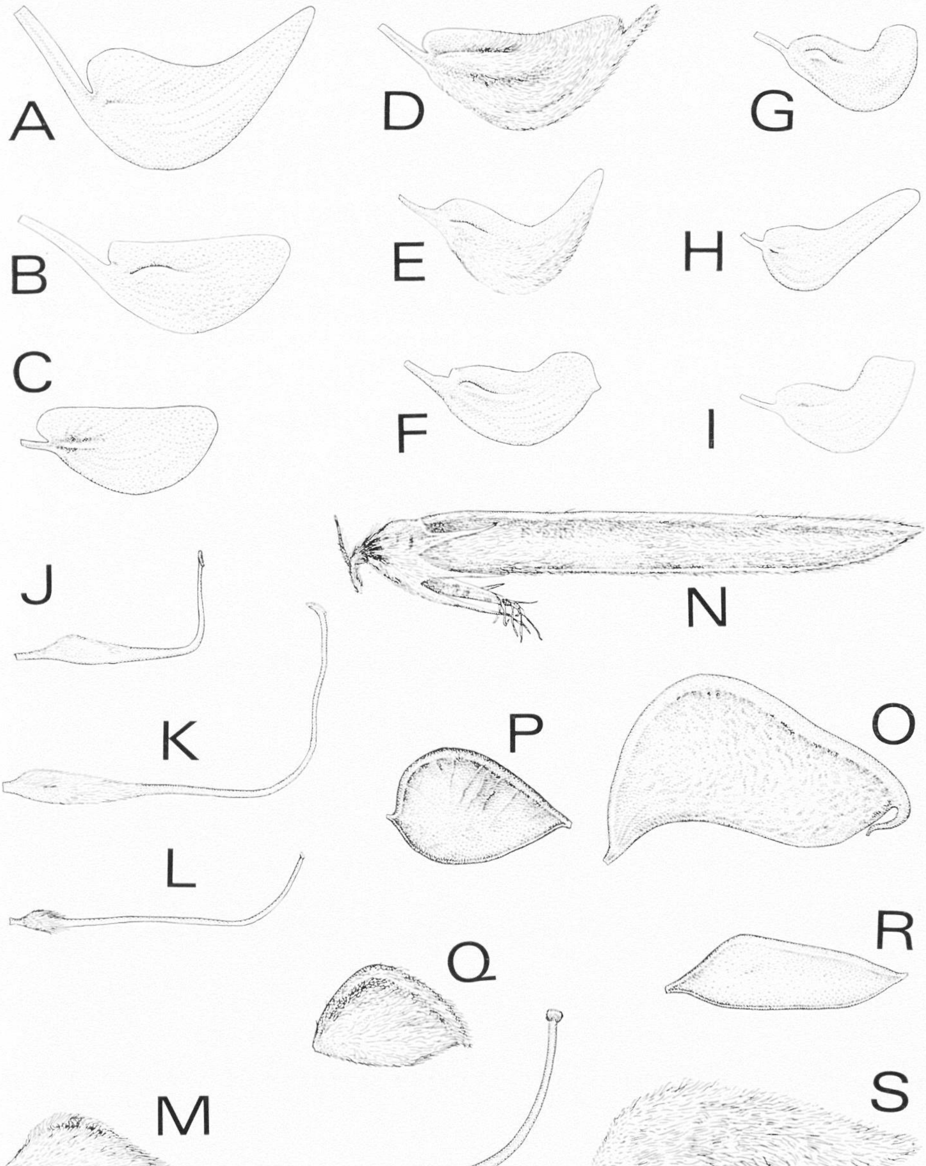

Fig. 4. *Aspalathus:* A—I: carina petals; J—M: pistils; N—S: pods. — A: *A. joubertiana* (ssp. *joubertiana*) × 4. — B: *A. pachyloba* (ssp. *pachyloba*) × 4. — C. *A. recurva* × 4. — D: *A. glossoides* × 4. — E: *A. rostripetala* × 4. — F: *A. patens* × 4. — G: *A. juniperina* (ssp. *juniperina*) × 4. — H: *A. lenticula* × 4. — I: *A. biflora* (ssp. *biflora*) × 4. — J: *A. nudiflora* × 4. — K: *A. rycroftii* × 4. — L: *A. prostrata* × 4. — M: *A. spectabilis* × 4. — N: *A. pinea* (ssp. *pinea*) × 2. — O: *A. citrina* × 4. — P: *A. hypnoides* × 4. — Q: *A. longipes* × 4. — R: *A. granulata* × 4. — S: *A. hystrix* × 4.

30 A. Ala blades with only one (—2) longitudinal row(s) of irregular folds and usually firmly attached to the lateral bulges of the carina (such as in fig. 3 U) .... 31 A
30 B. Ala blades with (3—) 4—6 rows of minute folds and not firmly attached to the lateral bulges of the carina .... 32 A
31 A. Bracts and bracteoles similar to the vegetative leaflets but slightly narrower (petals yellow .... *A. ericifolia* (ssp. *minuta*)
31 B. Bracts (and bracteoles if present) very small and subulate, ca. 0.2 mm broad or less (petals pale yellow) .... *A. hispida*
32 A. Flowers relatively large: carina blades more than 6 mm long; ala and carina claws usually attached at the base to the staminal sheath .. 33 A
32 B. Flowers relatively small: carina blades about 6 mm long or less; ala and carina claws (except in forms af *A. flexuosa*) free from the staminal sheath .... 36 A
33 A. Leaflets on the branch ends distinctly flattened (and weak) .. *A. confusa*
33 B. Leaflets not flattened (and often rigid) .... 34 A
34 A. Foliage bright-green with minutely tubercular hair bases .... *A. spicata*
34 B. Foliage greyish-green, without or with indistinct hair bases ...... 35 A
35 A. Ala and carina blades more than 6 and 7 mm long respectively *A. spicata*
35 B. Ala and carina blades less than 6 and 7 mm long respectively *A. incurva*
36 A. Calyx lobes, bracts and bracteoles filiform, less than 0.3 mm broad, minutely tuberculate at the hair bases (vexillum with apical tip ca. 1—2 mm long, fig. 2 K) .... *A. asparagoides*
36 B. Calyx lobes acicular, narrowly linear, subulate or lanceolate, not minutely tuberculate at the hair bases (vexillum without or with very short apical tip) .... 37 A
37 A. Leaves minutely and spreadingly puberulous or those on the lower parts occasionally subglabrous; carina blades broadest on basal half .. 38 A
37 B. Leaves glabrous or with sparse adpressed hairs; carina blades obtusely lunate, broadest near the middle .... 39 A
38 A. Ovary (and pod) minutely puberulous all over (bracteoles when present small and narrow, usually less than 1 mm long) .... *A. flexuosa*
38 B. Ovary (and pod) glabrous on basal and lower parts; bracteoles broadly subulate, usually ca. 2.5 mm long or more .... *A. campestris*
39 A. Vexillum blade ca. 4 mm long or less; carina blades less than 4 mm long (bracts and bracteoles minute) .... *A. florulenta*
39 B. Vexillum blade 4.5—7.5 mm long; carina blades 4—7 mm long .. 40 A
40 A. Branches weak, not thornlike in old stage; petals bright-yellow—ferruginous .... *A. wittebergensis*
40 B. Branches ± thornlike in old stage; petals mainly pale yellow *A. intricata*

KEY 16

1 A. Leaflets (2—5 cm) long, linear, ± flattened (flowers large, capitate) .... *A. stokoei*
1 B. Leaflets shorter, subterete, angular or canaliculate .... 2 A
2 A. Flowers in an elongate raceme (and relatively large) .... 3 A
2 B. Flowers in compact groups, heads, or umbels, or solitary .... 4 A

3 A. Calyx lobes 3—4 mm long; ovary almost glabrous ...... *A. erythrodes*

3 B. Calyx lobes ca. 1.5 mm long or less; ovary puberulous on most parts .... *A. corrudifolia*

4 A. Bracteoles ca. 4 mm broad or more (flowers very large and carnose, branchlets with whitish, glabrous segments) .... *A. capensis*

4 B. Bracteoles ca. 3 mm broad or usually less (branchlets not with whitish, glabrous segments) .... 5 A

5 A. Leaflets sharply spine-tipped or mucronate .... 6 A

5 B. Leaflets not sharp, obtuse—acute, acuminate or mucronulate .... 12 A

6 A. Calyx tube pubescent .... 7 A

6 B. Calyx tube glabrous .... 8 A

7 A. Flowers solitary or in pairs .... *A. collina*

7 B. Flowers usually 3 or more together .... *A. subulata*

8 A. Vexillum apex obtuse—retuse, sometime acute, sides of vexillum not firmly incurved .... 9 A

8 B. Vexillum ending in a distinct tip or spine; sides of vexillum firmly incurved .... 10 A

9 A. Bracts 1.5 mm broad or more; leaflets usually broadest on apical half (flowers usually 3—several together) .... *A. fusca*

9 B. Bracts ca. 1.2 mm broad or less; leaflets usually broadest near the base (flowers usually solitary or in pairs) .... *A. collina*

10 A. Leaflets glaucous (straight, 4—7 mm long; shrublets low) *A. potbergensis*

10 B. Leaflets green .... 11 A

11 A. Branches closely white-villous—woolly (shrublets procumbent or erect); bracteoles ca. 2.5 mm long or more .... *A. batodes*

11 B. Branches shortly pubescent (shrublets decumbent); bracteoles less than 2.2 mm long .... *A. crassisepala*

12 A. Bract 1.5—6 mm broad; flowers rather large and carnose, in terminal groups or headlike umbels .... 13 A

12 B. Bract not more than 1 mm broad; flowers small or medium-sized .. 15 A

13 A. Leaves sparsely pubescent (the alae and the rostrate carina partly ciliate on the margins) .... *A. capitata*

13 B. Leaves glabrous (petals not ciliate on the margins) .... 14 A

14 A. Pedicels 6—10 mm long; bracts partly with lobate-dentate margins, fig. 3 L .... *A. excelsa*

14 B. Pedicels less than 5 mm long; bracts entire, fig. 3 M (or seldom with one lobe on each side) .... *A. carnosa*

15 A. Calyx lobes triangular (and glabrous); pedicel ca. 4 mm long; bract accreted to the pedicel and emerging with the 4—5 mm long free part just below the calyx, figs. 2 M and 3 N .... *A. variegata*

15 B. Calyx lobes not triangular (or if so pubescent), of variable shape (from ovoid to subulate or linear-subulate); pedicels less than 2 mm long .. 16 A

16 A. Upper side of carina blades straight or only slightly curved (carina not particularly carnose) .... 17 A

16 B. Upper side of carina blades strongly curved (carina more or less rigid or carnose, fig. 4 G) .... 22 A

17 A. Flowers several together in headlike clusters .... 18 A

17 B. Flowers solitary or in pairs on branchlet tips .... 19 A

18 A. Ovules 4; shrubs procumbent; bracts oblanceolate-canaliculate *A. humilis*
18 B. Ovules 2; shrubs erect and relatively large: bracts narrowly linear *A. simii*
19 A. Calyx lobes more than 2 mm long .... *A. retroflexa*
19 B. Calyx lobes 1.5 mm long or less .... 20 A
20 A. Flowers solitary or binary on branch tips, but also solitary on lateral brachyblasts (calyx spreadingly puberulous) .... *A. simii*
20 B. Flowers solitary on branchlet tips only (calyx glabrous or with adpressed, short pubescence) .... 21 A
21 A. Flowers on peduncle-like branchlets; calyx lobes thickly subulate (pods at least up to 15 mm long, tapering at both ends) ...... *A. lanceicarpa*
21 B. Flowers on not particularly peduncle-like branchlets; calyx lobes narrowly linear, subterete .... *A. ramosissima*
22 A. Calyx tube pubescent on the outer side .... 23 A
22 B. Calyx tube glabrous on the outer side .... 26 A
23 A. Vexillum blade more than 6 mm long; pod ca. 9 mm long or more .... *A. retroflexa*
23 B. Vexillum blade less than 6 mm long; pod ca. 8 mm long or less .. 24 A
24 A. Calyx lobes ca. 1 mm long or less, globose-ovoid, fig. 1 E .. *A. concava*
24 B. Calyx lobes broadly or narrowly subulate .... 25 A
25 A. Ala blades 4.3—5.2 mm long; pods thick, with rather long hairs on part of the sides .... *A. retroflexa* (certain forms)
25 B. Ala blades 2.7—4.0 mm long; pods compressed, glabrous on the sides .... *A. crassisepala*
26 A. Vexillum blade less than 7.5 mm long; ala blades less than 6 mm long, fig. 4 G .... 27 A
26 B. Vexillum blade ca. 7.5 mm long or more; ala blades ca. 6.5 mm long or more .... 30 A
27 A. Leaflets very slender, ca. 0.2 mm thick (but 2—5 mm long); pod ovate, glabrous, glossy .... *A. hypnoides*
27 B. Leaflets less slender, 0.3 mm thick or usually more; pod of different shape .... 28 A
28 A. Calyx lobes ovoid (subterete; shrublets matlike, growing on calcareous ground) .... *A. repens*
28 B. Calyx lobes subulate or linear (shrublets decumbent or matlike) .. 29 A
29 A. Ovary sericeous at least on upper edge .... *A. crassisepala*
29 B. Ovary usually completely glabrous .... *A. juniperina*
30 A. Vexillum sides ± firmly incurved; vexillum back not ciliated on the midrib .... 31 A
30 B. Vexillum sides not firmly incurved (rather flat); vexillum back with scattered hairs on the midrib .... *A. condensata*
31 A. Ala blades usually wrinkled on half or more of the upper side, fig. 3 Y; bracts ca. 3 mm long or (usually) less .... *A. juniperina* (ssp. *grandis*)
31 B. Ala blades with relatively few folds on basal upper parts, fig. 3 Z; bracts 3.5—5 mm long .... *A. chrysantha*

KEY 17

1 A. Leaves closely grey-pubescent on most parts .... 2 A
1 B. Leaves glabrous or rather sparsely hairy, green .... 7 A

2 A. Flowers on ± peduncle-like branchlets with 1—2 exceptionally long internodes .... 3 A
2 B. Flowers on branchlets with internodes of ± uniform length ...... 4 A
3 A. Pods lanceolate, 12 mm long or more; flowers solitary .. *A. retroflexa*
3 B. Pods ovate, ca. 5 mm long or less; flowers commonly in pairs *A. longipes*
4 A. Vexillum puberulous on the apical 1/4 or less of the back; pod obliquely lanceolate, 10—12 mm long .... *A. digitifolia*
4 B. Vexillum pubescent on about half or more of the back; pods rather small, ca. 7 mm long or less .... 5 A
5 A. Leaflets ca. 0.7—0.8 mm broad (slightly flattened), white villous—tomentose .... *A. karrooënsis*
5 B. Leaflets ca. 0.5 mm thick or less, sericeous or shortly pubescent .. 6 A
6 A. Calyx adpressedly sericeous; shrublets prostrate .... *A. grobleri*
6 B. Calyx spreadingly pubescent; shrublets decumbent—ascending .... *A. intricata*
7 A. Pedicel glabrous (and often relatively long) .... 8 A
7 B. Pedicel pubescent .... 11 A
8 A. Leaflets spine-tipped .... 9 A
8 A. Leaflets acute—acuminate or apiculate, not spine-tipped .... 10 A
9 A. Calyx lobes usually less than 2.5 mm long, narrowly triangular; ovules usually 4—5 .... *A. rigidifolia*
9 B. Calyx lobes usually more than 2.5 mm long, subulate-acicular, with attenuate, often upcurved apices; ovules 2 .... *A. aristata*
10 A. Shrublets decumbent—prostrate, with non-thorny branches *A. pedicellata*
10 B. Shrublets erect, often with thorny branches .... *A. acicularis*
11 A. Ovary with 16—20 ovules; pod narrow and linear .... *A. filicaulis*
11 B. Ovary with less than 8 ovules; pods not linear .... 12 A
12 A. Vexillum base with pubescent, elongate callosities on the inner sides, fig. 3 R (large-flowered, with 4—6 ovules) .... *A. macrantha*
12 B. Vexillum base often pubescent, but not as above .... 13 A
13 A. Leaf bases with woody spines or spurs of 0.5—1.5 mm length .... *A. desertorum*
13 B. Leaf bases not spinelike .... 14 A
14 A. Leaves ± sparsely pubescent .... 15 A
14 B. Leaves glabrous .... 23 A
15 A. Tall shrubs (1.5—2.5 m); pedicels 3.5—5 mm long; pods ca. 15 mm long .... *A. decora*
15 B. Low shrubs or shrublets; pedicels less than 2 mm long; pods less than 10 mm long .... 16 A
16 A. Ala and carina claws adnate at the base to the staminal sheath (such as in fig. 2 L) .... 17 A
16 B. Ala and carina claws free from the staminal sheath .... 19 A
17 A. Bract and bracteoles slender, narrowly linear, 4—6 mm long .... *A. caespitosa*
17 B. Bract and bracteoles broader and usually less than 4 mm long .. 18 A
18 A. Bracts and bracteoles flat, ovate, about 1.3—2.0×0.8—1.2 mm large; calyx lobes ca. 2 mm long or less .... *A. prostrata*

18 B. Bracts and bracteoles linear, not flat; calyx lobes usually 3—6 mm long, spoon-shaped, lanceolate, oblong, or seldom linear .... *A. cymbiformis*
19 A. Calyx lobes with ± carnose apex or margins .... *A. prostrata*
19 B. Calyx lobes not with carnose apex or margins .... 20 A
20 A. Bracts more than 0.4 mm broad .... *A. cymbiformis*
20 B. Bracts narrower .... 21 A
21 A. Vexillum and carina blades ca. 4 mm long or less .... *A. florulenta*
21 B. Vexillum and carina blades more than 4.5 and 4 mm long respectively .... 22 A
22 A. Branches weak, not thorny in old stage; petals bright-yellow—ferruginous .... *A. wittebergensis*
22 B. Branches ± thorny in old stage; petals mainly pale yellow .. *A. intricata*
23 A. Pedicel 5—10 mm long; bract rhombic—ovate with slightly dentate margins, fig. 3 L .... *A. excelsa*
23 B. Pedicel less than 4.5 mm long; bract of different shape .... 24 A
24 A. Vexillum (beside on the base) with pubescence only along the midrib of the back side or with only few scattered hairs .... 25 A
24 B. Vexillum pubescent at least on the apical part of the back .... 32 A
25 A. Calyx lobes semicircular, at least the upper ones obtuse .... *A. carnosa*
25 B. Calyx lobes acute, acuminate, or spine-tipped .... 26 A
26 A. Calyx lobes narrowly triangular, not spine-tipped; pedicel ca. 4 mm long (bract emerging just below calyx), figs. 2 M and 3 N .... *A. variegata*
26 B. Calyx lobes linear or triangular and spiny; pedicel less than 3 mm long .... 27 A
27 A. Leaflets *sharply* spine-tipped .... 28 A
27 B. Leaflets minutely or not spine-tipped .... 29 A
28 A. Carina attenuately beaklike, carnose .... *A. astroites*
28 B. Carina upcurved but not pronouncedly beaklike nor especially carnose .... *A. collina*
29 A. Ovules 4; flowers in rounded heads .... *A. humilis*
29 B. Ovules 2; flowers mostly solitary or 2—3 .... 30 A
30 A. Closely matlike shrublets with glabrous calyx tube .... *A. condensata*
30 B. Procumbent or decumbent—ascending shrubs, often with puberulous or sparsely villous calyx tube .... 31 A
31 A. Calyx lobes (and leaflets) ending in fine spinelets .... *A. abietina*
31 B. Calyx lobes and leaflets acuminate (or apiculate) but not finely spine-tipped .... *A. retroflexa*
32 A. Calyx lobes with prominently thickened margins .... *A. marginalis*
32 B. Calyx lobes not with thickened margins .... 33 A
33 A. Pod ca. 5.5 mm broad or more; flowers relatively large (calyx lobes not spine-tipped or mucronulate; shrubs large, erect) .... *A. dianthopora*
33 B. Pod less than 5 mm broad; flowers small or/and with mucronulate—spine-tipped calyx lobes .... 34 A
34 A. Pods turgid, ovoid, very hard, and somewhat rugose; ovules 3—5 (usually 4) .... *A. collina*
34 B. Pods rather compressed or small, not particularly rugose; ovules always 2 (except in *A. biflora* ssp. *longicarpa* with relatively long, lanceolate pods) .... 35 A

35 A. Flowers on fine, slender peduncles; calyx lobes carnose, *not* spine-tipped or mucronulate .... *A. tenuissima*

35 B. Flowers either not on peduncles or *when so* always with spine-tipped or mucronulate calyx lobes .... 36 A

36 A. Calyx lobes carnose (0.5—1 mm broad), linear, acute—acuminate but not mucronulate or spine-tipped .... *A. retroflexa*

36 B. Calyx lobes either not carnose or *when so* either mucronulate or triangular or both .... 37 A

37 A. Calyx lobes spine-tipped or at least with a short mucro, generally triangular (carina blades usually rigid and upcurved) .... 38 A

37 B. Calyx lobes subulate or triangular, not spine-tipped nor with apical mucro (carina blades lunate, obtuse, not rigid, with straight or almost straight upper margins) .... 46 A

38 A. Leaflets ascending or patent, not pressed against the branches .. 39 A

38 B. Leaflets of young branches tightly pressed against the stem ...... 45 A

39 A. Carina apex narrow or broad, square or rounded, but not tapering and beaklike .... 40 A

39 B. Carina blades tapering and beaklike .... 44 A

40 A. Calyx lobes narrowly triangular, ending in a (sharp) spinelet .... 41 A

40 B. Calyx lobes deltoid, with short spinelet or mucro .... 42 A

41 A. Flowers solitary (seldom in pairs) on peduncle-like lateral branchlets usually with one, peduncle-like internode (procumbent shrublets) .... *A. serpens*

41 B. Flowers solitary—many together, on tips of ± leafy branchlets or branches (occasionally with the distal internode(s) somewhat prolonged; habit variable) .... *A. divaricata*

42 A. Vexillum and carina blades up to 7 and 5.7 mm long respectively (carina: fig. 4 I) .... *A. biflora* (ssp. *biflora*)

42 B. Vexillum blade at least 7.2 mm and carina blades at least 5.5 mm long .... 43 A

43 A. Pods 14.5 mm long or more, narrowly lanceolate .... *A. biflora* (ssp. *longicarpa*)

43 B. Pods ca. 12 mm long or less .... *A. aurantiaca*

44 A. Ala blades narrowly oblong or narrowly elliptic .... *A. divaricata* (certain forms)

44 B. Ala blades ovate or elliptic .... *A. attenuata*

45 A. Carina with square apex (such as in fig. 4 I); pod triangular-lanceolate .... *A. microphylla*

45 B. Carina tapering, beaklike, fig. 4 H; pod ovate .... *A. lenticula*

46 A. Vexillum and carina blades ca. 4 mm long or less ...... *A. florulenta*

46 B. Vexillum blade 4.5 mm long or more; carina blades ca. 4 mm long or more .... 47 A

47 A. Branches weak, not thorny in old stage; petals bright yellow—ferruginous (or red) .... *A. wittebergensis*

47 B. Branches ± thorny in old stage; petals mainly pale yellow .. *A. intricata*

KEY 18

1 A. Branches ending in sharp thorns .... 2 A
1 B. Branches not ending in thorns .... 6 A
2 A. Flowers on ± peduncle-like lateral branchlets .... 3 A
2 B. Flowers on the ± thornlike branch ends (which represent inflorescence axes) below the thorn tips .... 4 A
3 A. Leaflets and calyx lobes with (at least short) apical spinelets .... *A. pulicifolia*
3 B. Leaflets and calyx lobes acute—obtuse (leaves short, carnose) .... *A. acanthoclada*
4 A. Vexillum blade sericeous on central parts of the front side .. *A. secunda*
4 B. Vexillum blade glabrous on the front side (except on the base) .. 5 A
5 A. Ala blades about half as long as the carina blades or less .. *A. pulicifolia*
5 B. Ala blades normally more than half as long as the carina blades .... *A. acuminata*
6 A. Leaflets not spine-tipped or mucronate .... 7 A
6 B. Leaflets spine-tipped or mucronate .... 16 A
7 A. Leaflets closely white-pubescent .... 8 A
7 B. Leaflets green, glabrous or sparsely pubescent .... 11 A
8 A. Flowers (solitary) on long peduncles, subtended at the pedicel base by the bract only .... *A. nivea*
8 B. Flowers not on peduncles or, if so, subtended at the pedicel base by the bract and (opposite the bract) a fascicle of leaflets .... 9 A
9 A. Vexillum short-pubescent on most or all of the back side; carina extensively pubescent on lower parts .... 10 A
9 B. Vexillum pubescent only on apical parts of the back side; carina with only a few hairs .... *A. digitifolia*
10 A. Shrub erect, 1—2 m tall; upper margins of carina almost straight (hairs one-armed) .... *A. pedunculata*
10 B. Shrub decumbent, less than 50 cm high; upper margins of carina convex (hairs 2-armed) .... *A. rubens*
11 A. Carina extended in an apical tongue-like process ca. 1.5—2 mm long (such as in fig. 4 D) .... *A. proboscidea*
11 B. Carina without such a process .... 12 A
12 A. Flowers assembled in elongate racemes .... *A. corrudifolia*
12 B. Flowers solitary, in pairs, or in headlike groups .... 13 A
13 A. Bracts and bracteoles small, ca. 1 mm long or less .... 14 A
13 B. Bracts and bracteoles larger, ca. 2 mm long .... *A. retroflexa* (ssp. *empetrifolia*)
14 A. Calyx lobes triangular; carina blades with straight or concave (upcurved) upper margins .... 15 A
14 B. Calyx lobes linear—subulate; carina blades with ± convex upper margins .... *A. rubens*
15 A. Ala blades pubescent on most parts; carina with almost straight upper margins .... *A. vermiculata*

15 B. Ala blades pubescent only on lower parts; carina with distinctly concave (upcurved) upper margins .... *A. pilantha*

16 A. Pedicels and pods glabrous (or almost glabrous) .... *A. rigidifolia*

16 B. Pedicels pubescent; pods at least partly pubescent .... 17 A

17 A. Flowers very small; vexillum blade 3.2—4.2 mm large; flowers usually 2—several in small spike- or headlike racemes (leaflets green or grey-pubescent) .... *A. albens*

17 B. Flowers not so small; when the vexillum blade is less than 5 mm long the flowers are solitary .... 18 A

18 A. Carina with a marked tongue-like process from the apex, fig. 4 D .. 19 A

18 B. Carina without such a process .... 20 A

19 A. Shrublets erect; calyx tube glabrous on the outer side .... *A. glossoides*

19 B. Shrublets decumbent—procumbent; calyx tube pubescent on the outer side .... *A. proboscidea*

20 A. Calyx tube entirely glabrous on the outer side .... 21 A

20 B. Calyx tube more or less puberulous or villous on the outer side .. 25 A

21 A. Inflorescence on lateral branchlets with one (or two) peduncle-like internodes .... 22 A

21 B. Inflorescence on branchlet ends with moderately long and not peduncle-like internodes .... 23 A

22 A. Leaflets glabrous; carina pubescent on the lower parts only .... *A. spinosissima*

22 B. Leaflets (at least the larger ones) with sparse hairs; carina pubescent on most parts .... *A. ulicina*

23 A. Inflorescence with 1—2 flowers; carina blades less than 5 mm long (shrublets only up to 50 cm high or less) .... 24 A

23 B. Inflorescence multiflorous; carina blades more than 5 mm long; shrubs usually 1—3 m tall .... *A. vulnerans*

24 A. Ala blades more than 4.3 mm long; carina pubescent on less than half of the outer side .... *A. spinosissima* (ssp. *tenuiflora*)

24 B. Ala blades less than 3.5 mm long; carina pubescent on more than half of the outer side .... *A. acifera*

25 A. Carina tapering, distinctly beaklike, fig. 4 E .... *A. rostripetala*

25 B. Carina not distinctly beaklike .... 26 A

26 A. Pod triangular-lanceolate, more than 6.5 mm long; leaflets straight, patent, prickly; shrublets seldom matlike .... 27 A

26 B. Pod ovate, about 5.5 mm long or less; leaflets usually more or less incurved; shrublets matlike .... *A. leptoptera*

27 A. Branchlets closely villous and closely leafy; ala blades somewhat pubescent on lower basal parts .... *A. aristifolia*

27 B. Branchlets rather shortly and often sparsely pubescent, with relatively sparse groups of spreading leaflets; ala blades glabrous or almost glabrous .... *A. cuspidata*

KEY 19

1 A. Leaves strictly perfoliate (amplexicaul), surrounding the stem with the base, fig. 2 F; closest part of the leaf margin 2—5 mm from the stem .... *A. perforata*

1 B. Leaves at most semiamplexicaul (not entirely clasping the stem) .. 2 A

2 A. Leaves ± closely long-pubescent on the lower side .... *A. lanifera*

2 B. Leaves glabrous or sparingly pubescent on the lower side .... 3 A

3 A. Stem closely pubescent on youngest (upper) parts .... 4 A

3 B. Stem glabrous or sparingly pubescent on youngest (upper) parts .. 6 A

4 A. Pistil with more than 12 ovules .... *A. angustifolia*

4 B. Pistil with 2—4 ovules .... 5 A

5 A. Leaf margins glabrous; leaves broadly lanceolate or ovate.. *A. cordata*

5 B. Leaf margins ciliate at least on the lower parts; leaves lanceolate .... *A. barbata*

6 A. Pistil with 2 ovules only; pods ovate; carina blades ca. 3 mm long, fig. 2 O .... *A. monosperma*

6 B. Pistil with 4 or more ovules; pods lanceolate—linear or oblong; carina blades ca. 4 mm long or more .... 7 A

7 A. Carina blades more or less pubescent on the outer side .... 8 A

7 B. Carina blades glabrous .... 9 A

8 A. Shrublets gracile; ala blades ca. 7.5 mm long or less .... *A. lanceifolia*

8 B. Shrublets not gracile; ala blades ca. 8.5 mm long or more *A. angustifolia*

9 A. Branches terete, obtusely angular, or striated, not sharply angular or alate .... 10 A

9 B. Branches sharply angular or alate .... 14 A

10 A. Leaf margins roughened with distinct, minute—prominent tubercles or spinelike taps; leaves ovate—elliptic .... 11 A

10 B. Leaf margins smooth; leaves linear—lanceolate (seldom ovate); flowers normally on pseudolateral peduncles .... 13 A

11 A. Inflorescence with 1—many relatively large flowers; carina blades ca. 6 mm long or more .... 12 A

11 B. Inflorescence with numerous small flowers; carina blades ca. 4.6 mm long or less .... *A. complicata*

12 A. Branches usually low and decumbent, inflorescence 1—4-flowered; leaves usually not hard, with minutely tuberculate (and often undulate) margins .... *A. commutata*

12 B. Branches erect or suberect; inflorescence 7—25-flowered; leaves hard and usually with prominent marginal processes .... *A. perfoliata*

13 A. Calyx, bracts, bracteoles, and upper parts of stem with sparse, long, and patent hairs; vexillum ca. 8.5 mm broad or more .... *A. compacta*

13 B. Calyx, bracts, bracteoles, and upper parts of stem glabrous; vexillum less than 8.5 mm broad; fig. 1 D .... *A. alpestris*

14 A. Vexillum blade pubescent on about half or more of back .... 15 A

14 B. Vexillum blade almost glabrous (only with a few hairs on the midrib of the back, fig. 2 N) .... *A. leiantha*

15 A. Bracts and bracteoles usually less than 1 mm long; leaves elliptic—circular, with or without apical tip or mucro .... *A. elliptica*

15 B. Bracts and bracteoles usually more than 2 mm long; leaves ovate or elliptic-ovate, tapering into an apical mucro or spine ...... *A. crenata*

LIST OF THE ASPALATHUS SPECIES (AUTHORS' NAMES GIVEN)

abietina Thunb.
acanthes Eckl. & Zeyh.
acanthiloba R. Dahlgr.
acanthoclada R. Dahlgr.
acanthophylla Eckl. & Zeyh.
acicularis E. Mey.
acidota Garab. ex R. Dahlgr.
acifera R. Dahlgr.
aciloba R. Dahlgr.
aciphylla Harv.
acocksii (R. Dahlgr.) R. Dahlgr.
see below
aculeata Thunb.
acuminata Lam.
acutiflora R. Dahlgr.
albens L.
alopecurus Benth.
alpestris (Benth.) R. Dahlgr.
altissima R. Dahlgr.
angustifolia (Lam.) R. Dahlgr.
araneosa L.
arenaria R. Dahlgr.
argentea L.=*caledonensis* R. Dahlgr.
argyrella Mc Owan
argyrophanes R. Dahlgr.
arida E. Mey.
aristata Compt.
aristifolia R. Dahlgr.
aspalathoides (L.) R. Dahlgr.
asparagoides L. fil.
astroites L.
attenuata R. Dahlgr.
aurantiaca R. Dahlgr.

barbata (Lam.) R. Dahlgr.
barbigera R. Dahlgr.
batodes Eckl. & Zeyh.
bidouwensis Garab. ex R. Dahlgr.
biflora E. Mey.
bodkinii Bol.
borboniifolia R. Dahlgr.
bowieana (Benth.) R. Dahlgr.
bracteata Thunb.
burchelliana Benth.

caespitosa R. Dahlgr.
calcarata Harv.
calcarea R. Dahlgr.
caledonensis R. Dahlgr.
callosa L.
campestris R. Dahlgr.
candicans Ait.
candidula R. Dahlgr.
capensis (Walp.) R. Dahlgr.
capitata L.
carnosa Berg.
cephalotes Thunb.
cerrhantha Eckl. & Zeyh.
chenopoda L.
chortophila Eckl. & Zeyh.
chrysantha R. Dahlgr.
ciliaris L.
cinerascens E. Mey.
citrina R. Dahlgr.
cliffortiifolia R. Dahlgr.
collina Eckl. & Zeyh.
commutata (Vog.) R. Dahlgr.
compacta R. Dahlgr.
complicata (Benth.) R. Dahlgr.
comptonii R. Dahlgr.
concava Bol. in Schltr
condensata R. Dahlgr.
confusa R. Dahlgr.
cordata (L.) R. Dahlgr.
corniculata R. Dahlgr.
corrudifolia Berg.
costulata Benth.
crassisepala R. Dahlgr.
crenata (L.) R. Dahlgr.
cuspidata R. Dahlgr.
cymbiformis DC.
cytisoides Lam.

dasyantha Eckl. & Zeyh.
decora R. Dahlgr.
densifolia Benth.
desertorum Bol.
dianthopora Phill.
diffusa Eckl. & Zeyh.
digitifolia R. Dahlgr.
divaricata Thunb.
dunsdoniana Alst. ex R. Dahlgr.

elliptica (Phill.) R. Dahlgr.
ericifolia L.
erythrodes Eckl. & Zeyh.
esterhuyseniae R. Dahlgr.
excelsa R. Dahlgr.

fasciculata (Thunb.) Druce
ferox Harv.
filicaulis Eckl. & Zeyh.
flexuosa Thunb.
florifera R. Dahlgr.
florulenta R. Dahlgr.
forbesii Harv.
fourcadei L. Bol.
frankenioides DC.
fusca Thunb.

galeata E. Mey.
gerrardii Bol.
glabrata R. Dahlgr.
glabrescens R. Dahlgr.
globosa Andr.
globulosa E. Mey.
glossoides R. Dahlgr.
gracilifolia R. Dahlgr. = *juniperina* Thunb.
grandiflora Benth.
granulata R. Dahlgr.
grobleri R. Dahlgr.

heterophylla L. fil.
hirta E. Mey.
hispida Thunb.
humilis Bol.
hypnoides R. Dahlgr.
hystrix L. fil.

incana R. Dahlgr.
incompta Thunb.
incurva Thunb.
incurvifolia Vog. ex Walp.
inops Eckl. & Zeyh.
intermedia Eckl. & Zeyh.
intervallaris Bol. in Schltr
intricata Compt.

joubertiana Eckl. & Zeyh.
juniperina Thunb.

karrooënsis R. Dahlgr.

lactea Thunb.
laeta Bol.
lamarckiana R. Dahlgr.
lanata E. Mey.
lanceicarpa R. Dahlgr.
lanceifolia R. Dahlgr.
lanifera R. Dahlgr.
laricifolia Berg.
latifolia Bol.
leiantha (Phill.) R. Dahlgr.
lenticula Bol. in Schltr
leptoptera Bol.
leucophylla R. Dahlgr.
linearis (Burm. fil.) R. Dahlgr.
linguiloba R. Dahlgr.
longifolia Benth.
longipes Harv.
lotiflora R. Dahlgr. see below

macrantha Harv.
macrocarpa Eckl. & Zeyh.
marginalis Eckl. & Zeyh.
marginata Harv.
microphylla DC.
millefolia R. Dahlgr.
monosperma (DC.) R. Dahlgr.
mundiana Eckl. & Zeyh.
muraltioides Eckl. & Zeyh.
myrtillifolia Benth.

nigra L.
nivea Thunb.
nudiflora Harv.

obliqua R. Dahlgr.
oblongifolia R. Dahlgr.
obtusifolia R. Dahlgr.
odontoloba R. Dahlgr.
opaca Eckl. & Zeyh.
orbiculata Benth.

pachyloba Benth.
pallescens Eckl. & Zeyh.
pallidiflora R. Dahlgr.
parviflora Berg.
patens Garab. ex R. Dahlgr.
pedicellata Harv.
pedunculata Houtt.

pendula R. Dahlgr.
perfoliata (Lam.) R. Dahlgr.
perforata (Thunb.) R. Dahlgr.
pigmentosa R. Dahlgr.
pilantha R. Dahlgr.
pinea Thunb.
pinguis Thunb.
polycephala E. Mey.
potbergensis R. Dahlgr.
proboscidea R. Dahlgr.
prostrata Eckl. & Zeyh.
psoraleoides (Presl) Benth.
pulicifolia R. Dahlgr.
pumila R. Dahlgr.
pycnantha R. Dahlgr.

quadrata L. Bol.
quinquefolia L.

radiata Garab. ex R. Dahlgr.
ramosissima R. Dahlgr.
ramulosa E. Mey.
rectistyla R. Dahlgr.
recurva Benth.
recurvispina R. Dahlgr.
repens R. Dahlgr.
retroflexa L.
rigidifolia R. Dahlgr.
rosea Garab. ex R. Dahlgr.
rostrata Benth.
rostripetala R. Dahlgr.
rubens Thunb.
rubiginosa R. Dahlgr.
rugosa Thunb.
rupestris R. Dahlgr.
rycroftii R. Dahlgr.

salicifolia R. Dahlgr.
salteri L. Bol.
sanguinea Thunb.
sceptrum-aureum R. Dahlgr.
secunda E. Mey.
securifolia Eckl. & Zeyh.
sericea Berg.
serpens R. Dahlgr.
setacea Eckl. & Zeyh.
simii Bol.
singuliflora R. Dahlgr.
smithii R. Dahlgr.
spectabilis R. Dahlgr.
spicata Thunb.
spiculata R. Dahlgr.
spinescens Thunb.
spinosa L.
spinosissima R. Dahlgr.
stenophylla Eckl. & Zeyh.
steudeliana Brongn.
stokoei L. Bol.
suaveolens Eckl. & Zeyh.
submissa R. Dahlgr.
subulata Thunb.
sulphurea R. Dahlgr.

taylorii R. Dahlgr.
tenuissima R. Dahlgr.
teres Eckl. & Zeyh.
ternata (Thunb.) Druce
tridentata L.
triquetra Thunb.
truncata Eckl. & Zeyh.
tuberculata Walp.
tylodes Eckl. & Zeyh.

ulicina Eckl. & Zeyh.
uniflora L.

vacciniifolia R. Dahlgr.
varians Eckl. & Zeyh.
variegata Eckl. & Zeyh.
venosa E. Mey.
verbasciformis R. Dahlgr.
vermiculata Lam.
villosa Thunb.
vulnerans Thunb.
vulpina Garab. ex R. Dahlgr.

wittebergensis Compt. & Barnes
wurmbeana E. Mey.

zeyheri (Harv.) R. Dahlgr.

REMARKS

Aspalathus lotiflora R. DAHLGR. after reconsideration seems to be based on a hybrid (in which *A. araneosa* L. and possibly *A. juniperina* THUNB. may be involved) and has not been included in the key. Of names previously used in my publications, *A. gracilifolia* R. DAHLGR. has subsequently been included as a subspecies of *A. juniperina* THUNB., and *A. argentea* L. has been renamed to *A. caledonensis* R. DAHLGR. *A. concavifolia* ECKL. & ZEYH. has turned out to be, most likely, a form of *A. cytisoides* LAM. Finally, *A. acocksii* (R. DAHLGR.) R. DAHLGR. is included in the key under *A. quinquefolia* L.

Studies in Cleome III

Morphology and Distribution of Some African Species

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ABSTRACT

The present taxonomical study deals with the following taxa: *Cleome rubella* Burch., *C. coeruleo-rosea* Gilg & Bened., *C. oxyphylla* Burch., *C. schlechteri* Briq., *C. maculata* (Sond.) Szyszyl. and *C. conrathii* Burtt Davy. All species are confined to southern Africa except *C. coeruleo-rosea* which is known from Tsad, Cameroons and Sudan. One new variety is discribed from northern Transvaal, viz. *Cleome oxyphylla* Burch. var. *robusta* Kers. The distribution of the taxa has been mapped and the phytogeographical aspects of certain ranges are discussed. All species were found to have a characteristic, descending type of petal aestivation (Fig. 1 A), and they also have rudimentary stipules. They share these morphological features with many other African *Cleome*, though these particular characteristics do not seem to have been observed previously.

MORPHOLOGICAL NOTES

PETAL AESTIVATION

All species dealt with in the present study show the same general type of petal aestivation (cf. Fig. 1 A). The aestivation is characterized by the following featurs.

1. The upper and the lower petal-pairs act as separate units; the upper two petals always overlapping the lower ones in a descending manner.

2. The two median overlappings are directed either clockwise or anticlockwise. The latter alternative seems to be the more common. In some rare exceptions, the two median overlappings are both directed to the left or to the right.

The same type of aestivation was found to characterize all other African *Cleome*, which were studied from this point of view, viz. *Cleome angustifolia* Forsk. s. lat., *C. brachycarpa* Vahl ex DC., *C. elegantissima* Briq., *C. gynandra* L., *C. hirta* (Kl.) Oliv., *C. iberidella* Welw.

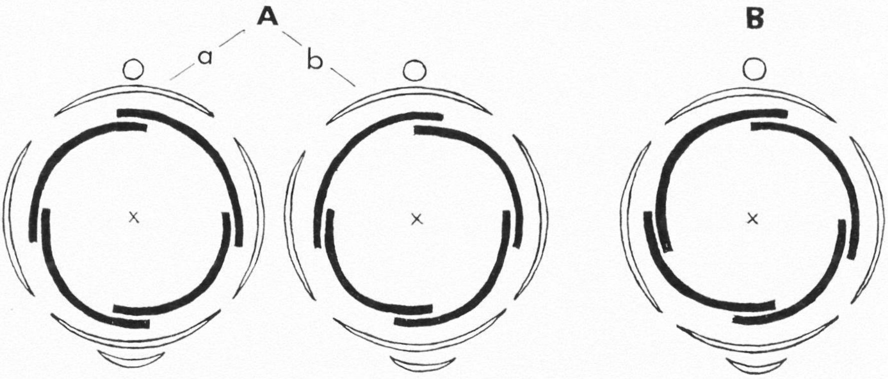

Fig. 1. Petal aestivation in *Cleome.* — A: Type of aestivation found in species treated in the present study. The upper petal-pair overlaps the lower petal-pair. The two median overlappings can be either directed clockwise (right figure) or anti-clockwise (left figure). — B: Twisted aestivation, found in some American species. Further explanations in the text.

ex OLIV., *C. macrophylla* (KL.) BRIQ., *C. parvula* R. A. GRAHAM, and *C. paxii* (SCHINZ) GILG & BENED. Also the Australian species *Cleome tetrandra* BANKS ex DC. shows this type of aestivation.

Contrary to this apparently stable Old World condition, some American species were found to have a twisted petal aestivation (cf. Fig. 1 B), viz. *Cleome speciosa* H. B. K., *C. spinosa* JACQ., and *C. regnellii* EICHLER. In *Cleome hirsuticaulis* MACBRIDE, the twisted type and the "Old World type" occur in separate flowers on the same inflorescence.

STIPULES

The species treated in this paper have rudimentary stipules. The stipules are shorter than one millimetre in length (0.1—0.5 mm long), and because of their diminutive size they are easily overlooked. Espe-

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Fig. 2. *Cleome rubella* BURCH. Scale for A. — A: Genera aspect of plant (LIEBENBERG 2987, PRE). — B: Gynophore in lateral view with portions of the pedicel and the ripe fruit. The scars of the stamens, petals and sepals are marked in black. Gynophore 2 mm long (LEWIS 313, SAM). — C: Flower in lateral view, 8.5 mm long (BRUECKNER 843, PRE). — D: Cauline hair, 0.45 mm long (MAGUIRE 1361, SAM). — E: Flower seen form above, dissected to show the minute, flat dorsal disc and the insertion of the stamens. The apical parts of the ovary, petals and stamens have been removed (BRUECKNER 843, PRE). — F: Stipule. Globose in outline, with short stalk and 0.1 mm in diametre (ROGERS 10402, S). — G: Petals. Lateral petal to the left, upper petal to the right, 7 mm long (BRUECKNER 843, PRE). — H: Apical portion of fruit with the style. Length of style: 4 mm (LEWIS 313, SAM).

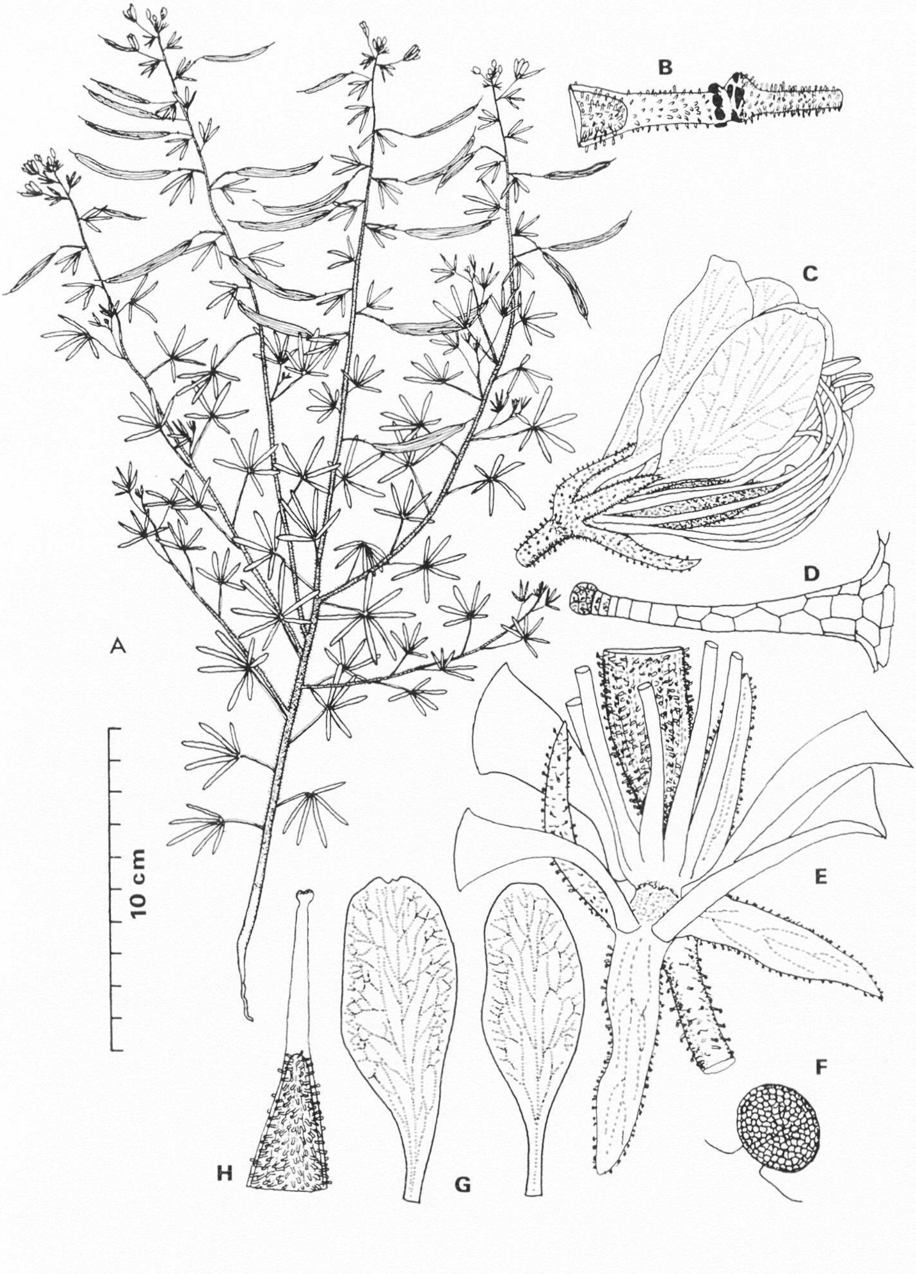

Fig. 2.

cially in species which have richly pubescent stems and petioles, they are very difficult to observe and separate from sessile glands. The stipules of each particular species have been illustrated (Figs. 2—7).

Cleome rubella BURCH. Trav. Inter. Southern Africa 1: 543 (1822).

Typus speciei: BURCHELL 2025, 16.II.1812, Cape Prov., Griqualand West, "The Kloof", in the southern parts of the Asbestos Mtns (BM, K).

Synonym: *Cleome rupestris* SONDER, Linnaea 23: 6 (1850). Type: ZEYHER s.n., May. Auf steinigen Hügelbergen, Vaal River (S, TCD).

Literature: BRIQUET (1914 p. 362); BURTT DAVY (1924 p. 224; 1926 p. 121); DE CANDOLLE (1824 p. 241); DINTER (1919 pp. 168, 172; 1921 pp. 42, 125, 139); DURAND & SCHINZ (1898 p. 160); ENGLER (1910 pp. 554, 566, 574, 582; 1915 p. 228); EXELL & MENDONÇA (1937 p. 56); GILG & BENEDICT (1915 p. 157); LETTY (1962 p. 145, t. 73: 1); MEDLEY WOOD (1908 p. 128); PAX & HOFFMANN (1936 p. 213); ROESSLER (1966 p. 47:12); SEINER (1912 p. 47); SONDER (1860 p. 56); SZYSZYLOWICZ (1888 p. 109); WILD (1960 p. 200).

Icon.: Figs. 2, 8 E — LETTY (1962 t. 73:1).

Distribution: Fig. 9 D.

Annual herb, erect, usually richly branched, 15—30 (—48) cm tall, viscid glandular—pubescent with stipitate and sessile glands. *Stem* herbaceous, seldom suffruticose at the base. *Leaves* 5—9-foliolate, gradually becoming shorter towards the racemes and grading into the floral bracts, petiolate; *petioles* up to 3.5 cm long; *stipules* rudimentary and exceedingly small, almost globose. *Leaflets* (5—) 10—25 mm long and 1.5—2 mm broad, linear, folded along the midrib or plane, acute at the apex, glabrous above and minutely glandular beneath. *Bracts* leafy, (3—4—) 5-foliolate, gradually diminishing in size upwards, shortly petiolate to subsessile, lamina 3—7 mm long. *Inflorescences* of terminal racemes, vaguely marked off from below due to the gradual transition from cauline leaves to bracts; intermittent sterility of the flowers not well developed. *Pedicels* thin and slender, yellowish, spread in ascending manner (c. 45°) at anthesis, whereas in fruits they become more spread out from the stem. *Sepals* 3—4 mm long, linear to lanceolate, acute at the apex, often with shades of violet, deciduous, puberulous. *Petals* (3—4—) 6—7 (—8) mm long and 1.5—2.5 mm broad, equal or nearly so, obovate, shortly unguiculate, rounded-obtuse to retuse at the apex, violet-red to rose-pink, without yellow markings. *Stamens* all fertile, (5—) 6—8 (—9), almost equalling the petals in length; *filaments* 5—7 mm long, glabrous, pink—violet, yellow near the base, curved in apical parts, equal or the lower ones somewhat longer than the others; *anthers* 0.5—1 mm long, yellowish. *Gynophore* (in fruits) 1.5—3 (—4) mm long, sparsely glandular—puberulous. *Fruits* comparatively short

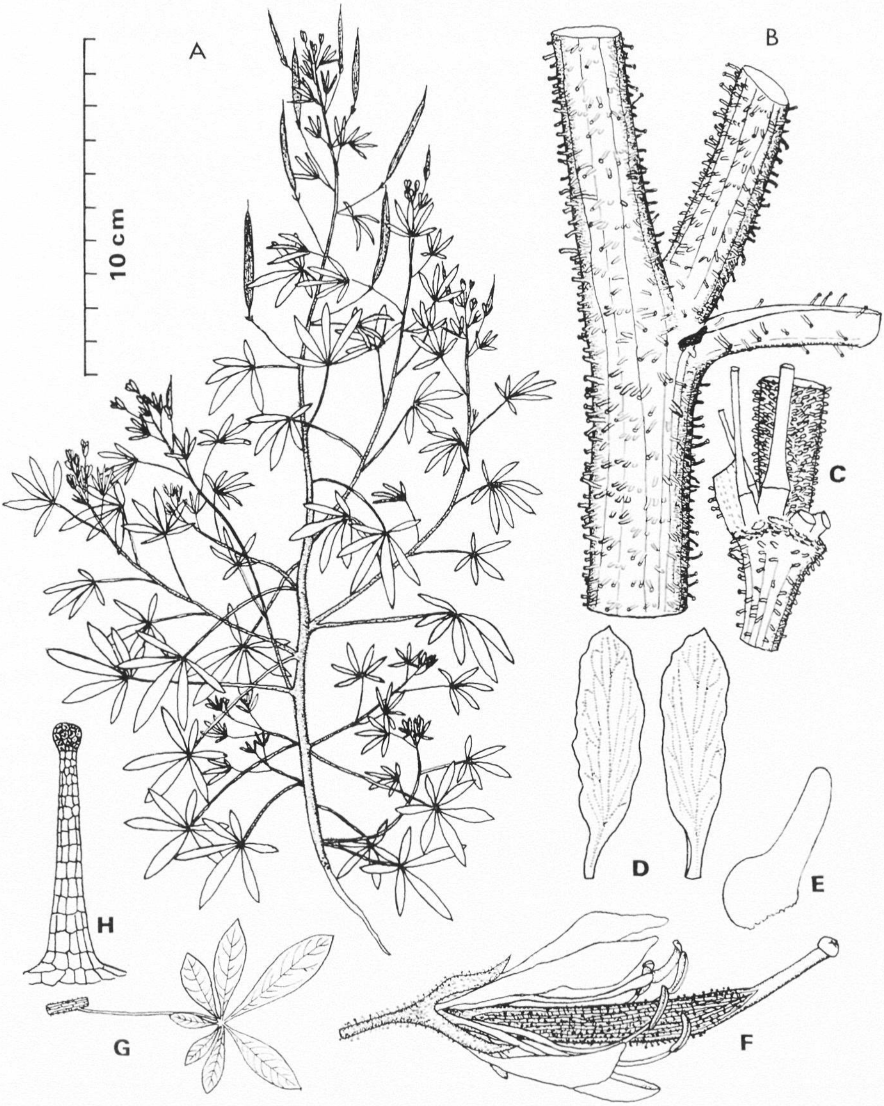

Fig. 3. *Cleome coeruleo-rosea* GILG & BENED. Scale for Figs. A and G. — A: General aspect of plant (RAYNAL 12435, P). — B: Portion of stem with a lateral branch, showing the glandular—puberulous indumentum. Note the rudimentary stipule (black) (LETOUZEY 7147, P). — C: Receptacle in a young fruit. The apical portion of the pedicel below. The stamens are regularly shed a little above their points of insertion. The basalmost parts of a sepal may be seen to the left (RAYNAL 12435, P). — D: Petals. Upper petal to the left, lateral petal to the right, 5 mm long (LEDERMANN 4096, B). — E: Stipule, 0.38 mm long, tapering from a broad base (CHEVALIER 9218, P). — F: Flower in lateral view (incl. style 9 mm long) (LEDERMANN 4096, B). — G: Cauline leaf from a specimen with comparatively broad leaflets (cf. Fig. A, drawn to same scale) (CREAC'H 66, P). — H: Cauline hair, 0.38 mm in length (CHEVALIER 9218, P).

and broad, (12—) 20—30 (—42) mm long and 2—3 mm broad, spreading when ripe; *valves* striated with about 9 longitudinal anastomosing veins, sparsely glandular-puberulous, completely dehiscing; *style* 2—4 (—5) mm long, filiform, glabrous, curved upwards in apical parts at anthesis, later becoming straight; *stigma* minute, subcapitate. *Seeds* c. 2 mm in diameter, rounded in outline, somewhat flattened, dark brown, sculptured with marked transverse ridges and inconspicuous longitudinal furrows (Fig. 8 E).

Cleome rubella BURCH. is a well-defined species, not easily confused with any other *Cleome* in southern Africa. This species is readily identified by the narrow linear leaflets, the small reddish flowers with short and rather few stamens, the comparatively short fruit and gynophore, and the low and rather dense habit of growth. *C. rubella* shows a clear affinity to *Cleome hirta* (KL.) OLIV., and young and depauperate specimens of the latter species may be rather similar to *C. rubella*. These species are clearly separated by their different seeds. *C. hirta* differs also in the following respects: the petals are much longer than in *C. rubella* and the median petals are marked with yellow, the filaments have sessile glands, and the plants have a tall and robust growth, often reaching 2 m in height. This comparison of *C. rubella* and *C. hirta* is based on the typical form-series of the latter species (southern Africa). Although *C. rubella* is clearly separated from *C. hirta* in southern Africa, the distinction is not always easily made when taking into account the material of *C. hirta* which comes from central tropical Africa and further north. In these northern areas, *C. hirta* is more variable and tends to have small flowers. But even these non-typical specimens of *C. hirta* can be distinguished from *C. rubella* owing to their long and slender fruits and differing seed characters.

When DE WILDEMAN in 1927 described *Cleome giorgii* from Congo

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Fig. 4. *Cleome oxyphylla* BURCH. — A, C—H: var *oxyphylla*; B: var. *robusta* KERS. Scale for Figs. A and B. — A: General aspect of plant (I. ÖRTENDAHL 59, UPS). — B: var. *robusta* KERS. Upper portion of inflorescence (POLE EVANS 1958, PRE). — C: Petals. Left: lateral petal, 10.5 mm long. Right: upper petal (KERS 874, S). — D: Flower in lateral view. The petals have been bent aside in order to show the dimorphic stamens more clearly. The yellow bases of the upper petals have been outlined (KERS 874, S). — E: Flower dissected to show the arrangement of the androecium. The petals and the apical portions of the basal stamens have been removed. The illustrated flower is 'female-sterile', hence the pistil is rudimentary and hardly visible (KERS 874, S). — F: Stipule, tapering obliquely from a broad base, 0.2 mm long (I. ÖRTENDAHL 59, UPS). — G: Apical portion of a fruit with the style. Stigma inconspicuous (KERS 872 b, S). — H: Cauline hair, 0.17 mm long (I. ÖRTENDAHL 59, UPS).

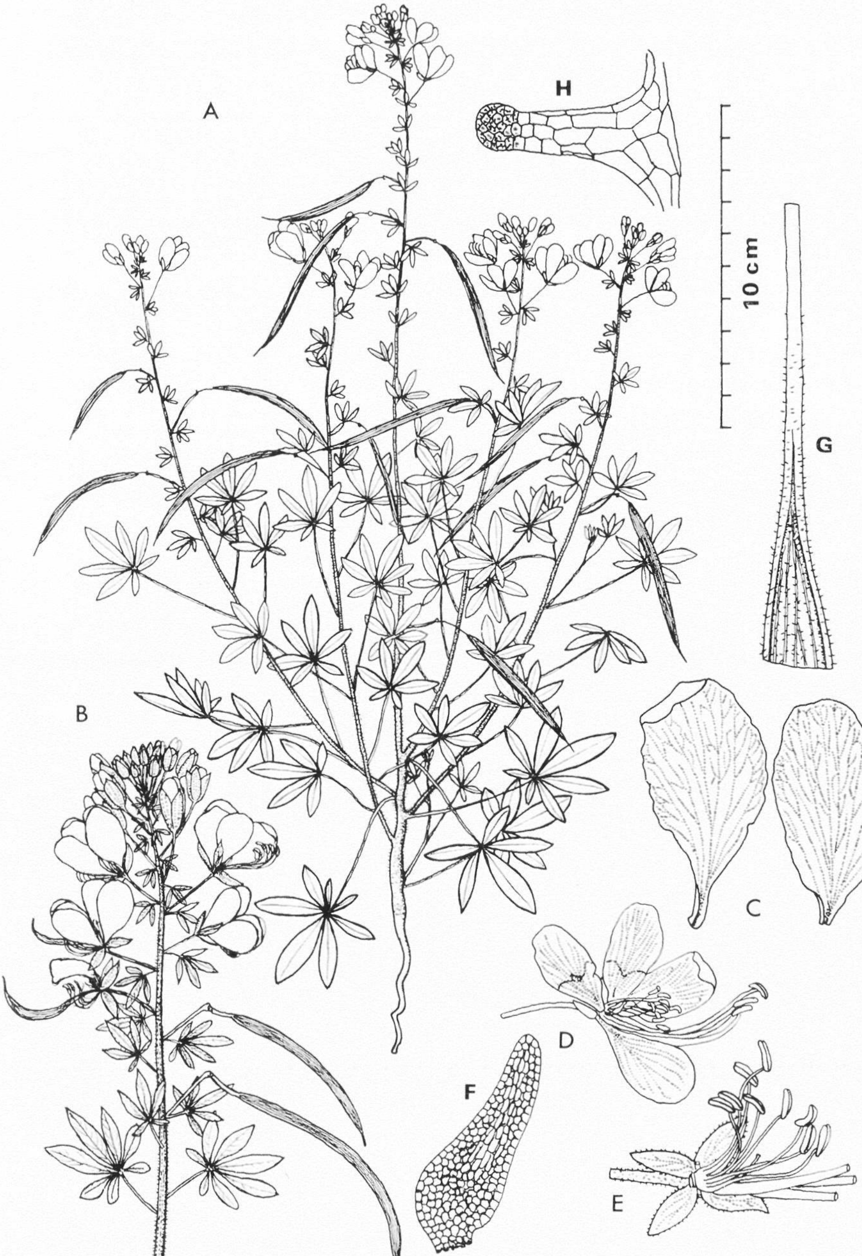

Fig. 4.

(Katanga), he compared his new species with *C. rubella,* a comparison later also made by PAX and HOFFMANN (1936 p. 213). However, the only collection of *C. rubella* cited by DE WILDEMAN, (viz. DINTER 20 from Okahandja, S. W. A.) is not *C. rubella* but the type of *Cleome elegantissima* BRIQ. The author has seen the type of *Cleome giorgii* DE WILD. and can confirm that this species is identical with *Cleome hirta* (KL.) OLIV. This has been suggested previously by HAUMAN and WILCZEK (1951 p. 515).

Sometimes *Cleome rubella* has been confused with *Cleome elegantissima* BRIQ. (= *C. welwitschii* EXELL). This latter species differs from *C. rubella* is having yellow-banded upper petals, prominent claws, long slender fruits, longer stamens and gynophore, and differs also in the more sparse indumentum. *C. rubella* resembles *Cleome coeruleo-rosea* GILG & BENED. (cf. Fig. 3), but the latter species has broader leaflets and erect capsules which are inconspicuously stipitate or even lack a marked gynophore. These two species also differ from each other in seed characters. The author considers *Cleome hirta* (KL.) OLIV. the closest relative of *C. rubella.*

Cleome rupestris SOND. does not differ from *C. rubella* BURCH. The slight differences given by SONDER (1860) fall within the comparatively narrow range of morphological variation shown by *C. rubella.*

The intermittent sterility, a common feature in *Cleome,* is only weakly developed in *C. rubella.*

DISTRIBUTION, ECOLOGICAL NOTES. *Cleome rubella* is a therophyte and summer annual and is confined to the semi-arid interior parts of southern Africa (Fig. 9 D). An old report of this species from Congo may be due to a confusion with *C. hirta* (DURAND & SCHINZ 1898 p. 160).

Cleome rubella occurs usually in dry sandy soil, generally not far from rocky habitats, e.g. on sandy plains situated among hills. It is also fairly common on the outskirts of the Kalahari region. In many localities the most plentiful occurrence of this species is found on disturbed soil (e.g. at roadsides). *C. rubella* is exceptionally found on hillsides, in rock crevices and from similar rocky habitats. I have not encountered any records from moist habitats, but rarely it occurs in dried-up, sandy water-courses.

Cleome rubella is occasionally found growing near other *Cleomes,* e.g. *C. hirta, C. gynandra* and *C. kalachariensis* ssp. *kalachariensis* and then often on disturbed soils.

The range of distribution is centred in the Kalahari region, but the

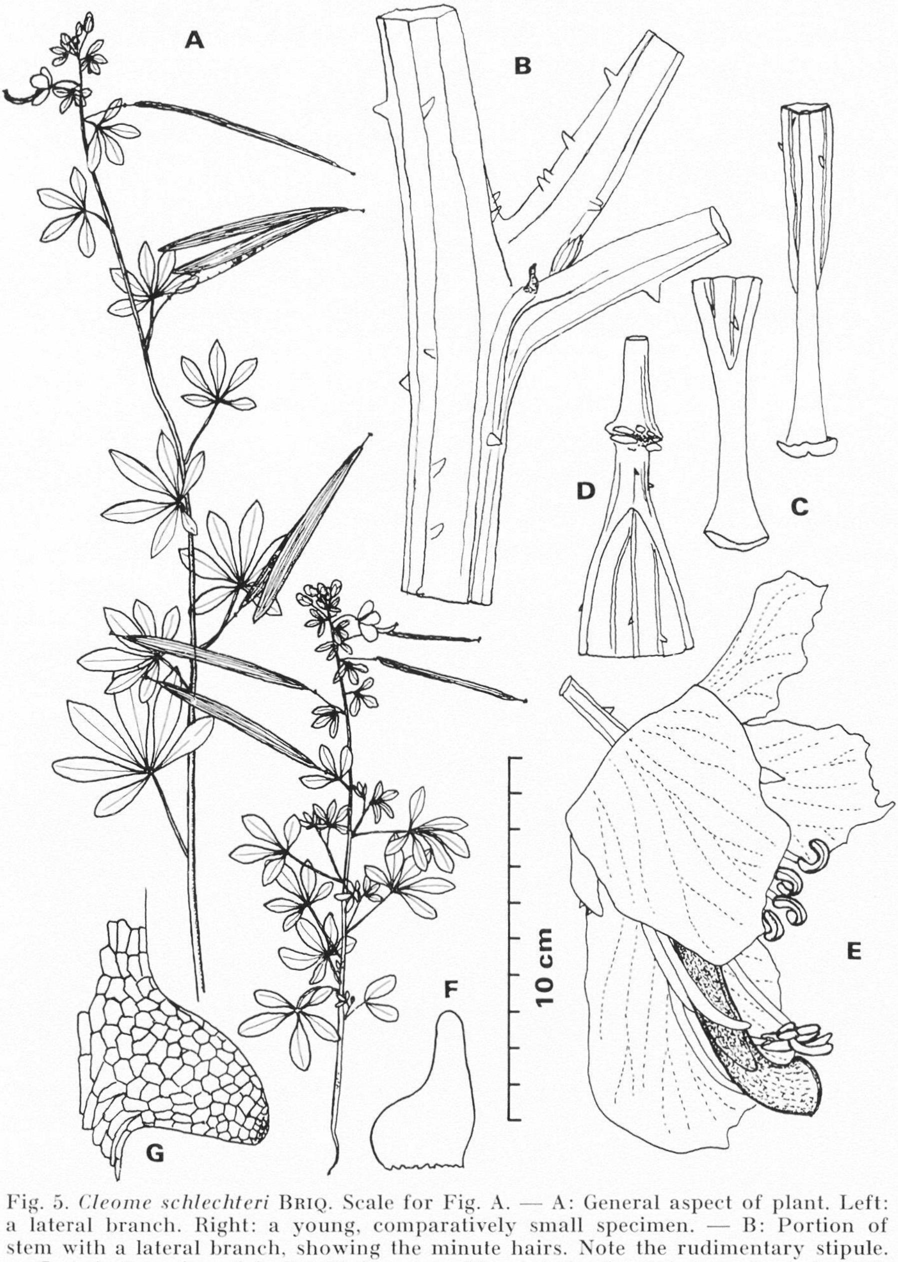

Fig. 5. *Cleome schlechteri* Briq. Scale for Fig. A. — A: General aspect of plant. Left: a lateral branch. Right: a young, comparatively small specimen. — B: Portion of stem with a lateral branch, showing the minute hairs. Note the rudimentary stipule. — C: Apical portion of fruit with the style. The style is directed downwards in both drawings. Style 4 mm long. Note the broad stigma. — D: Gynophore on a ripe fruit, 1 mm long. The receptacle and portions of the pedicel and fruit are also seen. — E: Aspect of flower in lateral view. Dorsal part to the right. The flower is 0.9 cm long. — F: Stipule, 0.48 mm long. Basal portion below. — G: Cauline hair, 0.25 mm long (The left specimen in A is drawn from Schlechter 11756, G; all other drawings from Ward 4470, PRE).

species occurs most frequently along the outskirts of that area (Fig. 9 D). Apparently *Cleome rubella* thrives best in areas receiving an annual precipitation of 250—750 mm (WELLINGTON 1955 map III). This means that the species is not successful in the dry Karroo-Namib Region, which thus delimits its range towards the west and south. Probably most parts of the central Kalahari are too dry for this species as well. On the other hand, increasing rainfall contributes to delimit its distribution further east and north.

Within its range, one can trace two centres of particularly high frequency. One of these is situated in the central parts of S. W. Africa (="Damaraland"), while another centre follows the eastern border of the Kalahari within the Transvaal and Cape Province. These centres might be characterized as semi-arid, mountainous—hilly regions, generally composed of a mosaic pattern of hills and sandy plains. *Cleome rubella* seems to prefer such varied environments to the vast uninterrupted sandy plains which dominate the interior parts of the Kalahari as well as the adjacent areas in the north. A rough sketch that outlines those drier — but not actually desertlike — regions of southern Africa which are particulary rich in the hilly landscape type mentioned above, will show a U-shaped figure. This U-shaped range embraces the Kalahari from the south. In the distribution pattern of *C. rubella* one may trace this outline (Fig. 9 D). The eastern extension of the arid Namaqua-

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Fig. 6. *Cleome maculata* (SOND.) SZYSZYL. Scale for Fig. A. — A: General aspect of plant. The bracts are very small, therefore the racemes appear 'ebracteate' (LIEBENBERG 3454, PRE). — B. Cauline hair, 0.1 mm long (ROGERS 6886, NH). — C: Portion of stem with a lateral branch, showing a stipule and the few minute hairs (THODE A 1349, NH). — D: Detail of an inflorescence axis. Note the subulate bract at the base of the pedicel and the minute stipules. Bract 1 mm long (HUTCHINSON 2698, BOL). — E: Apical portion of a staminode, showing the clavate portion of the filament and the rudimentary anther (DYER 3511, NH). — F: Petals. Left: upper petal-pair, inserted on the margin of the receptacle. Right: a lateral petal, 1.2 cm long (DYER 3511, NH). — G: Receptacle in lateral view, dorsal part to the left. The dorsal portion of the receptacle is characteristically widened into a pouch-like cavity. To the left may be seen the bases of one of the upper petals and one sepal and these are inserted on the margin of the pouch. The bases of four fertile stamens and three staminodes may be seen. The illustrated flower is 'female-sterile' and the pistil is therefore rudimentary (DYER 3511, NH). — H: General aspect of a 'female-sterile' flower, showing the ventral stamens and the dorsal staminodes (DYER 3511, NH). — I: Receptacle on a ripe fruit, lateral view. Dorsal part to the right; the gynophore base facing upwards. Note the swollen, funnel-shaped dorsal portion of the receptacle. The minute opening of the cavity marked with an arrow. Androgynophore + receptacle: 3 mm long (BOLUS 9879, BOL). — J: Apical portion of fruit with the style. Style 6 mm long (BOLUS 9879, BOL).

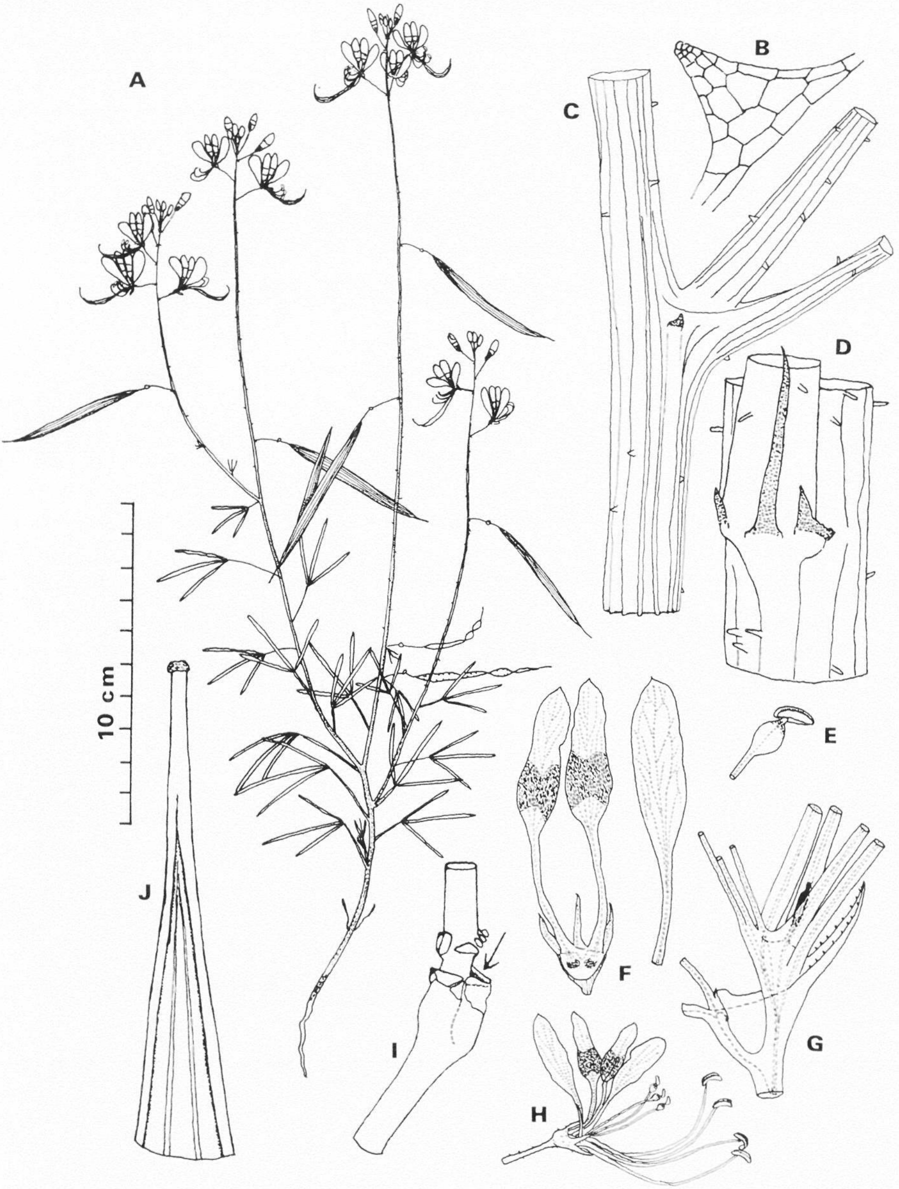

Fig. 6.

lands means, however, a constriction of the range in the southern parts of S. W. Africa and will give us the two centres mentioned above. This pattern of distribution is well exemplified in *Cleome oxyphylla* BURCH. (Fig. 9 E), and it can also be found in the distribution of *Anthephora pubescens* NEES, *Oropetium capense* STAPF (CHIPPINDALL 1959 p. 438 map 67, and p. 204 map 22 respectively), certain species of *Limeum* (FRIEDRICH 1956 maps on p. 165), *Osteospermum muricatum* E. MEY. (NORLINDH 1943 p. 411) as well as in the distribution of many others.

COLLECTIONS. (Complete list of references deposited in the Library, Natural History Museum, Botanical Section, Stockholm).

ANGOLA. Huila distr.: BONNEFOUX & VILLAIN 47. Humble, à bord du Cunene, Cyipelongo (P); KERS 3103. Road: Ruacana Falls—Naulila—Rocadas, 9 miles NE from the S. W. A. border (S); KERS 3249. Road: Rocadas—Sá da Bandeira, near Chiosse (S); MENDES 1618. Canhanhole (LISC); WELWITSCH 952. In arvis neglectis inter Nene et Humpata (BM, COI) — Benguela distr.: WELWITSCH 954. In sandy maritime stations to the south of the city Benguela (K pro parte with *Cleome welwitschii* EXELL).

SOUTH WEST AFRICA. Material studied: 59 collections, comprising 69 sheets (B, BOL, H, HBG, K, LD, PRE, S, SAM, UPS, Windhoek).

BOTSWANA. Northern distr.: CURSON 503. Ngamiland, Mankgane (PRE); LUGARD 189. Botlele Valley (K); RICHARDS 14672. Pan near Francistown—Maun road (K); RICHARDS 14707. Track to Kingogo Tsetse Camp (K, LISC, S); RICHARDS 14735. Near Matsibe Tsetse Camp (K, LISC); RICHARDS 14838. Near Nokanenge (K); RICHARDS 14882. Near Bushman Pits (K); RICHARDS 14838. Near Nokanenge (LISC); WILD & DRUMMOND 6833. Between Odiakwe and Kanye (K) — South Eastern distr.: HABOR s.n. Mochudi (PRE, SAM); HOLUB s.n. Bakwena Territory, c. 3500 ft. (K); HUMBERT 15302. Environs de Gaberones (P); ROGERS 6886. Mochudi (BOL pro parte with *Cleome maculata*, NH) — South Western distr.: LEISTNER 3065. Kgalagadi, 10 mls NW of Tsabang (STE); WILD 5043. 45 mls N of Kang (K); WILD 5153. Tsabong (K); DE WINTER 7428. 21 mls SW of Takatswane (K, PRE, Windhoek).

ZAMBIA. MACAULAY 15. Sesheke (K).

Fig. 7. *Cleome conrathii* BURTT DAVY. Scale for Fig. A. — A: General aspect of plant. — B: Portion of stem showing the few, minute hairs. Note the rudimentary stipule at the base of the petiole. — C: Cauline hair: 0.1 mm long. — D: Petals. Right: upper petal. Left: lateral petal, 6 mm long. — E: Flower just before anthesis. The upper petals have been turned to the sides in order to show the five fertile stamens. — F: Flower after anthesis, lateral view. The stamens have lost their anthers. The flower, incl. the pistil is 12 mm long. In this species the receptacle is not widened into a dorsal pouch, cf. *C. maculata*, Fig. 6 H and I. — G: Flower dissected and seen from above, showing the insertion of the stamens around the gynophore base (E drawn from SUTTON 428, PRE, all others from MARLOTH 1113, PRE.)

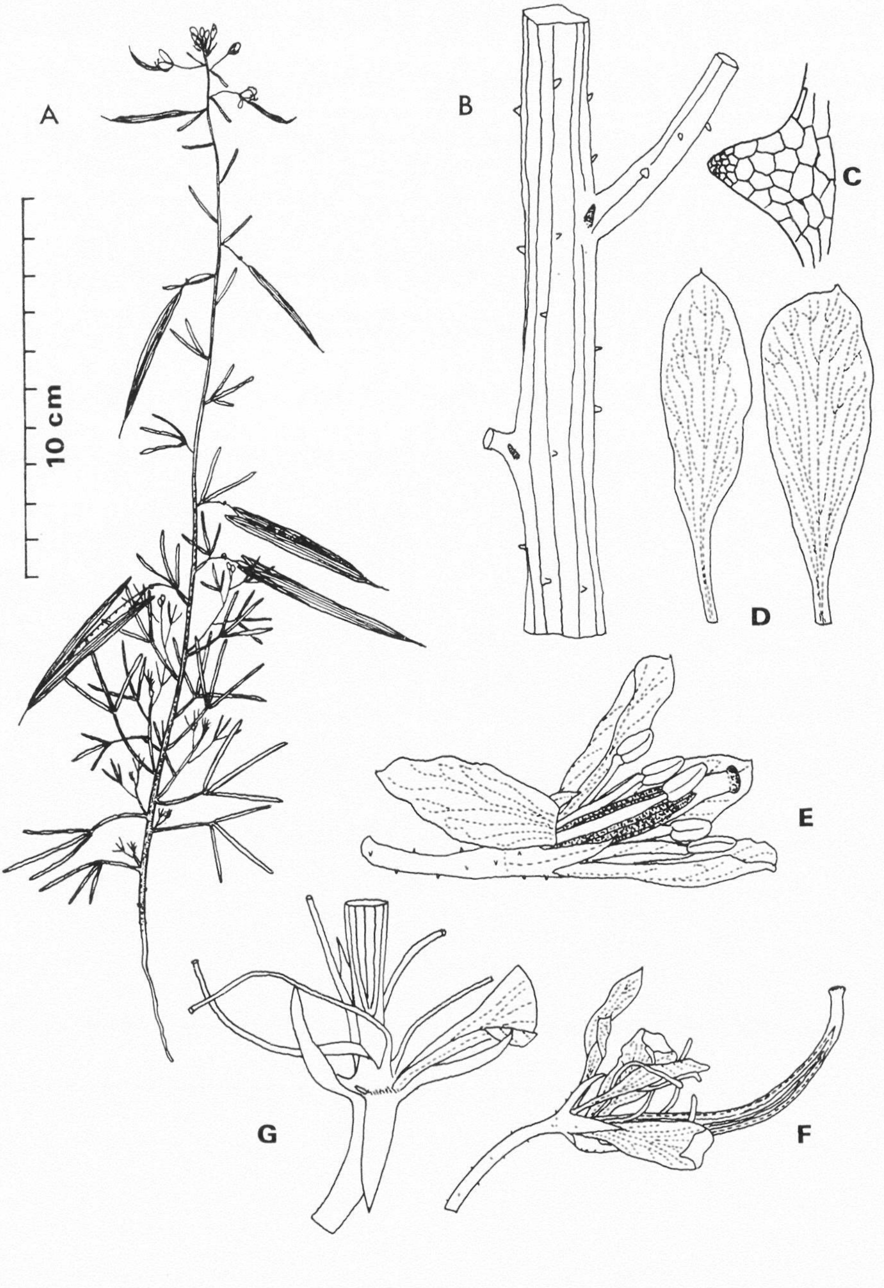

Fig. 7.

SOUTH AFRICA. Transvaal: Material studied: 41 collections, comprising 66 sheets (B, BM, BOL, BRLU, COI, K, NH, P, PRE, S, SAM, TCD, UPS). — Natal: Medley Wood 4431. "Natal, near Mooi River" or "In sandy soil near Mooi River" (K, NH); Medley Wood 993. Near Mooi River (BM, BOL, SAM); Owen s.n. Natal (TCD); Wylie s.n. Muiden, near Greytown (K, NH). — Orange Free State: Brandmuller 124. Heilbron distr., Macauvlei (PRE); Barrett-Hamilton s.n. Leeuw Spruit and Vredefort (BM); Barrett-Hamilton s.n. Vredefort Road (BM); Leistner 2994. Windburg distr., Willem Pretorius Game Res. (K); Goossens 1221. Bothaville distr., Bothaville (PRE); Rietriver Ex.-farm 1272. Edenburg distr. (PRE); Story 1035. Hoopstad distr., 12 mls from Bloemhof on Hertzogville road (PRE). — Cape Prov. Kimberley: Anneke 452. Rietriver Stn. (PRE); Brueckner 843. Spytfontein (K, PRE); Esterhuysen 5346. Picardi (BOL, FRE); Ferrar 138. Kimberley Carter's Ridge (NH); Hogarty 11. Kimberley (SAM); Kuntze s.n. Mooderriver Stn (K); Lewis 313. Kimberley (SAM); Lewis 4185. 30 mls W of Kimberley on Douglas rd. (SAM); Moss 10780. Slypklip, c. 20 mls N of Kimberley (BM); Oliver 156. Kimberley (SAM) — Vryburg: Burtt Davy 13758. Sheppard's Gift (PRE, S); Burtt Davy 13917. Takoon (PRE); Marloth 11602. Farm Middelkop (P fragm., PRE, STE); Mogg 8667. SW Vryburg, Armoris Vlakte (PRE, SAM); Rodin 3495. Farm Palmyra, 60 mls NW of Vryburg (BOL, K, S) — Kuruman: Ridgill s.n. Kuruman (BOL) — Prieska: Breyer 1045. Near Prieska (K); Bryands 1116. 40 mls N of Prieska (K); Schlieben 8799. 18 mls NW of Prieska (K, PRE) — Herbert: Orpen 235. In campis circa St. Clair, pr. Douglas (K, SAM) — Mafeking: Bolus 6432. On Pitsani road, near Moleman (BOL); Brueckner 546 a. Mochesh (K, PRE) — Gordonia: Mostert 1303. Upington distr., Kalahari area (PRE) — Hay: Burchell 2025. The Kloof. Type of *Cleome rubella* Burch. (BM, K) — Barkely West: Adams 124. Warrenton (PRE); Brueckner 239. "Knockbarragh" (PRE); Esterhuysen 768. Daniel's Kuil (BOL); Marloth 982. Groot Boetsap, Kuil (PRE, STE).

Cleome coeruleo-rosea Gilg & Bened. Bot. Jahrb. 53: 157 (1915).

Typus speciei: Ledermann 4096, 3.VI. 1909, Nord-Kamerun: Bei Rei-Buba, an einem Wassergraben, zwischen Kulturen, 300 m. (Holotype B).

Literature: Andrews (1950 p. 46).

Icon.: Figs. 3, 8 D.

Distribution: Fig. 9 A.

Annual herb, erect and richly branched, up to 50 cm tall, viscid glandular—pubescent. *Stem* herbaceous, seldom suffruticose at base, faintly striate, glandular-pubescent in the lower parts, in the upper portions

Fig. 8. *Cleome* seeds. — A: *Cleome schlechteri* Briq. (Schlechter 11756, G). — B: *Cleome oxyphylla* Burch. (I. Örtendahl 59, S). — C: *Cleome conrathii* Burtt Davy (Marloth 1113, PRE). — D: *Cleome coeruleo-rosea* Gilg & Bened. (Raynal 12623, P). — E: *Cleome rubella* Burch. (Sidney 1408, PRE). — F: *Cleome maculata* (Sond.) Szyszyl. (Codd 6573, PRE). — Magnification × 70.

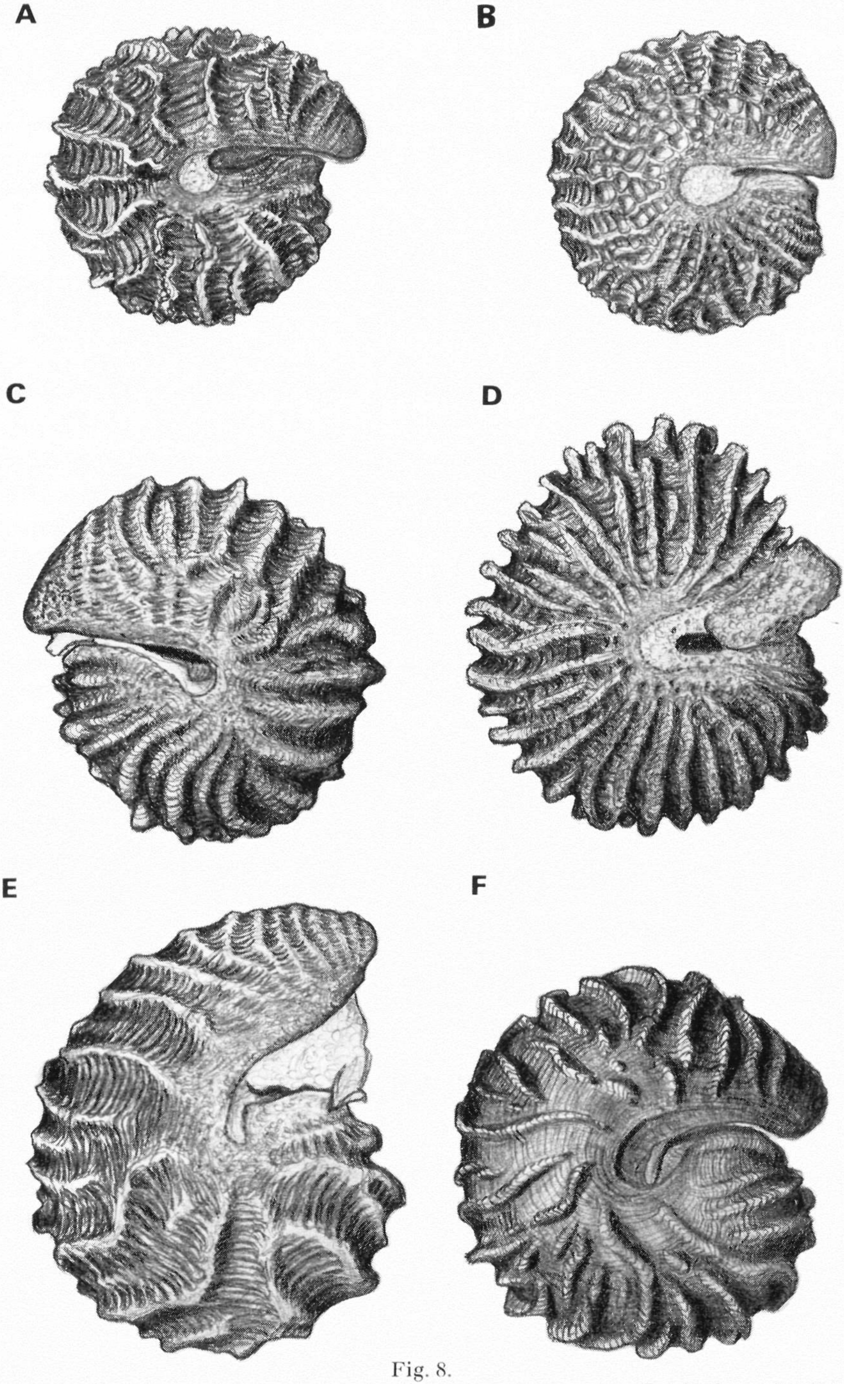

Fig. 8.

glandular-puberulous. *Leaves* (3—) 5 (—7)-foliolate, upwards merging into the floral bracts, petiolate; *petioles* up to 5 cm long in the lowermost leaves; *stipules* rudimentary. *Leaflets* obovate—elliptic, acute to mucronate at the apex (sometimes obtuse in the lowermost leaves), (1.5—) 2 (—4) cm long and 0.5—1.2 cm broad, minutely and sparsely glandular—puberulous on the nerves, minutely glandular—asperous on the margins, otherwise glabrous. *Bracts* leafy, (2—4—) 5-foliolate, shortly petiolate. *Inflorescences* of terminal, erect and rather loose racemes with small flowers showing intermittent sterility, the racemes not clearly marked off from below due to the gradual transition from leaves to floral bracts. *Pedicels* 1.2—2 cm long in ripe fruit, directed (c. 45°) upwards, sparingly glandular. *Sepals* 2—3 mm long, linear—narrowly ovate, acute at the apex, glandular, generally deciduous but sometimes persisting long. *Petals* inconspicuous, violet-rose to pale violet, 3.5—5 mm long and c. 2 mm broad, equal or almost so, obovate to elliptic, apex obtuse to acute–mucronate, shortly unguiculate at the base. *Stamens* 6 (—7), all fertile, 4—6 mm long, borne close to the petals, filaments glabrous, sometimes with the apical parts swollen; *anthers* c. 1 mm long. *Gynophore* in ripe fruits lacking or 2—3 (—5) mm long, sparsely glandular-puberulous, erect from the pedicel. *Capsules* erect, linear, rather abruptly tapering at both ends, 2.3—4.2 cm long and 3—4 mm broad; *valves* completely dehiscing, striated by about 10 longitudinal anastomosing nerves, glandular—asperous on the nerves; *replum* sparsely and minutely glandular-puberulous; *style* 1—1.5 (—2.5) mm long in ripe fruits, filiform and straight, glabrous; *stigma* c. 0.5 mm broad, capitate. *Seeds* c. 1 mm in diameter, reniform—rounded in outline, somewhat flattened from the sides, dark brown, sculptured with marked transverse ridges and a faint pattern of longitudinal furrows (Fig. 8 D).

This inconspicuous and little-known species has some aspects of *Cleome viscosa* L. owing to similar habit of growth, foliage, type of indumentum, size of flowers and erect pods. It differs from *C. viscosa* e.g. by the violet-rosy flowers and by commonly having a gynophore, although this is sometimes very short. While in *C. viscosa* the valves persist attached in the lower half of the fruit, they are completely dehiscing in *C. coeruleo-rosea*. This species also has some features in common with *Cleome hirta* (Kl.) Oliv. and *Cleome rubella* Burch., but is easily separated from both by seed characters and by the erect and very shortly stipitate fruits.

In the orginal description, the filament are stated to be "apice infalto-

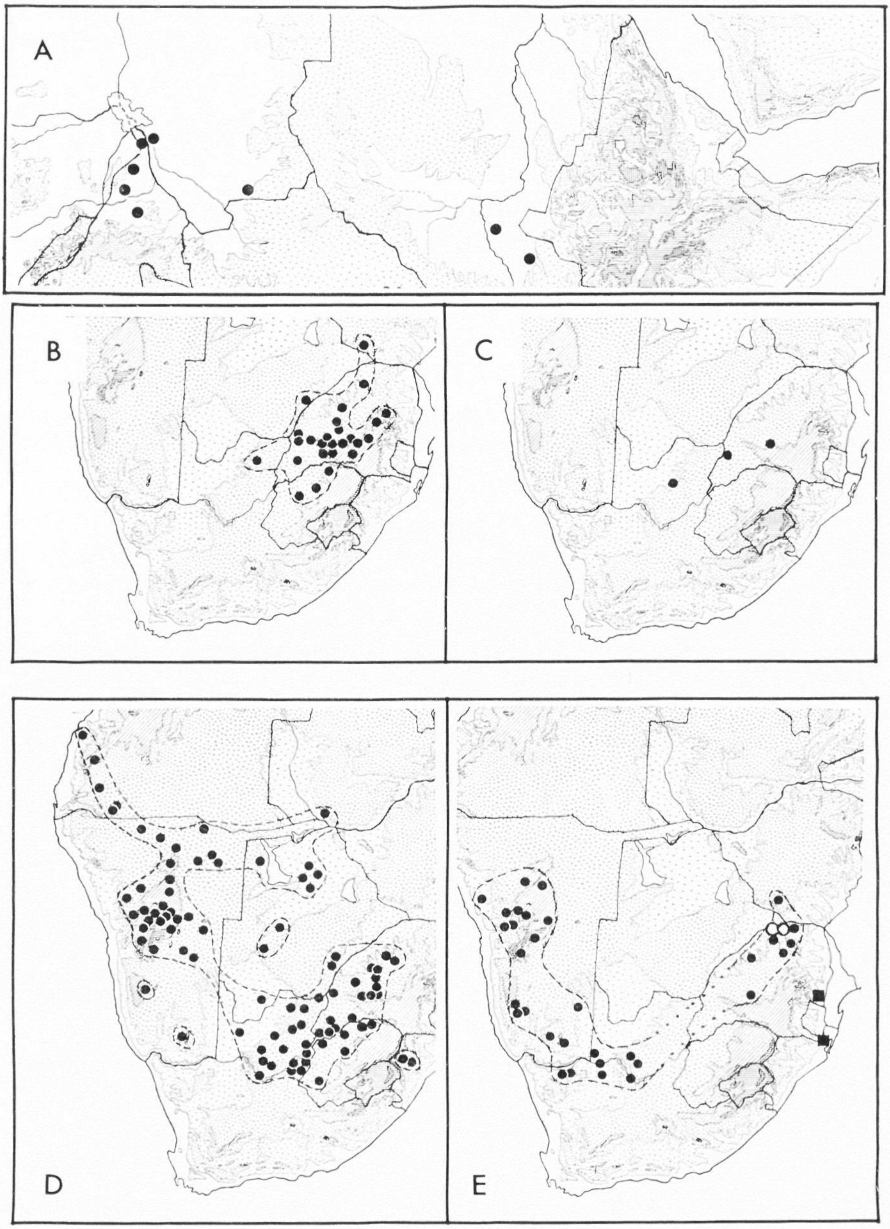

Fig. 9. Distribution of *Cleome* species. — A: *Cleome coeruleo-rosea* Gilg & Bened. — B. *Cleome maculata* (Sond.) Szyszyl. — C: *Cleome conrathii* Burtt Davy. — D: *Cleome rubella* Burch. — E: *Cleome oxyphylla* Burch. var *oxyphylla* (●), *Cleome oxyphylla* Burch. var *robusta* Kers (○), *Cleome schlechteri* Briq. (■).

incrassata". This feature, however, does not always seem to be present, or at least, is not found in all stamens of a flower. In the type specimen, there are flowers in which at least two stamens show this peculiarity. In other specimens some flowers have only one filament with the apical parts swollen, while in other flowers this feature is hardly visible or is lacking completely.

The stamens are not regularly shed from their point of insertion but instead from a point just a little above this (cf. Fig. 8 D). Collectors have characterized the petal colour variously as: 'coeruleo-rosea', 'jaune-verdate', 'rose-lilas', 'violet-pale' and 'blanc rosé'.

DISTRIBUTION, ECOLOGICAL NOTES. *Cleome coeruleo-rosea* is known from Sudan, Tsad and the northern parts of the Cameroons (Fig. 9 A). The range forms a rather narrow belt, running east-west parallel with the southern outskirts of the Sahara. The species usually occurs in dried-up, shallow water depressions within periodically flooded areas. Sometimes it behaves as a weed in *Sorghum* fields. This species has been found growing together with *C. viscosa*. Flowering period: June—December.

COLLECTIONS. **CAMEROONS.** Ledermann 4096, 3.VI. 1909, bei Rei-Buba, an einem Wassergraben, zwischen Kulturen, 300 m. Type of *Cleome coeruleo-rosea* Gilg & Bened. (B) — Letouzey 6298, 19.VIII. 1964, près Bobo, 35 km ENE Maroua (K,P). — Letouzey 7147, 30.IX. 1964, près Ngouima, 41 km a l'Oest de Fort Foureau K, P) — Raynal 12435, 13.XII. 1964, Ouro Haoussas, 20 km ENE de Garoua (P, S) — Raynal 12623, 21.XII. 1964, Gourima, 41 km W Fort Foureau (P) — Vaillant 1351, 14.IX. 1943, Tchonkouli, Nord Cameroun (P).

TSAD. Chevalier 9042, 2.VII. 1903, Terr. du Chari, Chari central: règ. du Iro. Cour Moural (P) — Chevalier 9170, 28—30.VI. 1903, Terr. du Chari, Chari central: règ. du Iro. Koulfé (P) — Chevalier 9218, 28.IV. 1903, Koulfé (P) — Creac'h 66, 15. VII. 1938, Tsad, Ford Lamy (P).

SUDAN. Broun 1735, 21.XII. 1909, Meshra Zeraf St. Upper Nile Prov. (K) — Douglas Simpson 7034, 4.VI. 1929, Khor Geyni, Pibor R. (BM, K).

Cleome oxyphylla Burch. var. **oxyphylla** Trav. Inter. Southern Africa 2: 226 (1824).

Typus speciei: Burchell 1887, 1812, 'At Griquatown in the Leeuwenkuil Valley' (BM, K).

Synonyms: *Polanisia oxyphylla* (Burch.) DC. Prodr. 1: 242 (1824). Comb. nov. Type as above. *Dianthera bicolor* Pax, Bot. Jahrb. 10: 15 (1889). Type: Marloth 1370, V. 1886, 'In arenosis prope Otyimbingue' (S. W. Africa, Karibib distr.) (B, BOL, PRE, SAM). *Polanisia bicolor* (PAX) PAX in ENGLER & PRANTL, Nat. Pflanz.-Fam. 3 (2): 224 (1891). Comb.nov. Type as for *Dianthera bicolor* PAX. *Cleome heterochroma* BRIQ. Ann. Conserv. Jard. Bot. Genève, 17: 361 (1913). Nomen novum. Type as for *Dianthera bicolor* PAX. *Cleome bicolor* (PAX) GILG, Bot. Jahrb. 53: 162 (1915). nom. illeg. non GARDNER (1843). Type as for *Dianthera bicolor* PAX. *Cleome breyeri* BURTT DAVY Kew Bull. 38: 224 (1924). Type: BREYER s.n., II, 1919, Transvaal, Wyllies Poort (BOL, K, PRE).

Literature: BURTT DAVY (1926 p. 121); DINTER (1919 p. 167; 1921 pp. 125, 133; 1928 p. 69); DURAND & SCHINZ (1898 p. 163); ENGLER (1910 pp. 546, 568; 1915 p. 229); GILG & BENEDICT (1915 p. 453); PAX & HOFFMANN (1936 p. 213); ROESSLER (1966 p. 47:11); SCHINZ (1897 p. 91); SONDER (1860 p. 57); WILD (1960 p. 200).

Icon.: Figs. 4, 8 B.

Distribution: Fig. 9 E.

An erect annual or short-lived perennial herb of weak or stiff growth, glandular-pubescent, up to 1 m tall but usually much smaller, becoming rather densely and diffusely branched, with the main stem only slightly overtopping the lateral branches. *Stem* usually herbaceous throughout, sometimes suffruticose and rarely fruticose at the base, faintly striate, basal (herbaceous) portions richly glandular—pubescent with stipitate hairs 1—2 mm long, intermingled with a few c. 3—4 mm long, stiff hairs, upper parts of the stem glandular-puberulous. *Leaves* (4—) 5—7-foliolate, upwards merging into the floral bracts, petiolated with *petioles* up to 7 cm long in the lowermost leaves. *Stipules* rudimentary, 0.3—0.4 mm in length, massive, obliquely tapering from a broad base (Fig. 4 F). *Leaflets* up to 3.3 cm long and 1 cm broad, elliptic to obovate, acute—obtuse, attenuate at the base, almost glabrous above, minutely glandular beneath (chiefly on the nerves), minutely and sparsely glandular—puberulous on the margins. *Bracts* leafy, 5- to unifoliolate, gradually smaller up the racemes, petiolate to subsessile, petioles 0.2—1 cm long. *Inflorescences* of erect, rather loose racemes, up to 22 cm long, which are vaguely marked off from below due to the gradual transition from cauline leaves to floral bracts; flowers show intermittent sterility. *Pedicels* 0.7—1.5 cm long, the young ones ascending, later spreading straight from the axis, sparsely glandular—puberulous. *Sepals* 1—2 mm broad, deciduous, elliptic, acuminate, faintly glandular-puberulous, usually greenish violet. *Petals* 9—15 mm long and 4—7 mm broad, obovate, rounded at the apex, bases obtuse, with minute, c. 1—2 mm long claws, usually pale rose—violet to pink (seldom purplish) with the bases pale yellowish, somewhat unequal: upper *petals* slightly narrower than the lateral ones and more distinctly clawed than these and with the yellow base more marked. *Stamens* 9—21, all fertile, filaments glabrous, pale yellow—violet, separated into two unequal groups: *lower stamens* (3—) 4—6, 9—13 mm long, slightly curved in apical parts, equalling or exceeding the petals, anthers 2.5—3 mm long; *upper stamens* (6—) 9—15 (—17), 4—7 mm long, not exceeding the petals, straight but becoming coiled. filaments thinner than in the lower stamens, anthers 1.5—2.5 mm long. *Gynophore* 1—7 mm long in fruits, minutely and sparsely glandular-puberulous. *Capsule* 5—9.5 cm long and 1.5—3 mm broad, spreading—hanging when ripe and usually curved in the apical parts, fruits produced at long intervals along the racemes due to the intermittent sterility of the flowers; *valves* deciduous, dehiscing from the gynophore end, striated with 5—7 longitudinal anastomosing nerves, minutely and sparsely glandular; *style* 3—9 mm long in ripe fruits, filiform, straight, glabrescent at the base or glabrous; *stigma* inconspicuous, in the fruit hardly marked off from the style. *Seeds* 1.5 cm in diametre, brown, reniform—circular in outline, slightly flattened from the sides, with numerous but minute transverse ridges and a faint pattern of longitudinal striations (Fig. 8 B).

Cleome oxyphylla has previously often been misinterpreted or confused with other species. This misfortune is quite explicable when considering the poor type material and the brief and vague orginal description of the species.

Cleome oxyphylla was described by BURCHELL in 1824 from his collection made 'at Griquatown in Leeuwenkuil Valley'. The locus classicus is situated near the Asbestos Mountains in the northern Cape Province (Hay Division, Griqualand West). PAX (1889) described *Dianthera bicolor* from a collection made by MARLOTH near Otjimbingue in the central parts of S. W. Africa (Karibib distr.). The type specimen of *D. bicolor* does not differ in any essential details from *C. oxyphylla*. *D. bicolor* was later transferred by its author to *Polanisia* and then by GILG in 1915 to *Cleome*. However, the new combination '*Cleome bicolor*' could not be accepted as it had already been used for an American species. Therefore BRIQUET in 1914 gave our species, as based on *Dianthera bicolor* PAX, a new name and called it *Cleome heterochroma* BRIQ. This parts of the synonymy has recently been cleared up (ROESSLER 1966). The present author also places *Cleome breyeri* BURTT DAVY among the synonyms of *C. oxyphylla*. This species was described from the Transvaal and is morphologically not distinguishable from *C. oxyphylla*.

Besides this typical form-series of *Cleome oxyphylla* (viz. var.

oxyphylla) there exist an aberrant population in the northernmost parts of the Transvaal which the author has distinguished here as var. *robusta*.

Cleome oxyphylla is separated from other rosy or violet-flowered species by the broad obovate petals, which have very short claws and are almost equal in shape and size, by the comparatively broad (elliptic to obovate) leaflets, by the seed sculpture, by the type of indumentum and by the androecial features.

Cleome oxyphylla comes especially close to *Cleome schlechteri* BRIQ., a little-known species which differs chiefly in the scanty and minutely asperous hairiness and the comparatively broad stigma. A more distant relationship exists between *C. oxyphylla* and e.g. *Cleome elegantissima* BRIQ., *C. hirta* (KL.) OLIV. and *C. rubella* BURCH. *C. elegantissima* bears a superficial resemblance to *C. oxyphylla* owing to similar foliage, indumentum and aspect of fruits, but differs essentially in the floral parts. *C. hirta,* which is closely allied to *C. rubella,* has sometimes been confused with *C. oxyphylla,* probably because they have shortly unguiculate petals and similar fruits and hairiness, but these species differ markedly with respect to flowers, number and shape of leaflets as well as in androecial features.

The androecium shows a characteristic organisation in *Cleome oxyphylla,* a feature which it shares with *C. schlechteri.* Probably due to duplication of the upper staminal primordia the androecium has become differentiated into a ventral group of some few (3—6) long stamens and a dorsal group of numerous, short stamens. These upper members have smaller anthers than the lower prominent stamens. Although the stamens are very unequal in size, they are all fertile. The number of the upper stamens varies a good deal (6—17) and mainly between different collections. The variation in number, however, seems to the author not to show any significant geographical variation in var. *oxyphylla*.

The petal-colour also varies fairly much and ranges from pale rose-pink to pale red-violet and (rarely) "maroon". The yellow-coloured base of the petals has a dentate and rather indistinct upper boundary. Flowers in pale rosy shades are the most common and are usually found in specimens which have a weak habit of growth, whereas more vividly coloured flowers are regularly correlated to a rigid growth of the plants. The petal-shades supposedly depend on environmental conditions, viz. pale flowers occur on specimens which have grown in especially well shaded habitats.

Most of the specimens have obovate leaflets. Elliptic leaflets are less common and are mainly found in plants which have apparently grown in exposed surroundings. Specimens from such habitats also tend to have richer hairiness.

All the morphological features mentioned show continuous variation to judge from the material which the author has investigated. All attempts to trace a geographically significant variation within *Cleome oxyphylla* var. *oxyphylla* have failed.

The type variety does not have especially beautiful flowers. They are not strikingly coloured and not vividly yellow-banded as in *Cleome elegantissima* or *C. maculata.* Generally they have a dull, pale rosy or pink colour which looks a little bit faded. In the living specimens which the author has studied in S. W. Africa the petals did not spread out completely free from each other and they were slightly curved inwards along their margins which gave them a somewhat spoonlike appearance.

DISTRIBUTION, ECOLOGICAL NOTES. *Cleome oxyphylla* in confined to semi-arid parts of southern Africa, including portions of S. W. Africa, northern Cape, the Transvaal and Rhodesia (Fig. 9 E).

One collection from Ibo, Mozambique, contains both *Cleome oxyphylla* Burch. and *Cleome monophylla* L. (leg. Frère Gromans?, II. 1901, LD). According to the verified distribution of *C. oxyphylla* (Fig. 9 E) it is unlikely that this species has been collected from these northern, coastal parts of Mozambique. The author has found it advisable to ignore that odd specimen as he believes that the locality stated only refers to the specimen of *C. monophylla.*

The outline of the distribution forms a peculiar U-shaped area, which, however, includes an interval between the northeastern Cape and the central parts of the Transvaal. This roughly U-shaped outline embraces the Kalahari from the south, and is also traceable in the distribution of *Cleome rubella* Burch. The author suggests that this kind of range coincides chiefly with a natural edaphic area, characterized as a semi-arid and hot region with summer rainfall and which, though mainly a sandy region, includes a high frequency of rocky habitats. The distribution of those species which show this U-shaped distribution is probably delimited by the increasing humidity towards the north and east, by the Namib Desert in the west and towards the interior parts of southern Africa by the absence or scarcity of rocky habitats within the Kalahari. Probably the winter rainfalls and the decreasing temperature delimit the southern move of these species. The gap in the continuous distribution of *C. oxyphylla,* found between the northeastern Cape and the central parts of the Transvaal, cannot merely be explained by insufficient collecting. Within this gap, *C. oxyphylla* seems to be replaced by *C. maculata.*

Cleome oxyphylla grows in rocky habitats. It is the *Cleome* peculiar to those kopjes, table mountains or ridges which are so characteristically scattered over the vast sandy plains in these interior parts of southern Africa. These rocky areas stand out against the surrounding dry and monotonous plains like 'islands' where one can find rocky pools of water with *Aponogeton, Marsilia, Limosella* and *Chamaegigas* and some rare moisture loving plants in sheltered places. In such "Buchman Paradises" one can find *Cleome oxyphylla.*

Cleome oxyphylla grows in sheltered habitats e.g. under trees and shrubs and in the shade of boulders and rocks as well as in clefts. When found in S. W. Africa, this was always in rocky habitats where the soil constantly obtained locally a relatively large amount of water (often siltering and not stagnant) and where the moisture did not quickly disappear to the deeper parts of the ground or get lost by evaporation. This species has not been reported from plains, water courses or similar habitats which are restricted to relatively low altitudes, and where the upper layers dry out rapidly.

The author has not found *Cleome oxyphylla* growing together with any other *Cleome,* although *Cleome monophylla* L. may occur in same habitats. Sometimes *C. elegantissima* can be found in similar rocky surroundings, but then in less shaded habitats, usually in fissures and crevices of bare rock surfaces which are fully exposed to the sun.

Cleome oxyphylla has been collected in every month except October. Most gatherings have been made between January and July. The species usually behaves as a therophyte and summer annual but sometimes as a short-lived perennial. In their natural environments, most specimens will not survive to a subsequent growing season. A specimen collected at the Erongo Mtns in S. W. Africa (leg. WANNTORP 938, S) is a rare representative of a definitely perennial plant (hemicryptophyte), with the basal portions of the stem 1.5 cm thick and woody.

COLLECTIONS. (Complete list of references deposited in the Library, Natural History Museum, Botanical Section, Stockholm).

SOUTH WEST AFRICA. Material studied: 36 collections, comprising 54 sheets (B, BM, BOL, COI, G, HBG, K, LD, LISC, M, PRE, S, SAM, UPS).

SOUTH AFRICA. Cape Province: Great Bushmanland: SCHLECHTER 116. Wortel (BM, BOL, COI, G, K, PRE, S) — Kenhardt: ACOCKS 14277.

Kakamas Veld Res. (PRE); LEIPOLDT s.n. Augrabies Falls (BOL, PRE); LEISTNER 2481. 15 mls SW of Pofadder (K, PRE); LEWIS 154. Augrabies Falls (SAM); WASSERFALL 1045. Kakamas—Kenhardt road, 3—4 mls from settlement (PRE) — Prieska: SCHLIEBEN 8780. 8 mls NW of Prieska (BM, K, PRE, S); WILMAN s.n. Kalahari Div., reg. Stofbakkies (BOL) — Upington: BARNAD s.n. Bak River (SAM) — Hay: BURCHELL 1887. At Griquatown in Leeuwenkuil Valley. Type of *Cleome oxyphylla* BURCH. (BM, K); MARLOTH 2046. Asbestos Mtns (K, PRE); WILMAN 2246. Dunmurry (BOL, K) — Kuruman: ACOCKS 2290. E slope of Langebergen, at Seremaning (K, PRE); MARLOTH 1094. Great Mhana Mtns, near Kuruman (BM, K, PRE). — Transvaal: Pretoria: MOGG 19159. Norscot, Witkoppen, 16 mls N of Johannesburg (PRE) — Potgietersrust: GALPIN 8911. Pyramid Estate (PRE) — Pietersburg: ACOCKS 16802. SSW of Bandolierskop (K, PRE); STREY & SCHLIEBEN 8613. Blouberg (BM, K) — Zoutpansberg: BREYER s.n. Wyllies Poort. Type of *Cleome breyeri* BURTT DAVY (BOL, K, PRE); CODD 8361. S end of Wyllies Poort (COI, K, PRE); CODD & DYER 3919. In Wyllies Poort (BM, K, LD, PRE); GILLETT 2944. N side of Wyliespoort, "Fogwell's Paradise" (BOL); HUTCHINSON 2046. Wyllies Poort, northern slopes (K); HUTCHINSON & GILLETT 4462. Matoko (BM, COI, K, LISC); ROGERS 21208. Messina (K); ROGERS 22533. Waterbank in Sand River Poort (K); SCHLIEBEN 7522. W side of Vivo (G, HBG); STORY 1838. Mtn Tun, N facing valley (PRE).

RHODESIA. CHEESMAN 78. Matopo Mission, Matabeleland (BM); MILLER 2064. Matopo distr., farm Bema Kohila (K, LISC); MILLER 4093. Distr. Matopo, 4800 ft (K).

Cleome oxyphylla BURCH. var. robusta KERS, var. nov.

Diagnosis: Herba perennis ad 1 m alta, habitu robusta; quam var. *oxyphylla* omnibus partibus multo major. Petala 17—23 mm longa et 9—12 mm lata, stamina superiora numero 21—30 variantia, gynophorum in fructu ultra 8 mm longum.

Typus varietatis: CODD & DYER 3852, 15.III. 1948, Transvaal, Zoutpansberg distr., Dongola Reserve, farm Schroda 616, 5 mls NE of Mapungubwe, 1700 ft. (Holotype PRE, isotype K).

Icon.: Fig. 4 B.

Distribution: Fig. 9 E.

This handsome variety differs from *Cleome oxyphylla* var. *oxyphylla* in the robust growth and in having large, showy flowers in dense inflorescences. The gynophore is regulary longer than in the type variety, the stamens are more numerous and the filaments are longer.

Although, at first sight, this variety appears very distinctly separated from var. *oxyphylla*, the differences between them are mainly quantitative: var. *robusta* being larger in all vegetative parts. The seeds are of same size in both taxa. The author does not believe that this handsome variety merely represents a modified form of var. *oxyphylla*. Both varieties occur in the northernmost parts of Transvaal, but the material available from there shows no intermediate specimens. Nevertheless, the gaps found in a number of morphological features are all small. A comparison of var. *oxyphylla* and var. *robusta* as to certain morphological details will be given here (var. *oxyphylla* within square brackets).

Leaves: (6—) 7—9-foliolate [4—5—7-foliolate]. *Bracts:* 3—5-foliolate [1—3-foliolate]. *Pedicels:* 17—20 mm long [7—15]. *Gynophore:* 9—12 mm long [1—7]. *Stamens:* 24—37 [9—21]. *Small stamens:* 21—30 [6—17]. *Long stamens:* 5—7 [3—6]. *Filaments:* 9—10 mm long in the small stamens [4—7], 13—20 mm long in the long stamens [9—13]. *Fruits:* 3—4 mm broad [1.5—3]. *Sepals:* 9—11 mm long [4—5]; 2—4 mm broad [1—2]. *Petals* incl. claw: 17—23 mm long [9—15], 9—12 mm broad [4—7].

Cleome oxyphylla var. *robusta* is confined to the northernmost parts of Transvaal, where it has a restricted distribution within the mountainous areas just south of the river Limpopo (Fig. 9 E).

COLLECTIONS. **SOUTH AFRICA.** Transvaal: Zoutpansberg distr.: CODD & DYER 3852, 15.III. 1948, Dongola Reserve, farm Schroda 616, 4 mls NE of Mapungubwe. Mixed bush on rocky ridge, near Limpopo River. Erect 3 ft. Large pink flowers with yellow eye. 1700 ft. Type of var. *robusta* (K, PRE); MUHLOPI s.n., (H 3285), XII. 1915, on the Messina Botanical Reserve, c. 1950 ft. (PRE); POLE EVANS 1698, VI. 1925, Messina (PRE); POLE EVANS 1915, XI. 1925, Messina Bot. Res. (K); POLE EVANS 1958, II. 1926, Botanical Reserve, P. O. Schroda, Messina (K, PRE); SMUTS & GILLETT 4032, s.d. summit of mountain (K, PRE); SMUTS & GILLETT 4054, 22. XII. 1938, Messina, Mapungubwe (K, PRE).

Cleome schlechteri BRIQ. Ann. Conserv. Jard. Bot. Genève 17: 357 (1915).

Typus speciei: SCHLECHTER 11756, 15.XII. 1897, Komati Poort (Holotype G, isotypes B, K).

Synonym: *Cleome pachycephala* GILG & BENED. Bot. Jahrb. 53: 156 (1915). Type same as for *Cleome schlechteri* BRIQ. (B, G, K).

Literature: BURTT DAVY (1924 p. 224, note; 1926 p. 121); GILG & BENEDICT (1915) p. 452); PAX &HOFFMANN (1936 p. 213).

Icon.: Figs. 5, 8 A.

Distribution: Fig. 9 E.

Annual erect herb with general aspect of *Cleome oxyphylla* BURCH., up to 30 cm tall, simple or moderately branched, minutely and sparsely asperulous—aculeolate with hairs which are barely visible to the naked eye. *Stem* herbaceous, striated—grooved. *Stipules* rudimentary, triangular in outline, flat, 0.5 mm in length or smaller. *Leaves* (3—) 5—7-foliolate, gradually smaller up the stem and grading into the floral bracts, petiolate; *petioles* up to 4 cm long, channelled above, descending the stem which consequently appears minutely ribbed—grooved. *Leaflets* obovate—elliptic, up to 2.5 cm long and 0.5 cm broad, obtuse to acute, cuneate at the base, glabrous above, sparsely and minutely asperulous beneath and on the margins. *Bracts* leafy, (3?—) 4—5-foliolate, similar to the cauline leaves but smaller and the leaflets usually mucronate at the apex, petioles ranging from 0.1 to 3.5 cm in length. *Inflorescences* of terminal racemes, erect and loose, vaguely marked off from below due to the gradual transition from cauline leaves to bracts. *Pedicles* terete, 1—1.5 cm long (in fruit), spreading, glabrous or sparsely and minutely asperulous. *Sepals* lanceolate — narrowly ovate (in expanded flower), acuminate — mucronate, c. 2.5 mm long, deciduous, glabrous, pale green. *Petals* pale violet—rose, pale yellow at the base, obovate, cuneate at base and with very short claws, somewhat unequal in shape: lateral petals c. 7 mm long and 4 mm broad, obtuse; median petals smaller, c. 5 mm long and 4 mm broad, acuminate and with undulate margins at least in dried flowers. *Stamens* 8 (—10?), all fertile, unequal: 4 lower stamens are more prominent than the others, their filaments c. 7 mm long and slightly curved in apical parts, anthers about 1.5 mm long; 4 stamens are smaller than the rest and are dorsally arranged in the flower, their filaments c. 4 mm long and straight, anthers about half as long as those of the lower stamens. *Capsule* 4.5—6 cm long and 2—3 mm broad, spreading when ripe; gynophore 0.5—2 mm long, glabrous; valves deciduous, dehiscing from the gynophore end, striated lengthwise by about 5—7 nerves, between these some inconspicuous anastomoses, minutely and sparsely asperulous on the nerves; *style* 1 mm long and 1 mm broad at anthesis, in ripe fruits 3—4 mm long, broadening apically into the stigma, glabrous; *stigma* almost flat, comparatively broad, c. 1 mm in diameter. *Seeds* 1—1.25 mm in diameter, brown, rounded or somewhat comma-shaped in outline, blunt in the cotyledon end, slightly flattened from the sides, sculptured with marked transverse ridges and a faint pattern of longitudinal furrows (Fig. 8 A).

Cleome schlechteri BRIQ. is one of the most rare species of *Cleome* in southern Africa. BRIQUET (1914) and GILG and BENEDICT (1915) described this species almost at the same time from a collection made by

SCHLECHTER at Komati Poort in the easternmost parts of the Transvaal Province. Until recently the species has been known solely from this type collection. But amongst the herbarium material which was labelled as *C. oxyphylla,* the author has come across one subsequent collection which is doubtless identical with this species, viz. WARD 4470, originating from Natal. The material of *C. schlechteri* is thus extremely meagre. In all six sheets of it have been studied. The material is especially poor with respect to expanded flowers of which only a few exist.

Although the available material is poor, the author considers that *Cleome schlechteri* without doubt represents a distinct and well-marked species. It is, however, closely related to *Cleome oxyphylla* BURCH. These two species are similar in foliage, general aspect of flower, petal shape, androecial features, fruit characters and maybe also in petal colour. *C. schlechteri* differs from *C. oxyphylla* especially in the peculiar, broad and blunt stigma, the indumentum and the type of hairs, and also, though less strikingly, in the petals. In addition these two species have different ranges of distribution and have certainly quite different ecological demands.

In *Cleome schlechteri* the hairs are exceedingly small and are not visible to the naked eye. They are pale green and rather stiff and taper gradually towards the apex and are consequently conical in shape. The vestiture is minutely and sparsely asperulous—scabrid and similar to that in *Cleome maculata* (SOND.) SZYSZYL. *C. oxyphylla,* on the contrary, has filiform and rather weak hairs which are much longer than those in *C. schlechteri* and they are easily visible and give the plants a glandular—pubescent indumentum.

The stipules are rudimentary, at most 0.5 mm long and are therefore not easily distinguishable from the cauline hairs (cf. Fig. 5 F, G). But whereas the hairs are filiform and unequally scattered in the stem, the stipules are flat and scale-like and have the characteristic insertion at the petiole-bases.

According to the description by GILG and BENEDICT (1915), the number of stamens ranges between 8 and 10, whereas BRIQUET (1914) records them as "probably" eight. The author can only verify eight stamens from the few flowers investigated.

The author has not found any clear evidence of intermittent sterility in the flowers of this species. Furthermore the scarcity of the floral material means that there is no certain indication as to whether the (median) petals have a distinctly outlined yellowish base or if the violet colour of the petals gradually merges into the pale yellow-coloured base and claw.

DISTRIBUTION, ECOLOGICAL NOTES. *Cleome schlechteri* BRIQ. is known to the present author only from two collections, one from the eastermost parts of Transvaal (Komati Poort) and another from Natal (Ubumbo distr.). Apparently it is a very rare species, though it may have been much overlooked in the field (Fig. 9 E). According to the notes made by Mr. WARD (in sched.) referring to his collection from Natal, this species is common locally at the Nsuma Pan in northern Natal, occurring on deep black loam "in well-grazed open area at outer fringe of floodplain". From these notes it is obvious that the ecological demands of *C. schlechteri* differ from those of *C. oxyphylla.* The latter species characteristically grows among boulders (generally in partial shade from these) on hills within drier regions, and has never been found in floodplains and similar wet places nor at low altitudes. GILG and BENEDICT (1915) give the habitat of the type as "on hills" ("Auf Hügeln"), but the author has not found any note as to this on the type sheets. Flowering period: September—December.

COLLECTIONS. **SOUTH AFRICA.** Transvaal: SCHLECHTER 11756, 15.XII. 1897, Komati Poort, c. 1000 ft. Type of *Cleome schlechteri* BRIQ. as well as of *Cleome pachycephala* GILG & BENED. (B, BM, G, K) — Natal: WARD 4470, 5.X. 1962, Ubumbo distr., Mkuzi Pan, c. 75 ft. (K, PRE).

Cleome maculata (SOND.) SZYSZYL. Rozpr. Akad. Um. (Kraków Wydz. Mat.-Przyr. 17: 109 (1888).

Typus speciei: ZEYHER s.n., Grasreiche, steinige Hügel am Moojerivier. Type as *Polanisia maculata* SOND. (Holotype S).

Synonyms: *Polanisia maculata* SOND. Linnaea 23: 6 (1850). Type as above. *Tetratelia maculata* (SOND.) SOND. in HARVEY & SONDER, Fl. Capensis 1: 58 (1860). Comb. nov. Type as above. *Cleome maculata* (SOND.) SCHINZ, in Bull. Soc. Bot. France. Mém. 8: 6 (1908). Comb. superfl. Type as above. *Chilocalyx maculatus* (SOND.) GILG & BENED. Bot. Jahrb. 53: 168 (1915). Comb. nov. Type as above. *Cleome maculata* (SOND.) BURTT DAVY, Kew Bull. 38: 224 (1924). Comb. superfl. Type as above.

Literature: ARWIDSSON (1935 p. 358); BAKER (1899 p. 423); BRIQUET (1914 p. 363); BURTT DAVY (1926 p. 121); DURAND & SCHINZ (1898 p. 163); EICHLER (1865 a p. 551; 1865 b p. 340); EYLES (1916 p. 355); LETTY (1962 p. 145); PAX & HOFFMAN (1936 p. 219); WILD (1958 p. 39; 1960 p. 202).

Icon.: Figs. 6, 8 F — LETTY (1962 t. 73: 2) — WILD (1960 t. 30 B).

Distribution: Fig. 9 B.

Annual erect herb, 10–25 (—43) cm tall, simple or branched, sparsely and minutely asperulous—scabrid with pale stiff hairs which are up to 0.5 mm long. *Stem* faintly striated, generally herbaceous, rarely suffruticose at the base. *Stipules* rudimentary, at most 0.5 mm long, flat, scaly, tapering apically from a broad base (Fig. 6 C—D). *Leaves* 3—4 (—5—7)-foliolate, petiolate; *petioles* up to 4 cm long, gradually shorter up the stem. *Leaflets* linear—filiform, up to 4.3 cm long, folded on the upper side or plane, acute or mucronate, tapering at the base abruptly into the minute petiolules. *Bracts* much reduced in size and hardly visible to the naked eye, subulate and easily falling off (Fig. 6 A, D), the lowermost ones are somewhat larger than the rest and reach up to 1 mm in length. *Inflorescences* of terminal, loose but rather stout racemes, up to 30 cm long, well marked off from the vegetative stems due to the abrupt reduction in bract-size, with intermittent sterility in the flowers, hence fruits develop at ± distinct intervals along the axis. *Pedicels* (5—) 7—8 (—9) mm long, usually longer than the gynophore, sometimes equal in length to the gynophore, pale green. *Sepals* almost linear in the expanded flowers, up to 8 mm long and c. 2 mm broad, cuspidate at the apex, slightly connate at the base, deciduous, brown-red in colour. *Petals* directed upwards in the expanded flower, unequal: *lateral petals* violet, 9—15 mm long and 2—3 mm broad, obovate, apiculate at the apex, tapering at the base into a short claw; *median petals* violet with a basal, transverse yellow band. *Androgynophore* 0.5—3 mm long, inserted on the ventral side of the widened receptacle (Fig. 6 G). *Gynophore* 5—10 mm long in the fruits, glabrescent. *Capsules* gradually tapering at both ends, spreading, (15—) 30—60 (—70) mm long; *valves* completely dehiscing, glabrous, striated by 3 longitudinal nerves, the anastomosing nerves few and inconspicuous; *replum* glabrescent; *style* filiform, (2—) 5—6 (—9) mm long in fruits, glabrous; *stigma* minute, subcapitate. *Receptacle* widened into a dorsal minute sac (Fig. 6 G). *Stamens* c. 7, unequal; fertile ones 2—4, exserted, ventrally grouped in the expanded flowers, filaments incurved, 10—15 mm long, anthers c. 1 mm long; sterile ones (*staminodes*) (2—) 3 (—4), shorter than the lower stamens, c. 5—7 mm long, dorsally grouped in the flower, filaments very thin, clavate in the apical parts and with rudimentary anthers. *Seeds* 1.5—2 mm in diameter, brown, reniform—rounded in outline, slightly flattened from the sides, tapering towards the radicle end and blunt in the cotyledon end, sculptured by ridges which are irregularly spaced in a transverse pattern, longitudinal sculpture absent or very faint (Fig. 8 F).

Cleome maculata (SOND.) SZYSZYL. is closely related to *Cleome macrophylla* (KL.) BRIQ., both species having an almost identical and exceptional type of receptacle which is only known in these two species. *C. maculata* also shows a close affinity to *Cleome conrathii* BURTT DAVY (cf. p. 581).

Cleome maculata differs from *C. macrophylla* in having apophysate upper stamens (staminodes) and in lacking the minute scale which is found inside the dorsal widened part of the receptacle in *C. macrophylla*. In addition *C. maculata* has the upper petals markedly yellow-banded and the flowers are more attractive than those of *C. macrophylla*. Moreover, the leaflets are always narrow-linear and the pedicels are never shorter than the gynophore. The construction of the receptacle has been illustrated in Fig. 6 G, I. This pouch-like type of receptacle probably functions as a nectary.

Cleome maculata shows a clear affinity to *C. conrathii,* which species differs essentially from *C. maculata,* e.g. in lacking its distinct type of receptacle and in having leafy bracts. *C. maculata* much resembles the general aspect of *Cleome polyanthera* SCHWEINF. & GILG and *Cleome paxiana* GILG, two hardly distinguishable species from the drier, northern—tropical parts of Africa. These northerly species have the following features in common with *C. maculata*: linear leaflets, inconspicuous bracts, club-shaped upper stamens and same type of indumentum. They differ from *C. maculata* in the number of stamens, seed sculpture, type of receptacle and shape of petals. In addition, *C. paxiana* and most specimens of *C. polyanthera* are yellow-flowered.

Cleome maculata has rudimentary stipules which reach at most 0.5 mm in length. They retain the same minute size from the lowermost leaves to the uppermost bracts (cf. Fig. 6 C—D).

Cleome maculata is a distinct species not easily confused with any other, but it has appeared under different generic names, such as *Polanisia, Tetratelia, Chilocalyx* and *Cleome.* Previous authors had different views when pointing out the affinity, if any, between *Cleome maculata* and other species. The controversial views regarding this species may be summarized as follows. Shall this species, due to its extraordinary receptacle (and the presence of staminodes?), be separated from *Cleome?* And if so, under which genus shall it be treated: *Tetratelia* or *Chilocalyx?* Is in fact *Cleome maculata* closely allied to *Cleome macrophylla* due to their similar receptacle, or are they not nearly related because the latter species lacks staminodes? In the following paragraphs, the author makes a survey of these ideas and arguments, followed by his own comments.

In 1860 SONDER created the genus *Tetratelia* for his *Polanisia maculata*. The new genus was apperently characterized by including a species with a "short and swollen calyx-tube" but also with sterile stamens the number of these also being significant (SONDER 1860 p. 58). The "calyx-tube" undoubtedly presented the essential generic character, although SONDER did not especially stress this fact. SONDER obviously found the receptacle ("calyx-tube") to be distinctly separated from that in *Polanisia,* but he seems not to have studied the construction in detail. An excellent presentation of a receptacle, which undoubtedly is the same as in *Tetratelia* was given by KLOTZSCH (1862 p. 154, t. 28) when he described the new genus *Chilocalyx,* which comprised *Chilocalyx macrophyllus* KL. and *C. tenuifolius* KL. Although the distinctiveness of this type of receptacle was first fully demonstrated through KLOTZSCH's detailed investigation, the present author considers that the genus *Chilocalyx* KLOTZSCH is merely a synonym of *Tetratelia* SOND. The essential generic character (the receptacle) is in fact the same in both genera.

By BRIQUET (1914), the two above mentioned original species of *Chilocalyx* were united as *Cleome macrophylla* (KL.) BRIQ., a treatment which seems the author to be correct.

In their monographic work on the African *Capparidaceae* GILG and BENEDICT (1915 p. 168) treated our species as *Chilocalyx maculatus* (SOND.) GILG & BENED., and they listed *Polanisia triphylla* CONRATH among the synonyms. In the author's opinion, the latter species is distinctly separated from *Cleome maculata,* and in this paper the species has been treated under the name *Cleome conrathii* BURTT DAVY.

Because of the remarkable and almost identical receptacle in *Cleome maculata* and *C. macrophylla,* ARWIDSSON considered them to be closely allied. He treated them as belonging to the genus *Tetratelia,* hereby regarding *Chilocalyx* as a synonym (ARWIDSSON 1935 p. 358, as '*Tetrateleia*'). The author has found ARWIDSSON's treatment of these two species to be quite logical — on the assumption that one considers *Tetratelia* as distinct from *Cleome.* Thus the author disagrees with WILD when he stressed the differing androecial conditions in *C. maculata* and *C. macrophylla* (presence or absence of staminodes), and therefore, in opposition to ARWIDSSON, denied a close affinity between these species (WILD 1960 p. 205). The author cannot find, however, any reason for retaining the genus *Tetratelia* (=*Chilocalyx*). The author considers that its type of receptacle merely represents one of many types within the genus *Cleome*. Moreover, *Cleome conrathii* is closely allied to *Cleome maculata* and *Cleome macrophylla*, but has not their specialized receptacle. The species-pair of *Cleome maculata* and *C. macrophylla* is in fact an example that two species of *Cleome* may be very closely allied, though the one has staminodes, the other not.

The original material of *Cleome maculata* was collected by ZEYHER from "Mooijerivier". It has been previously stated that the type originates from Mooi River in the Natal Province (e.g. WILD 1960). If this is true it means a rather isolated find. It would certainly seem much more likely that the type material does not come from there, but in fact from another Mooi River which is situated in the southern parts of the Transvaal Province (for identification of the locality, cf. DRÈGE 1847). We know several subsequent gatherings of this species from that area. The holotype is kept in the Museum of Natural History, Stockholm (S), and it originates from SONDER's herbarium.

DISTRIBUTION, ECOLOGICAL NOTES. *Cleome maculata* shows a continuous distribution within a comparatively narrow range, the centre of which covers the drier regions of the Transvaal. Some collections have also been made from the adjacent parts of Rhodesia, Botswana, north-western Cape and the Orange Free State (cf. Fig. 9 B). The range may be characterized as a transitional zone between the drier and more desertlike areas in the west and south-west (=Kalahari and the Karroo) and the more humid areas on the east and north. The rainfall within the ranges is about 500—750 mm/year (WELLINGTON 1955 map III).

The ranges of *Cleome maculata* and the closely allied species *C. macrophylla* do not overlap. The latter species occurs within the north-eastern parts of Transvaal and from there further north and east. In the Transvaal, *C. maculata* and *C. rubella* show about the same pattern of distribution.

Cleome maculata is mainly found on sandy plains, especially where these are situated within hilly regions. A few specimens have been collected from rocky habitats, e.g. rock crevices and rocky hillslopes. This handsome species generally behaves as an annual but may occasionally survive to a subsequent season, especially in rocky habitats. A collection made in the month of November may in fact represent the rare survival of such a plant (CODD 8064, PRE). Flowering period: November—May.

A collection from Botswana of *Cleome maculata* mixed with *C. rubella* may indicate that these two species grow close to each other and in similar habitats. The following two examples of *Brachiaria nigropedata* (MUNRO) STAPF and *Hirpicium bechuanense* (S. MOORE) ROESSLER can be given as verifications of species showing a similar pattern of distribution to that of *Cleome maculata* (CHIPPINDALL 1959 p. 375; ROESSLER 1959 p. 460).

COLLECTIONS. (Complete list of references deposited in the Library, Natural History Museum, Botanical Section, Stockholm).

RHODESIA. Rand 22. Near Sashi River (BM).

BOTSWANA. South Eastern distr.: HARBOR sub ROGERS 6478. Mochudi. (BOL pro parte with *Cleome rubella* BURCH., NH); HARBOR sub ROGERS 6886. Mochudi (BOL); HARBOR 9125. Mochudi (SAM).

SOUTH AFRICA. Transvaal: Material studied: 59 collections, comprising 88 sheets (B, BM, BOL, K, LD, NBG, NH, PRE, S, SAM, STE). — Cape Province: Vryburg distr.: ROGERS 12563. 20 miles N of Genisa, Kalahari Region (BOL). — Orange Free State: Brandford: HAAGNER 10757. At Brandford (PRE) — Winburg: GILLILAND A 247. Winburg to the end of the Free State. Roadside at drifts (BM) — Heilbron: BRANDMULLER 125. Heilbron, Maccauvlei (PRE).

Cleome conrathii BURTT DAVY, Kew. Bull. 38: 224 (1924)

Typus speciei: CONRATH 11, 26.XII. 1897, felsige Hänge bei Fonteinen bei Pretoria (Holotype K).

Synonym: *Polanisia triphylla* CONRATH. Kew Bull. p. 220 (1908). Type as above.

Literature: BURTT DAVY & POTT-LEENDERTZ (1912 p. 143); BURTT DAVY (1926 p. 121); GILG & BENEDICT (1915 p. 168).

Icon.: Figs. 7, 8 C.

Distribution: Fig. 9 C.

Annual erect herb, inconspicuous, small and delicate, c. 10—30 cm tall, sparsely and minutely asperulous—scabrid with hairs which are hardly visible to the naked eye. *Stem* herbaceous, markedly striated. *Stipules* rudimentary, up to 0.5 mm in length, flat, tapering from a broad base (cf. Fig. 7 B). *Leaves* 3-foliolate, petiolate; *petioles* glabrous to sparsely asperulous, up to 1.5 cm long. *Leaflets* filiform—linear, up to 2.5 cm long and 0.5—1 mm broad, pointed at the apex, glabrous and channelled above, sparsely and minutely asperulous—scabrid below and on the margins: petiolules c. 0.5 mm long, flat, pale whitish. *Bracts* leafy, 0.5—1.7 cm long, lowermost ones 3-foliolate, up the racemes gradually smaller and unifoliolate, usually persisting, petiolate to subsessile. *Inflorescences* of terminal, loose racemes, up to 16 cm long, vaguely marked off from below due to the gradual transition from cauline leaves to bracts, the flowers showing intermittent sterility, hence fruits develop at certain intervals along the racemes. *Pedicels* 5–8 mm long, longer than the gynophore, slightly broadening towards the apex, in fruits directed somewhat upwards or spreading straight from the axis, sparsely and minutely asperulous. *Sepals* green, almost equal, 1.5—3 mm long, c. 0.5 mm broad at base, narrowly triangular, slightly connate at the very bases, deciduous, minutely asperulous. *Petals* pink-rose to mauve, almost equal, 4—6 mm long and c. 2 mm broad, upper ones elliptic, lateral ones obovate, apiculate, attenuate at the base into a short claw (c. 1 mm long), the upper petals somewhat shorter than the lateral ones. *Stamens* 5—6, all fertile (?), unequal: 2 stamens ventrally grouped in the expanded flower and with filaments c. 8 mm long and apically incurved; 3—4 small stamens, dorsally grouped in the flower, their filaments c. 5—6 mm long, slightly curved in apical parts, at least one of these smaller stamens with a minute, clavate apical swelling and then with the anther reduced in size (staminodial?); anthers 1—1.5 mm long. *Androgynophore* up to 0.5 mm long. *Gynophore* 1—3 mm long in the fruits, glabrous—glabrescent. *Capsule* linear, 3.5—6.5 cm long (incl. style), gradually tapering at both ends, spreading; *valves* deciduous, dehiscing from the gynophore end, glabrous, striated by about 4 longitudinal nerves, between these some few anastomoses; *replum* glabrous; *style* 3—5 mm long, filiform, straight, glabrous; *stigma* minute and only just marked off from the style. *Seeds* c. 2 mm in diameter, dark brown, reniform—rounded in outline, somewhat flattened from the sides, sculptured by numerous, irregularly spaced transverse ridges of varying size, the longitudinal sculpture lacking or present as a few faint striations at the radicula end (Fig. 8 C).

Owing to the extremely scant and poor material, the author has had difficulties to overcome in order to understand *Cleome conrathii* clearly. This species was orginally described as *Polanisia triphylla* by CONRATH. In the description CONRATH compared his species with *C. maculata* and pointed out some distinguishing features between these species. GILG and BENEDICT obviously found these features unimportant and therefore placed *Polanisia triphylla* in the synonymy of *Chilocalyx maculatus* (SOND.) GILG & BENED. [=*Cleome maculata* (SOND.) SZYSZYL.].

BURTT DAVY did not agree with GILG and BENEDICT and he considered the species to be well distinguished from *Clome maculata.* He also transferred the species to *Cleome* and named it *C. conrathii* because the combination '*Cleome triphylla*' was already in use for an other species. The descriptions of *C. conrathii,* given by the previous authors, are in fact brief and do not point out the characteristic features by which this species is clearly separated from *C. maculata* as well as from the allied *Cleome macrophylla* (KL.) BRIQ.

Cleome conrathii has some characters in common with *Cleome macrophylla* (KL.) BRIQ., e.g. the small flowers and the few stamens. On the other hand, the length of the pedicles (in relation to the gynophore) and the probable, though faint development of staminodes point towards a close affinity to *C. maculata.* Taking all characters into account, the author considers *C. conrathii* to be more closely allied to *C. macrophylla* than to *C. maculata;* the latter species being more specialized in the floral parts. A comparison between *C. conrathii* and its two allies *C. maculata* and *C. macrophylla* will be presented later in this paper.

In the following paragraphs the author will comment on the rather questionable androecial condition in *Cleome conrathii.* In CONRATH's description, the species was stated to have six stamens and out of them should four be staminodes with clavate-tipped filaments. In the few flowers which the present author has dissected, only five stamens were found. Moreover, the author is not quite sure that sterile staminodes are a constant feature in this species. Unfortunately the flower material is very scant and fragmentary and gives no clear answer to this problem. There are few expanded flowers available, and none with all the anthers intact. In some flower buds, just before anthesis, the author has also found five stamens. The anthers of these stamens were almost equal in size, and all of them seemed to be fertile. These observations agree with the notes (in sched.) made by Mr. MARAIS, who had previously dessected some flowers from two of the collections (viz. MARLOTH 113 and SUTTON 428).

Some drawings of the floral parts are attached to the type sheet as well as a brief description of the androecium. Very likely these drawings and notes were made by CONRATH when he dissected the original material. His notes are of interest and are as follows: "Der Beschreibung nach *Tetratelia maculata* SOND. fl. cap. entsprechend, ich finde jedoch 5—6 fruchtbare oder weningstens mit Antheren versehene Staubfäden, davon sind 3—4 im oberen Drittel anfangs schwanenhalsartig, später bogig gekrümmt und unter den Antheren blasig verdickt, die beiden anderen sind im Anfang bogig aufwärts gekrümmt, später gerade vorgestreckt und oben nicht verdickt." These observations are also well confirmed by his drawings of the floral parts. As regards the androecial condition, the notes cited come close to the interpretation made by Mr. MARAIS and the present author, and do not exactly match the original latin diagnosis ('six stamens, four of which are staminodes'). Possibly the reduction of the upper stamens has not proceeded so far in this species as to produce a complete sterilization of the anthers. Whether *Cleome conrathii* has true sterile staminodes or not, can, however, only be determined when new material of this species has been collected. The knowledge of androecial features are of particular interest when evaluating the degree of affinity between the three closely related species: *Cleome conrathii, C. macrophylla* and *C. maculata.*

Hitherto *Cleome conrathii* has been known solely from the original collection, but the author has also identified three other collections as belonging to this species.

Cleome conrathii shows a clear affinity to *Cleome macrophylla* (KL.) BRIQ. and *Cleome maculata* (SOND.) SZYSZYL. *C. conrathii* differs from *C. macrophylla* in the leafy bracts, in having pedicles which are longer than the gynophore and in the completely different construction of the receptacle. In the last mentioned character it differs essentially from both *C. macrophylla* and *C. maculata.* The latter two species are chiefly characterized by their extraordinary type of receptacle, which forms a small dorsal pouch, and to this feature is correlated a unique insertion of the stamens (cf. Fig. 6 G and KLOTZSCH 1862 t. 28). One may call this construction of the receptacle a '*Chilocalyx*-type', because it provided the essential diagnostic character of the genus *Chilocalyx* KLOTZSCH and also because it was first accurately studied and illustrated by KLOTZSCH. In *Cleome conrathii* we cannot find any such specialization; the receptacle is of a fairly regular and trivial type, with all floral parts free from each other (Fig. 7 G).

Cleome maculata differs from *C. conrathii* also in its large and handsome flowers, in having the bracts much reduced in size (false 'ebracteate racemes' as is *C. macrophylla*), and in the clear splitting of the androecium into fertile stamens and clavate-tipped sterile staminodes.

At first sight, *Cleome conrathii* greatly resembles certain low-growing specimens of *Cleome macrophylla* (KL.) BRIQ. var. *maculatiflora* (MERXM.) WILD, which are characterized by their particularly small flowers and narrow leaflets (LEACH 114, LISC, MILLER 4841, COI, both from Rhodesia, and WARD 39992, PRE, from Natal). All these specimens have grown on rocky and apparently dry habitats and therefore in environments similar to those from which we know *C. conrathii.* However, the similarity of *C. conrathii* to these specimens is superficial only. Despite the fact that these specimens of var. *maculatiflora* may be greatly modified, they show the essential characteristics of *C. macrophylla,* viz. 'ebracteate racemes', *'Chilocalyx type'* of receptacle and pedicels usually shorter than the gynophore. One can certainly reject, therefore, the theory that *C. conrathii* is merely a modified form of *C. macrophylla.*

Cleome conrathii BURTT DAVY is not identical with *Cleome inconcinna* BRIQ. (syn. *Cleome nationae* BURTT DAVY). *C. inconcinna* shows the essential characters of *Cleome macrophylla* (KL.) BRIQ. (sensu auct. pl.) and comes close to var. *maculatiflora* (MERXM.) WILD, an almost distinguishable variant within the variable species *C. macrophylla.*

Likewise *Cleome conrathii* might have been supposed to represent modified specimens of *C. maculata,* especially since these species have about the same range of distribution. But this suggestion will also be rejected here. In the abundant herbarium material of *C. maculata,* the author has found no tendencies in the plants to approach the features of *C. conrathii.* With regard to *C. maculata* such a variation would have meant a drastic remodelling of the receptacle and a considerable reduction of the petal-size, and these reductions would then have been correlated with a development of leafy bracts. Although the specimens of *C. conrathii* are small they show a vigorous growth, and they are certainly not dwarf modifications of some other species.

Consequently the author can find no reason to unite *Cleome conrathii* with *C. macrophylla* or *C. maculata,* nor to treat it as an intraspecific entity under either of them. Such a treatment would spoil the quite natural circumscriptions of *C. macrophylla* and *C. maculata* and would result in the loss of the clear and convenient distinction between these two well-known species.

The author considers that *Cleome conrathii* may represent a more primitive type as compared with *C. macrophylla* and *C. maculata.* The suggested primitive characters are: leafy bracts, 'regular' type of receptacle, few stamens with an apparently weak tendency to be transformed into staminodes. Also the small and almost equal petals may be regarded as a primitive character when compared with *C. maculata.*

Some previous authors treated *Cleome macrophylla* and *C. maculata* as belonging to the genus *Chilocalyx* KLOTZSCH (= *Tetratelia* SOND.). *Chilocalyx* was distinguished from *Cleome* (or *Polanisia*) mainly by the peculiar receptacle ('*Chilocalyx* type'). By its intermediate features *Cleome conrathii* is especially interesting because it gives us definite evidence that there is no reason to maintain a generic distinction between *Cleome* and *Chilocalyx* (or *Tetratelia*).

DISTRIBUTION, ECOLOGICAL NOTES. *Cleome conrathii* is known to the author from only four collections. These originate from the Transvaal and the northernmost parts of the Cape Province (Kuruman Distr.). One collection made by OWEN (probably Miss OWEN), is labelled as originating from "Natal". Dr. CODD, Pretoria, has kindly informed me that Miss OWEN also collected in the western Transvaal, and he believes that this collection belongs to her material from that region rather than from Natal (CODD 1969, in letter). The localities for *C. conrathii* are situated far apart and one can hardly trace any clear pattern in its distribution (Fig. 9 C). In the north, the range partly overlaps that of *C. maculata*. On the other hand the range seems to be well separated from that of *C. macrophylla,* which has a more northern distribution.

Cleome conrathii has been collected from rocky environments (rocky hillsides, rocky ridges) situated in 'open veld'. Probably its ecology does not differ essentially from that of *C. maculata*. Very likely this low-growing species has been much overlooked due to the inconspicuous habit of the plant.

COLLECTIONS. **SOUTH AFRICA.** Transvaal: Pretoria: CONRATH 11, 26.XII. 1897, felsige Hänge bei Fonteinen bei Pretoria. Holotype (K) — Lichtenburg: SUTTON 428, 21.V. 1930, Garsfontein, 5000 ft. Open veld. Ridge plant. Klipveld, red sand. Occasional. Flowers mauve (PRE — Cape Province: Kuruman: MARLOTH 1113, II. 1886, Kuruman, 1200 ft. (PRE) — Without precise locality: OWEN s.n., s.d., "Natal" (probably collected in the western Transvaal) (TCD).

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Tripterospora (Sordariaceae s. lat., Pyrenomycetes)

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ABSTRACT

Descriptions and a determination key are given to the five known species of *Tripterospora* and finds known to the author are compiled. A new species is described and a new combination proposed, *T. latipes* n.sp. and *T. leucotricha* (SPEG.) LUNDQ. n. comb. respectively. *Chaetomium fiscicolum* PETRAK and *T. brevicaudata* CAIN have been reduced to synonyms of *T. leuchotricha*. A species of the Hyphomycete genus *Humicola* has been found associated with *T. latipes*, and might be its imperfect state.

TRIPTEROSPORA CAIN, Can. Journ. Bot. 34: 700 (1956).

Type species: *T. longicaudata* CAIN, selected by CAIN 1956.

Terricolous, fimicolous, lignicolous, herbicolous, or seed-borne. *Cleistothecia* superficial, rarely immersed, globose, dehiscing irregularly, ± covered with flexuous hairs. Peridium pseudo-parenchymatous, membranaceous, dark to light-coloured, rather thin, with an outer textura angularis or prismatica. Paraphyses poorly developed or lacking. *Asci* fascicled, 4—8-spored, clavate to cylindrical, stipitate, ± fugacious, with or without an apical ring. *Spores* at first hyaline, one-celled, cylindrical, clavate, obovoid, or "sole-like" in profile, then transversely uniseptate; upper cell at last brown, smooth, equilateral, ± ellipsoidal to broadly fusiform, with a truncate base and an apical or subapical germ pore; pedicel basal, cylindrical to triangular, hyaline, at maturity devoid of plasma and collapsing.

CAIN (1956) and LUNDQVIST (1967) have commented on the taxonomy of the genus and the taxonomic significance of cleistocarpy. Both agree that *Tripterospora* is related to *Podospora,* but CAIN prefers to keep it in a family of its own. Problems connected with the circumscription of the *Tripterosporaceae*, the *Sordariaceae,* and the *Lasiosphaeriaceae* are discussed in a forthcoming work.

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KEY TO ALL KNOWN SPECIES

1. Asci 4-spored; spore head 27—35×20—25 μ; terricolous .... 5. *T. tetraspora*
1. Asci 8-spored; spore head smaller
   2. Asci without apical ring; young spores obovoid to clavate; germ pore apical; pedicel tapering to triangular .... 3. *T. leucotricha*
   2. These characters not combined
      3. Asci with apical ring; young spores "sole-like" in profile; germ pore subapical; pedicel 5.5—7 μ wide, unilaterally collapsing .... 2. *T. latipes*
      3. Pedicel narrower, irregularly collapsing; germ pore apical
         4. Pedicel 3.5—8.5 μ long; spore head 9.5—12×6.5—8.5 μ .... 1. *T. erostrata*
         4. Pedicel 10—17 μ long; spore head 13—15×8—9.5 μ.......... .... 4. *T. longicaudata*

1. **Tripterospora erostrata** (GRIFF.) CAIN (Figs. 1 A, 5 C, E)

Pleurage erostrata GRIFF., Mem. Torrey Bot. Club 11: 71 (1901). — Lectotype on horse dung from Aberdeen, South Dakota, U.S.A., 10.X. 1895, leg. GRIFFITHS (NY), selected by GRIFFITHS & SEAVER 1910. — *Sordaria erostrata* (GRIFF.) SACC. & D. SACC., Syll. Fung. 17: 604 (1905). — *Tripterospora erostrata* (GRIFF.) CAIN, Can. Journ. Bot. 34: 702 (1956).

Cleistothecia scattered, superficial, 240—385 μ in diam., covered with very long, flexuous, sometimes geniculate, simple, septate, brown, thick-walled, 4.5—5 μ thick hairs with straight, obtuse tips and often curved and dilated at the base. Peridium semitransparent to somewhat opaque, olivaceous brown with angular, slightly thick-walled, outer cells, 5—10 μ in diam. Paraphyses short, up to 12 μ broad, composed of swollen cells, evanescent. *Asci* 8-spored, 50—70×12—15 μ, clavate, with a short stipe and a tapering, rounded apex; apical ring hardly visible; subapical chamber rounded, c. 1.2 μ broad. *Spores* biseriate, clavate to obovoid-fusiform when young, filled with large oil drops, becoming transversely uniseptate; upper cell ranging through olivaceous to light brown, 9.5—12×6.5—8.5 μ, broadly ellipsoidal, somewhat truncate below and umbonate at the apex, with an apical germ pore; pedicel cylindrical, 3.5—8.5×2.5—3 μ. Gelatinous equipment lacking or possibly in the form of an evanescent cauda at each end of the spore.

SPECIMENS EXAMINED: **Egypt:** Giza, along the Cairo—Alexandria desert road, c. 40 km WNW of Cairo, on camel dung, 26.II. 1968, LQT 5620-g (UPS). — Ditto, on goat dung, LQT 5621-c. (BP, C, DAOM, E, M, O, PR, S, UPS). — Maryut Region, along the coastal highroad, c. 32 km SW of

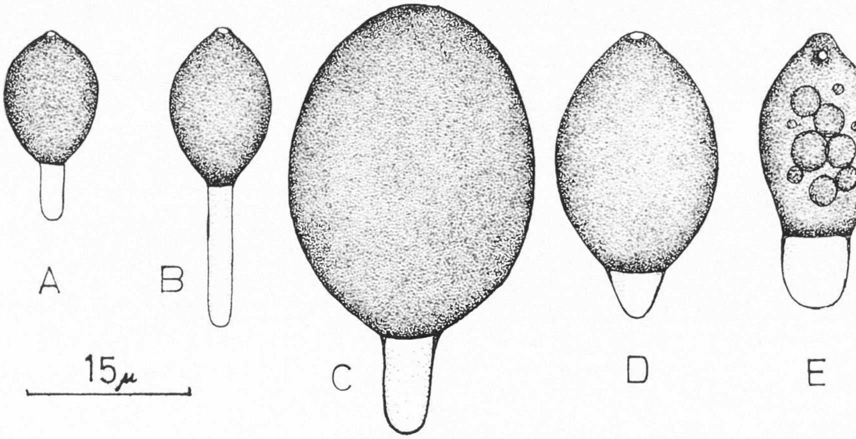

Fig. 1. — A: *Tripterospora erostrata*, Nordenstam, 24.IV. 1963. — B: *T. longicaudata*, Lqt 2074-k. — C: *T. tetraspora*, holotype. — D: *Chaetomium fiscicolum*, Petrak 1101. — E: *T. latipes*, holotype. — A—B, E drawn from living specimens, C—D from material in lactophenol.

Alexandria, on donkey dung, 27.II. 1968, Lqt 5704-d (BPI, CLF, IMI, NY, S, TRTC, UC, UPS). — Ditto, El Alamein, on donkey dung, 27.II. 1968, Lqt 5776-a (BP, BPI, FH, FI, H, LE, NY, PC, RSA, SOM, UPS, W); +1 on donkey dung. — **South Africa:** Cape, Namaqualand, Buffelsrivier, 30 km N of Kamieskroon on the road to Springbok, on sheep (?) dung, 26.X. 1962, Nordenstam (UPS). — Ditto, on donkey dung (L slide, IMI, S, UPS). — **South West Africa:** Rehoboth, Gamsberg Pass, NE of Mt. Great Gamsberg (=c. 95 km W of Rehoboth), on baboon dung, 24.IV. 1963, Nordenstam (PRE, TRTC, UPS). — **Canada:** Manitoba, Winnipeg, Manitoba Agricultural College, on horse dung, 8.IV. 1933, Bisby 2176 (DAOM). — **U.S.A.:** 2 lectotype slides (NY). — Arizona, Tucson, on rabbit dung, I. 1900, Tyler, herb. Griffiths (NY). Griffiths 1901. — Ditto, on burro dung (NY). — Colorado, Boulder, W base of Mt. Steamboat in Front Range (=3 km NW of Lyons, near mouth of St. Vain Creek), alt. 1900 m., on cow dung, 30.IV. 1966, Santesson 18499-u (UPS).

UNVERIFIED RECORDS: **Hungary:** on red deer dung, Tóth 1965. — **Canada:** on dung of horse and rabbit, Cain 1956. — **U.S.A.:** on dung of cow 3, horse 2, sheep, Griffiths 1901; on horse dung 3, Wilson 1947. — **Algeria:** on dung of camel 4, goat 2, Faurel & Schotter 1965 a; on dung of camel 4, goat 4, wild sheep 2, donkey 2, gazelle, Faurel & Schotter 1965 b. — **Tchad:** on dung of camel 3, donkey 3, goat 3, sheep, "daman", hare, Faurel & Schotter 1966.

CHOICE OF SUBSTRATE: 13 (56) finds: On dung of camel 1 (12), goat 1 (10), donkey 4 (9), horse 2 (8), cow 1 (4), sheep 1 (3), rabbit 1 2), wild sheep (*Ammotragus lervia*) (2), burro 1, red deer (*Cervus elaphus*) (1), gazelle (*Gazella*) (1), "daman" (*Procavia antineae*) (1), hare (*Lepus kabylianus*) (1), baboon 1. (Figures in parentheses are all records; figures without parentheses are the collections studied by the author).

ILLUSTRATIONS: GRIFFITHS (1901, pl. 4: 11—13); CAIN (1956 Figs. 11—16).

Under moist chamber conditions *T. erostrata* appears very late on the substrate, one month or more after the start of the culture. The exact length of time from germinating spore to mature cleistothecium on intact dung is not known to me, but GRIFFITHS (1901 p. 17) reports that the development of his specimens took nine days. The species seems to have a wide ecological amplitude as regards its choice of substrate, even though it concentrates on the dung of domesticated herbivores. *T. erostrata* is obviously warmth-loving with its main distribution in warm-temperate, subtropical, and perhaps also tropical regions. It is new to Egypt, South and South West Africa.

GRIFFITHS must have investigated at least ten samples of the species, two of which are still preserved. The syntype collection consists of a few specimens on a single dung pellet, associated with i.a. *Sordaria superba* DE NOT. Only two slides of the lectotype collection remain, one with nine mature cleistothecia, the other with one immature. Their quality is not good as all spores have collapsed.

According to GRIFFITHS the spores have evanescent, gelatinous caudae, one at each end, but these cannot be seen on his material now. Both CAIN and the present author have investigated fresh material and yet not been able to observe these caudae, not even in India ink mounts, a method that I tried on NORDENSTAM's specimens. These have 9.5—11×6.5—7.2 μ large spores with a 3.5—6 μ long pedicel. The other extreme is found in SANTESSON's American collection with the corresponding measurements 11—12×7.2—8.5 μ, and 6—8.5 μ respectively. GRIFFITHS's material, however, is intermediate in these respects. Even if GRIFFITHS was right about the existence of caudae, I believe that all specimens cited here must represent one and the same species.

2. **Tripterospora latipes** LUNDQ. n. sp. (Figs. 1 E, 2—4 D)

DERIVATION: Latin *latus,* broad, and *pes,* foot, referring to the pedicel of the spores.

Terricola vel lignicola. *Cleistothecia* ± solitaria, superficialia, fuscoatra, globosa, 290—700 μ diam., pilis hyalinis vel dilute brunneis, flexuosis, ramosis, 2—2.5 μ crassis obtecta. Peridium membranaceum, semipellucidum, ochraceobrunneum; cellulae externae peridii angulatae, 5—10 μ diam., parietibus tenuibus. Paraphyses evanescentes. *Asci* fasciculati, 8-spori, 100—110×14—16 μ, clavati, breviter stipitati, apice truncato, maturitate evanescentes, anulo apicali modice incrassato, c. 2.1 μ diam. *Sporae* biseriatae, initio unicellulares, cylindraceae, hyalinae, deinde infra medium modice constrictae, transversaliter uniseptatae; cellula superior ± elipsoidea, apicaliter conica, basaliter truncata, 16.5—20.5×10—13 μ, brunnea, guttis oleiferis magnis repleta, poro germinali subapicali instructa; pedicellus hyalinus, 6.3—9 (—10) μ longus, 5.5—7 μ latus, cylindraceus, maturitate sine plasmate, unilateraliter collabens. Sporae gelatina carentes.

Terricolous or lignicolous. *Cleistothecia* ± irregularly scattered, superficial, globose, irregularly dehiscing, 290—700 μ in diam., dark, covered with hyaline to greyish-brown, flexuous, septate, ramified, 2—2.5 μ thick hairs. Peridium pseudoparenchymatous, membranaceous, semitransparent, ochraceous to olivaceous brown, 40—50 μ thick, with angular, thin-walled, outer cells, 5—10 (—12) μ in diam. Paraphyses rapidly dissolving, composed of up to 12 μ broad, vesicular cells. *Asci* fascicled, 8-spored, 100—110×14—16 μ, clavate, broadest in the middle, with a short stipe and a tapering, truncate, c. 5 μ broad apex with a somewhat thickened, simple, c. 2.1 μ wide, apical ring. *Spores* biseriate, at first hyaline, one-celled, cylindrical with rounded ends, then "sole-like" in profile, slightly constricted below the middle and transversely one-septate at the constriction; upper cell ranging through olivaceous to brown, smooth, thin-walled with a few, large, clearly visible oil drops, ± ellipsoidal, 16.5—20.5×10—13 μ, with a truncate base and a conical, often umbonate apex with a subapical germ pore; pedicel hyaline, 6.3—7.7 μ long, 5.5—7 μ wide, cylindrical, with a broadly rounded end, at maturity devoid of plasma; proximal part of the pedicel wall rather thick on 3 sides, slightly melanized, the end and fourth side thin-walled, collapsing, giving the pedicel a cup-like form and in lateral view a triangular outline. Gelatinous equipment lacking.

SPECIMENS EXAMINED: **Denmark:** Zealand, Copenhagen, the Botanical Garden; isolated from compost soil from a greenhouse, 26.II. 1968, A. KJØLLER, holotype (UPS). Isotypes will be distributed to BP, BPI, BUCU, C, CLF, DAOM, E, FH, FI, ILLS, IMI, H, L, M, NY, PC, PR, PRE, S, SOM, TRTC, UC, W. — **U.S.A.:** Maryland, Patuxent River. Isolated from submerged balsa wood blocks at Chesapeake Biological Laboratory, Solomons, Maryland, 20.IX. 1967, C. A. SHEARER & J. L. CRANE (ILLS 34539, not seen, UPS).

Dr KJØLLER has given me some information about her cultures: — a suspension of compost soil was poured on filter paper placed on SY-agar of the following composition: — 3.0 g NH_4NO_3; 1.0 g KH_2PO_4; 0.5 g $MgSO_4$, $7H_2O$; 0.4 g KCl; 0.1 g $CaCl_2$, $2H_2O$; 0.1 g Bacto Yeast Extract; 5 ml solution of micronutrients; 15.0 g agar (Davis); 1000 ml distilled water; pH of the substrate 5.5—6.5. The cultures were kept in darkness at a temperature of 25°C and cleistothecia appeared after 1 month's incubation.

The mycelium is rather inconspicuous in the cultures I have studied and no zonation or special grouping in the perithecia can be seen. It is possible that the species might have some cultural properties in this medium, but they would not be of much diagnostic value in general. The most characteristic features in *T. latipes* are the size and form of the pedicel, the shape of the young spores, and the subapical germ pore. The "sole-like" outline of the hyaline spores is not found in the other *Tripterospora* species, but it is very similar to that in young spores of *Triangularia angulospora* CAIN & FARROW and *T. obliqua* CAIN. The unilateral collapsing of the pedicel as a specific character seems to be rare in the *Sordariaceae* s.lat. It occurs in *Tripterospora leucotricha* and *Zopfiella tabulata* ZOPF ex WINT. too. In front view it looks as if the spore has two short fingers extending from the margin of the septum, but this is, of course, due only to the effect of the indented cell wall (Figs. 2 E, 3 A—B). There does not seem to be any correlation between the position of the germ pore and that of the thin-walled part of the pedicel.

Occasionally the germ pore may be located far down on the spore. Other anomalies may also occur, for example one-celled, totally melanized spores, or extremely large or narrow spores. The oil drops in the spore head number 4—10 in fresh specimens, but after heating in lactophenol they usually unite into two or three large globules in a longitudinal series.

Associated with the cleistothecia is a Hyphomycete of the genus *Humicola* TRAAEN. The conidia (or chlamydospores) are globose, 11—15 μ in diam., brown, without visible oil drops, smooth, with c. 1 μ thick, probably double wall. They have 2—4, round, rather large but diffuse, light-coloured, scattered areas that might be germ pores. There is also a very small pore in the septum between the conidium and the conidiophore. Sometimes the conidia appear to be united two and three (Fig. 2 J). The conidiophores are simple, hyphal branches of various length, cylindrical to ventricose, 2.8—3 μ thick, ± hyaline. The fungus agrees fairly well with *H. grisea* TRAAEN (=*Monotospora daleae* MASON), a species isolated from soil from various parts of the world. I have, however, not made great efforts to get a correct determination of it. Nor have I sure evidence that it constitutes the imperfect state of *T. latipes*. It may be a parasite or perhaps only a contaminant

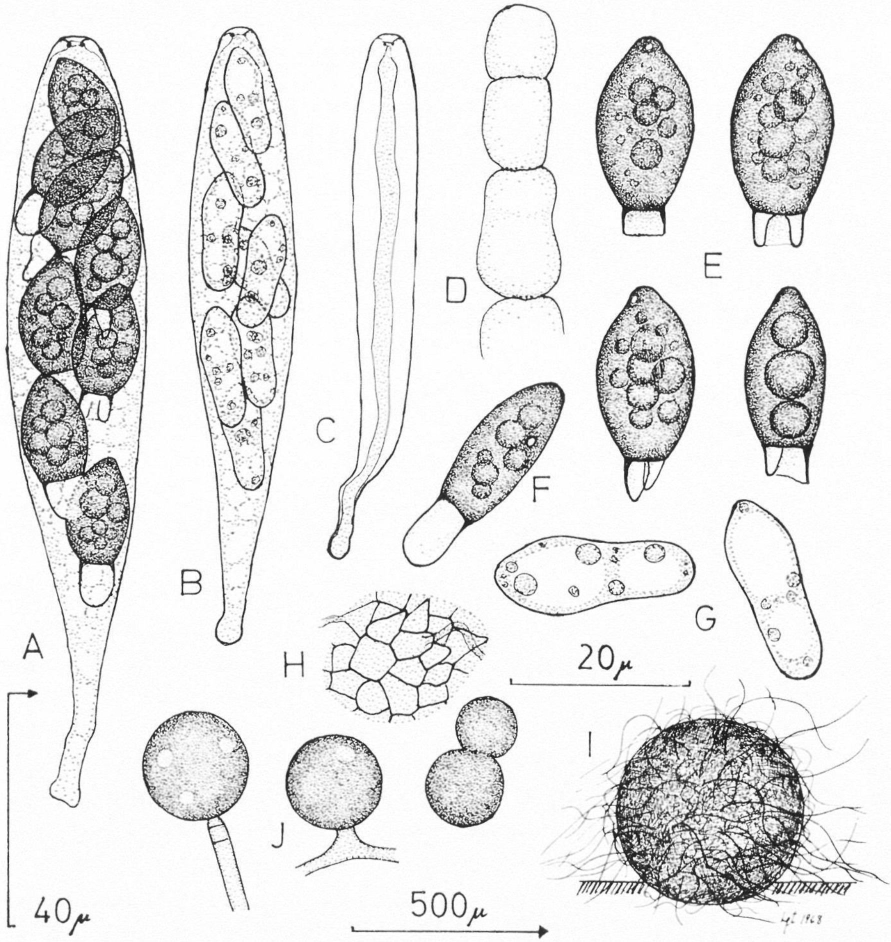

Fig. 2. *Tripterospora latipes*, holotype. All figures drawn from living specimens. — A: Mature ascus and spores. — B—C: Immature asci and spores. — D: Paraphysis. — E: Mature spores with collapsed pedicels. — F: Mature, abnormal spore with lateral germ pore and large pedicel. — G: Immature spores. — H: Peridium in horizontal view. — I: Cleistothecium. — J: Conidia of *Humicola* sp.

in the cultures. In later cultures sent to me by Dr. KJØLLER the Hyphomycete was absent. It should be noted, however, that the mycelium of the species cannot be distinguished as to form, size, and colour from the mycelium and hairs of the cleistothecia. Sometimes the latter are even covered by *Humicola*. No phialides have been observed in this material, but MASON saw such in all his isolations of

M. daleae. So far no conidial state has been reported to exist in *Tripterospora*. For a discussion of the species and the generic nomenclature, see MASON (1933) and WHITE and DOWNING (1953).

3. **Tripterospora leucotricha** (SPEG.) LUNDQ. n. comb.
(Figs. 1 D, 4 A—C, 5 A)

Sordaria leucotricha SPEG., Michelia 1: 225 (1878). — Holotype on rotten branches of *Sambucus nigra* from Conegliano, Venezia, Italy, IX. 1877, SPEGAZZINI, herb. SACCARDO (PAD). — *Podospora leucotricha* (SPEG.) NIESSL, Hedwigia 22: 156 (1883). — *Pleurage leucotricha* (SPEG.) O. K. Rev. Gen. Plant. 3(3): 505 (1898).

Chaetomium fiscicolum PETRAK, Ann. Myc. 13: 45 (1915). — Type on decaying, barkless *Salix* twigs from Mähr. Weisskirchen, Moravia, Czechoslovakia, IX. 1914, PETRAK (in herb. PETRAK?); not seen.

Tripterospora brevicaudata CAIN, Can. Journ. Bot. 34: 701 (1956). — Holotype isolated from radish seed from British Columbia, Canada, IV. 1940, GROVES (TRTC 31779); not seen.

Cleistothecia 250—640 μ in diam., covered with hyaline to light brown, flexuosus, septate, 2—4 μ thick hairs. Peridium membranaceous, semitransparent, ochraceous, with angular, thin-walled, outer cells. *Asci* 8-spored, 140—220×20—28 μ, clavate to cylindrical, without apical ring. *Spores* 1—2 seriate, obovoid to clavate when young; upper cell 18—26×12—17 μ, ± broadly ellipsoidal, conical above, truncate below, with an apical germ pore and several oil drops; pedicel tapering to triangular, 4—8 μ broad, 3.5—5 μ long, unilaterally collapsing. Gelatinous equipment lacking.

For a more detailed description, see CAIN l.c. and PETRAK l.c.

SPECIMENS EXAMINED: **Czechoslovakia:** Moravia, Mähr. Weisskirchen (=Hranice), bank of Betschwa (=Bečva) River, on an old wicker basket, 14.VIII. 1914, PETRAK; PETRAK: Fl. Boh. Mor. Exs. II: 1, Pilze No. 1101 (S). — **Italy:** the holotype of *S. leucotricha* (PAD). — **Canada:** Saskatchewan, Saskatoon, isolated from *Avena sativa* seeds, 23.I. 1964, FISCHER, DAOM 93544 (FH).

UNVERIFIED RECORDS: **Canada:** isolated from tomato seeds, CAIN 1956. — **U.S.A.:** isolated from living yellow birch branch infested with bronze birch borer, CAIN l.c.

ILLUSTRATIONS: SACCARDO (1879 Fig. 619); CAIN (1956 Figs. 1—10).

The type collection of *Sordaria leucotricha* in SACCARDO's herbarium is certainly the only one existing as no specimens are preserved in SPEGAZZINI's herbarium at LPS. The Padova collection may, of course,

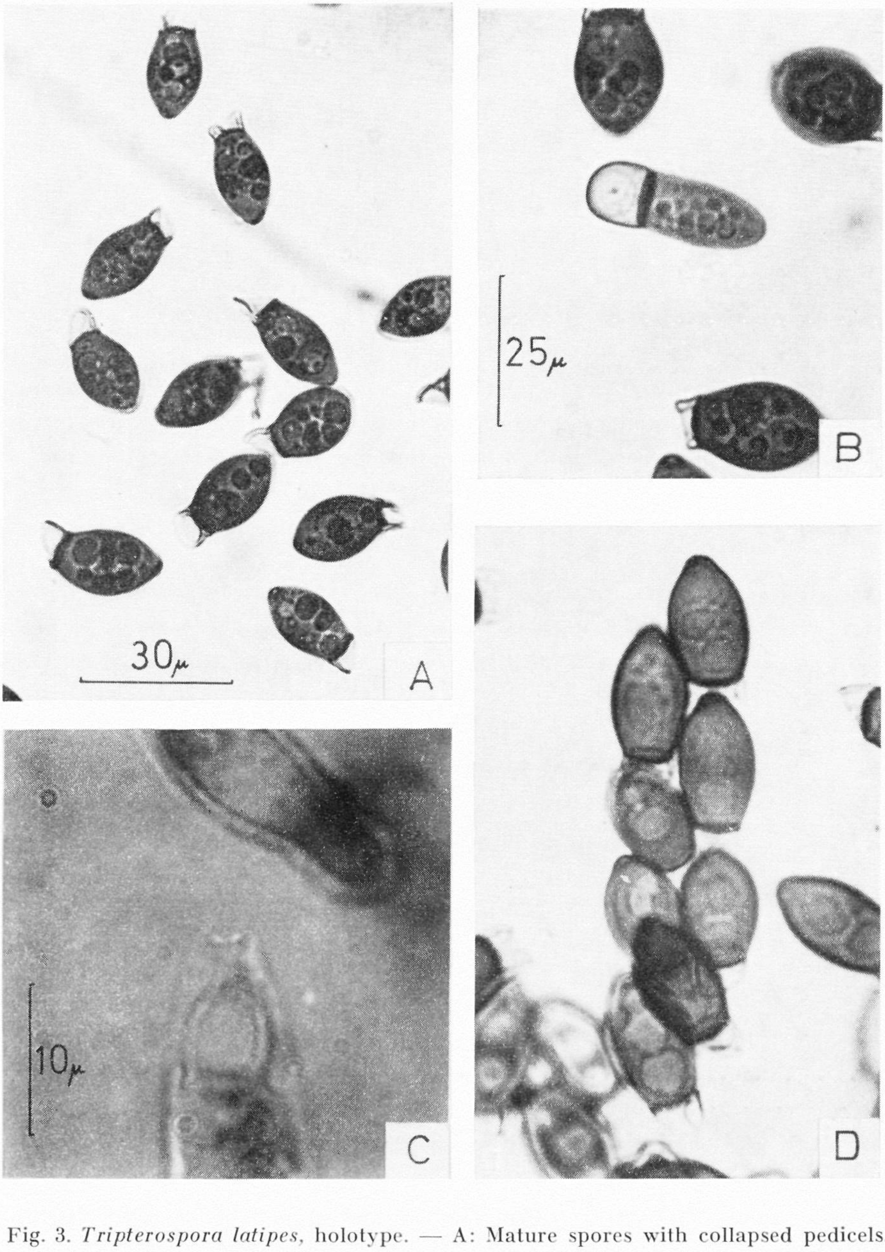

Fig. 3. *Tripterospora latipes,* holotype. — A: Mature spores with collapsed pedicels. — B: Mature spores, one of which has an unusually narrow, pigmented cell and a broad, intact pedicel. — C: Ascus tip with visible, apical ring. — D: Ascus with mature spores; ascus wall invisible. — Magnification: D=B. — A—B Photos from living specimens, C—D from material in lactic blue.

be an isotype or a syntype, but as long as nothing can be proved about it I prefer to regard it as the holotype. The material is poor, consisting of a few ascocarps on two pieces of a *Sambucus* branch.

As regards the type of *Chaetomium fiscicolum,* PETRAK (l.c.) cites his exsiccata number 1101, and this material may be a part of the type collection in spite of the difference in date. An eventual lectotypification should, however, be postponed until some more samples of 1101, especially PETRAK's own, have been examined.

After having compared authentic specimens of *S. leucotricha* and *C. fiscicolum* with CAIN's excellent diagnosis and figures of *T. brevicaudata,* I feel convinced that they represent one and the same species. PETRAK gives a smaller ascus width then CAIN and states to have seen ostiolate ascocarps, but this disagreement should not be taken seriously. Asci vary much according to their inflation and all the specimens of No. 1101 that I have scrutinized are cleistothecial. The occurrence of ostiolate ascocarps here must be a rare and atypical phenomenon and can be considered a parallel of the occasional development of cleistothecia in certain *Chaetomium* species. SACCARDO (1879) also depicted ovoid ascocarps, which may indicate an ostiolum, but his poorly preserved material does not admit a confirmation of this feature. The large spore size given by SPEGAZZINI, 30—32×18—28 μ, does not agree with his specimens. He may have measured some abnormally large spores, or perhaps included the pedicel in the measure of length.

4. **Tripterospora longicaudata** CAIN (Figs. 1 B, 5 B)

Tripterospora longicaudata CAIN, Can. Journ. Bot. 34: 703 (1956). — Holotype on horse dung from N of Palgrave, Peel Co., Ontario, Canada, 10.X. 1955, CAIN (TRTC 31528); not seen.

Cleistothecia scattered or gregarious, superficial or wholly and deeply buried in the substrate, 100—270 μ in diam., covered with flexuous, ± hyaline, branched, sometimes anastomosing, septate, 2.5 μ thick hairs. Peridium semitransparent, yellowish brown, with irregularly shaped outer cells, 6—10 μ in diam., having straight or undulating walls. Paraphyses consisting of short chains of inflated, 10—18 μ wide cells, evanescent. *Asci* 8-spored, 80—90×17—18 μ, clavate, short-stipitate, tapering above with a rounded, c. 5 μ broad apex and a distinct, but hardly thickened, apical ring. *Spores* biseriate, at first cylindrical, then clavate, becoming transversely uniseptate; upper cell ranging through olivaceous to brown, broadly ellipsoidal, with a truncate base and an

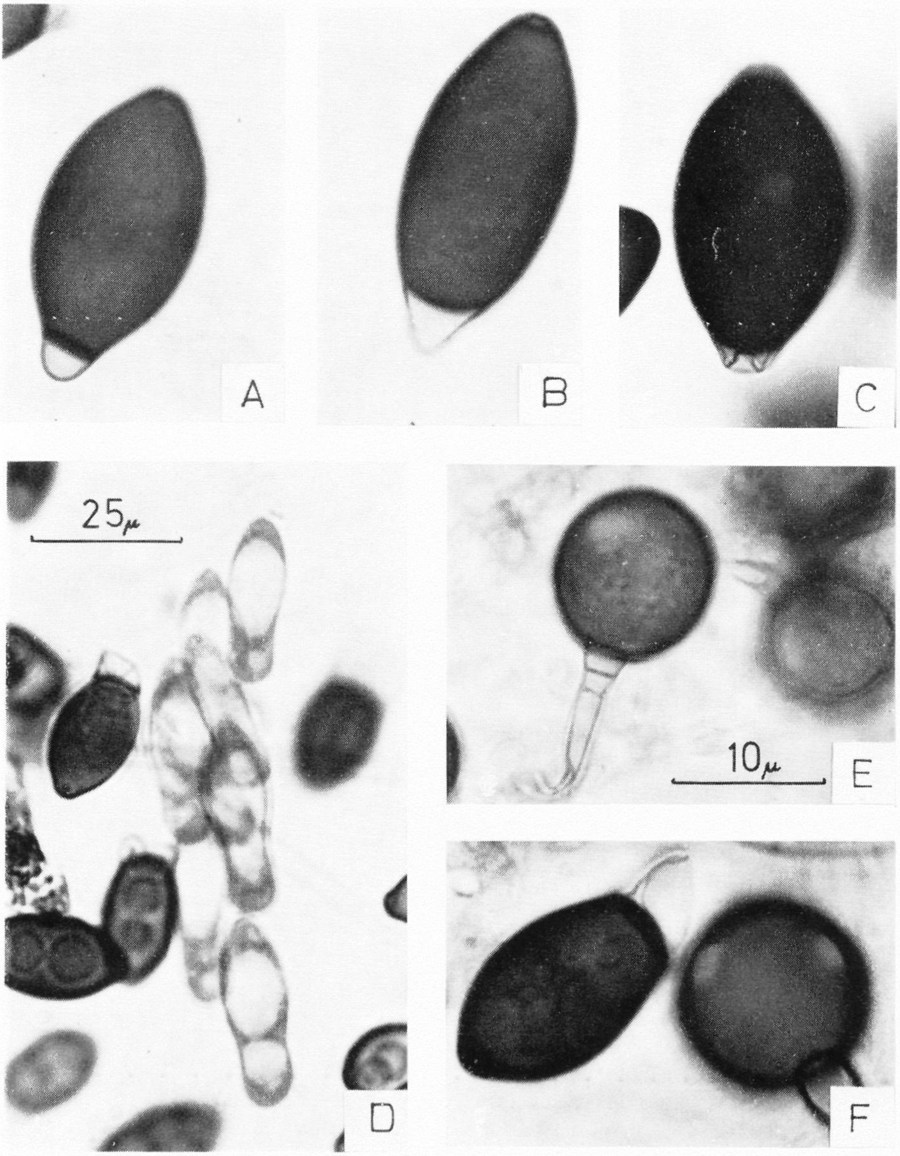

Fig. 4. — A—C: *Chaetomium fiscicolum,* PETRAK 1101, mature spores, one with collapsed pedicel. — D: *Tripterospora latipes,* holotype, immature ascus and spores; ascus wall invisible, but note the apical ring. — E: *Humicola* sp., chlamydospore. F: *Humicola* sp., chlamydospore, and T. *latipes,* ascospore; note the light areas (pores?) in the former. — Magnifications: A—C, F=E. — A—F photos from material in lactophenol or lactic blue.

umbonate apex, 12—15×7.5—9.5 μ, with a single oil drop and an apical germ pore; pedicel 13—15×2.8—3.5 μ, cylindrical, straight or somewhat curved. No gelatinous equipment.

SPECIMENS EXAMINED: **Sweden:** Gotland, Hejnum, S of the church, on horse dung, 4.VI. 1959, LQT 2074-k (TRTC, slide, UPS, slide). — Uppland, Bälinge, Lytta, on cow dung, 1.X. 1960, LQT 2804-d (UPS); northernmost find, 59°57′ N. — Söderby-Karl, Brölunda, on horse dung, 4.VII. 1960, LQT 2514-d (UPS). — Uppsala, on horse dung, 20.X. 1967, GUNNERBECK 1327-c (UPS). — Ditto, 21.III. 1968, GUNNERBECK 1403-a (CLF, E, IMI, NY, PR, TRTC, UC, UPS). — Ditto, 11.IV. 1968, GUNNERBECK 1415 (UPS); this one will be distributed in LUNDELL & NANNFELDT: Fungi Exsiccati Suecici; new to Europe. — **Canada:** Isotypes at FH, UPS.

UNVERIFIED RECORD: **Canada:** on Swiss chard, CAIN 1956.

CHOICE OF SUBSTRATE: 7 (8) finds: on dung of horse 6 (6), cow 1, and on Swiss chard (1).

ILLUSTRATION: CAIN (1956 Figs. 17—33).

This fungus apparently favours the dung of domesticated herbivores, notably horse dung. On GUNNERBECK's three samples from Uppsala, taken on different occasions, *T. longicaudata* always grew in company with *Doratomyces* cfr. *purpureofuscus* (FR.) MORTON & G. SM. On No. 1327 also mycelium with phialids was observed, which might belong to *T. longicaudata*. On all his collections the species was at first found in very small quantities, but then I detected that it grew abundantly and fructificated in the interior of the droppings, whereas few cleistothecia appeared on the surface.

Numerous coprophiles are indifferent to light as regards their spore dispersal, for example *Hyphomycetes*, many *Mucorales* and *Agaricales*, but nevertheless they all grow on the substrate surface, because light in most cases stimulates the formation of fruit bodies and sporangiophores. Several cleistocarpous species, however, seem to be rather independent of light in this respect. When the substrate is coarse and porous, fruit bodies may be found on all levels within it. In the case of *T. longicaudata* the explanation could be that the outer layer of the fresh dung was too dense and well transformed, possibly also containing too high a concentration of chemical substances, to be favourable. Fungi with this way of living may to some extent depend upon insects, mites, and other dung-inhabiting animals for their dispersal.

5. **Tripterospora tetraspora** RAI et al. (Figs. 1 C, 5 D)

Tripterospora tetraspora RAI et al., Can. Journ. Bot. 41: 327 (1963). — Holotype isolated from soil (pH 8.2) from Salethu, Rae Bareli, Uttar

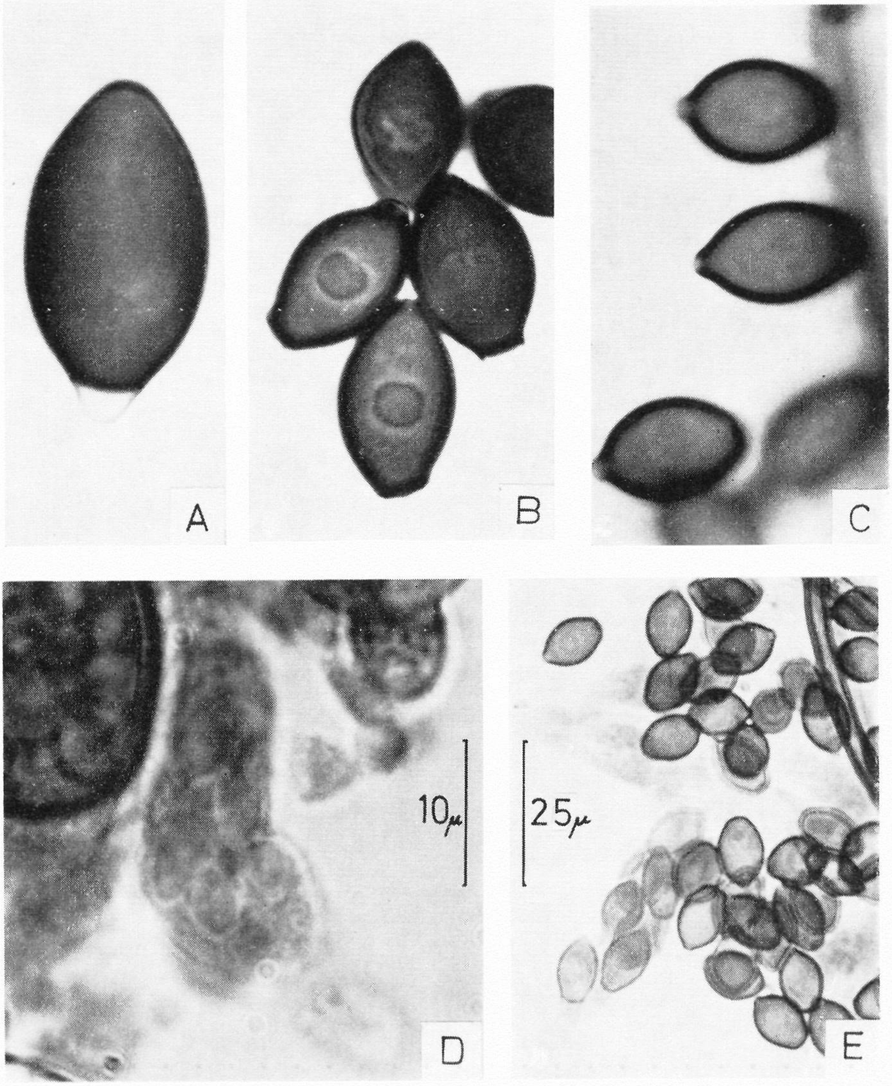

Fig. 5. — A: *Sordaria leucotricha,* holotype, mature spore. — B: *Tripterospora longicaudata,* isotype (UPS), mature spores. — C, E: *T. erostrata,* TYLER, I. 1900, mature spores and asci; ascus wall invisible. — D: *T. tetraspora,* isotype (IMI 92686), ascus with 8 immature spores. — Magnifications: A—E = D. — A—C photos from material in lactic blue.

Pradesh, India, IX. 1959 (IMI 92686); isotypes at the American Type Culture Collection (ATCC 14742, not seen), Rockville, Maryland, U.S.A., and at the Mycological Herbarium, Lucknow University, India (S-R. C-K. B-L 35 and RUP-80), not seen.

Cleistothecia 200—450 μ in diam., glabrous or covered with light-coloured hairs. Peridium membranaceous, semitransparent, light-coloured with an outer prismatic or epidermoid texture. Paraphyses absent. *Asci* 4-spored, with 4 aborted spores, c. 80×40 μ, ± clavate, without apical ring. Young *spores* clavate; upper cell 27—35×20—25 μ, broadly ellipsoidal, brown, thick-walled, with one or a few large oil drops and an apical germ pore; pedicel cylindrical 9—15.7×4.5—5.5 μ. Gelatinous equipment lacking.

The description is a shortened and modified version of the original one. It should be noted that Fig. 10 in RAI et al. of the mature spores is not quite to the point as it shows the spores to have a more tapering apex with a subapical germ pore. Nor did they observe the aborted spores. Their ascus measurements are also rather small, perhaps based on immature asci. The approximative size given above is calculated from their Fig. 13. I have seen holotype slides of the species, but ripe asci and spore pedicels could not be seen on this material.

T. tetraspora has also been isolated from soil from other localities in Uttar Pradesh (RAI et al. 1963), and is also reported from Lucknow and Kanpur by MUKERJI (1966 table V). There is at UPS a duplicate of IMI 117030, a culture isolated from a wheat field at Banara Hindu University, India, 2.VIII. 1965, J. P. SINGH, det. G. MORGAN-JONES, which contains mycelium only.

ACKNOWLEDGEMENTS

Mrs. C. HÖRNER, Uppsala, and Dr. H. SMITH, Uppsala, have kindly checked the English and the Latin respectively. I am indebted to Dr. A. KJØLLER, Copenhagen, and Dr. L. CRANE, Urbana, Illinois, for permitting me to take over their material of *Tripterospora latipes* for publication. Dried specimens for examination have also been gratefully received from DAOM, FH, IMI, NY, PAD, S.

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Smärre meddelanden
(Brief Articles and Reports)

Några för Sverige nya förvildade eller adventiva fanerogamer
(Some Subspontaneous or Adventive Plants New to Sweden)

ABSTRACT. — A list is given of some plants which have not hitherto been recorded from Sweden but are now shown as having been found there as garden escapes or adventives. To the former category belong: *Abies balsamea, Tradescantia×andersoniana, Corydalis capnoides, Alyssum argenteum, Ribes sanguineum, Prunus virginiana, Spiraea×bumalda* and *S. tomentosa, Cotoneaster divaricatus, Cytisus supinus,* and probably *Aster alpinus,* to the latter a number of annual species found by S. Ahlner at Gävle in 1929 [an addition to the finds there published by him in Svensk Bot. Tidskr. 23 (1929)]: *Trifolium aurantiacum, T. preslianum* and *T. suffocatum, Trigonella aurantiaca, Ziziphora capitata, Plantago Loeflingii, Asteriscus aquaticus, Anthemis coelopoda,* and *Crepis zacintha* (*Zacintha verrucosa*), all determined by C. Blom, further the following species, collected at various places by various collectors: *Polygonum plebejum, Amaranthus tamariscinus, Galeopsis pubescens, Ibicella lutea* (*Proboscidea lutea*), *Achillea Gerberi, Evax rotundata, Parthenium hysterophorus,* and *Carduus personata.*

Under mina studier i de svenska offentliga herbarierna i samband med fortsättningen på min nordiska kärlväxtflora och mitt arbete på en komplettering och revision av Otto Nordstedts »Prima loca plantarum suecicarum» av 1920 har jag funnit belägg från svenska fyndplatser av en del förvildade eller adventiva arter, vilka mig veterligt ej tidigare publicerats som med säkerhet funna i Sverige, fastän ett par av dem på grund av felbestämt eller osäkert material angetts som sådana. Då jag gärna vill att den nya »Prima loca», som jag hittills utarbetat och som omfattar förvildade och i senare tid inkomna växter, skall på samma gång vara en så komplett förteckning som möjligt över dessa kategorier men inte finner det lämpligt att publicera fynden där, har jag här sammanställt följande lilla lista. I denna står jag själv ej för något enda fynd och endast i några fall för bestämningarna; de flesta av dessa härröra från vår främste adventivspecialist, Carl Blom. Detta gäller bl.a. en hel rad arter från Gävle, samlade av Sten Ahlner (1929) och nu publicerade med dennes benägna tillåtelse; de utgöra alltså en efterskörd till de fynd han själv publicerade därifrån i Svensk Bot. Tidskr. 23 (1929). Dr. BLOM har också vänligen låtit mig publicera ett par fynd, som han själv gjort men ej offentliggjort. Direkt från insamlaren, docent BERTIL HYLMÖ, har jag fått uppgiften om förvildad *Abies balsamea,* en av de få jag känner om verklig förvildning utanför odlingsplatsen av ett utländskt barrträd.

Abies balsamea (L.) MILL. (confirm. T. NITZELIUS)

Sm Liatorp: Gamlelycke, talrika ex. i fuktig barrskog ända till 500 m från moderexemplaren i skolträdgården, iakttagen sedan c. 1950, B. HYLMÖ.

Tradescantia×andersoniana LUDW. & ROHW. (det. N.H. 1969)

Gbg Göteborg: Delsjöupplaget, in ruderatis 1963, C. BLOM (GB, ut *T. virginica*).

Namnet *T.×andersoniana* betecknar en grupp av storblommiga trädgårdsformer, vari *T. virginica* L. ingår och som i trädgårdskatalogerna alltjämt mestadels går under detta namn. En av C. BLOM samlad och som *T. virginiana* i Acta Horti Gotob. 24(3): 77 (1961) publicerad form från Gbg Backa: nära Brunnsbo 1946 utgör däremot enligt min mening en nordamerikansk vildtyp, närmare bestämt tillhörande *T. bracteata* SMALL (belägg i GB, det. N.H. 1969).

Polygonum plebejum R. BR. (det. N.H. 1965)

Upl Bromma: Sandvik, torget 1912, HJ. DU RIETZ (UPS, ut *P. aviculare,* f. *flor. ros*).

Amaranthus tamariscinus NUTT. [*Acnida tamariscina* (NUTT.) WOOD]

Gbg Göteborg: Högsbotorpen, in ruderatis 1947, C. BLOM (GB, ut *Acnida tamariscina*).

Corydalis capnoides (L.) WG

Upl Uppsala: »i grusbacken vester om Sjukhuset» 1882, H. FRÖDING (GB, det. F. AHLBERG).

I GB ligga även ett par kollekter utan uppgift om förekomstsättet:

Vg Leckö slott 1865, C. LINROTH, distr. genom Sällsk. Linnaea, Karlstad (det. H. A. FRÖDING; ursprungligen som *Fumaria capreolata*).

Stockholm 1887, O. WIJK (det. C. BLOM; ursprungligen som *Corydalis pumila*).

Alyssum argenteum VITM.

Sk Mölle: klippbranter nära Grand Hotell 1941, TH. LANGE (LD).

Ribes sanguineum PURSH

Sk Skanör: tallplanteringen i hörnet av Väktare- och Koggevägarna, förvildad i flera ex. 1956, C. A. TORÉN (LD).

Prunus virginiana L.

Vsm Badelunda: nära Tibble gård 1945, E. ALVÉN (LD, S).

Spiraea×bumalda BURV.

Gbg Göteborg: Ringön, in ruderatis 1962—63, C. BLOM (GB).

En tidigare uppgift hos B. HOLMGREN: Blekinges flora (1942): 178 om *S.×bumalda* som förvildad i Bl Sölvesborg: Valje, på banvallen vid Sissebäck, grundar sig enl. belägg i GB och LD (leg. BJ. HOLMGREN 1932) på *S. japonica* L. FIL. var. *Fortunei* (PLANCH.) REHD. (det. N.H. 1967, 1968).

Spiraea tomentosa L.

Sk Hästveda: »vid stranden av Lillsjön, naturaliserad och spridd» 1935, O. J. Hasslow (LD).

Arten uppgavs av B. Holmgren: Blekings fanerogamer och kärlkryptogamer (1921): 94 som funnen i Bl Nättraby: Sjuhalla skog, C. Blom, men kollekten ombestämdes sedermera korrekt av Blom till *S. Douglasii*, under vilken den redovisas hos B. Holmgren: Blekinges flora (1942). Ett par här — och något tidigare av H. i Bot. Notiser 1941 — meddelade fynd av *S. tomentosa* från Bl Ronneby: brunnsparken, Hj. Hylander, och Kyrkhult: Röshult, R. Jändel, torde behöva bekräftelse; jag har ej sett några belägg, och på den förra lokalen kunde jag vid besök 1969 (tillsammans med H. Wachtmeister) ej finna denna art, däremot flera andra *Spiraea*-former, bl.a. *S.×Billiardii*, vilken kan tänkas ha misstagits för *S. tomentosa*.

Cotoneaster divaricatus Rehd. & Wils. (det. B. Hylmö 1958)

Sk Båstad: på Hallandsås åt Småryd 1943, Henning Nilsson.

Trifolium aurantiacum Boiss. & Sprun. (det. C. Blom)

Gstr Gävle: Näringen 1929, S. Ahlner (S).

Trifolium preslianum Boiss. (det. C. Blom)

Gstr Gävle: Näringen 1929, S. Ahlner (S).

Trifolium suffocatum L. (det. C. Blom)

Gstr Gävle: Näringen 1929, S. Ahlner (GB, S).

Trigonella aurantiaca Boiss. (det. C. Blom)

Gstr Gävle: Näringen 1929—30, S. Ahlner (S).

Cytisus supinus L. (*C. capitatus* Scop.)

Sk »Ö om Vombsjön i en grusgraf (förv.)» 1886, A. Roth (LD, ut *C. capitatus*).

Galeopsis pubescens Bess. (det. N.H. 1969)

Mpd Vindskärs varv vid Sundsvall, 1 ex. på barlast 1903, G. Hjort (LD, ut *G. versicolor×bifida*).

Tidigare uppgifter för arten från Sverige äro oriktiga; se Murbeck Bot. Notiser 1901.

Ziziphora capitata L. (det. C. Blom)

Gstr Gävle: Näringen 1929, S. Ahlner (GB).

Ibicella lutea (Lindl.) Van Eselt. [*Proboscidea lutea* (Lindl.) Stapf] (det. N.H. 1968).

Sk Lackalänga: Furulund 1935, G. Norrman (LD, ut *Aristolochia* sp.).

Plantago Loeflingii L. (det. C. Blom)

Gstr Gävle: Näringen 1929—30, S. Ahlner (S).

Aster alpinus L. (det. T. Hasselrot & I. Segelberg)

Bl Sölvesborg: »grusig ruderatmark omkring oljeupplag i S-s hamnområde» 1955 (1 ex.), U. Starbäck (S).

Asteriscus aquaticus (L.) Moench (det. C. Blom)

Gstr Gävle: Näringen 1929, S. Ahlner (GB).

Anthemis coelopoda Boiss. (det. C. Blom)

Gstr Gävle: Näringen 1929, S. Ahlner (S).

Achillea Gerberi M.B. (scr. H. Dahlstedt)

Klm Kalmar: barlastplats (»Kattrumpan») 1909, Elsa Berggren (S).

Evax rotundata Moris

Klm Kalmar, på barlast 1913, E. Nordström (GB).

Parthenium hysterophorus L.

Vg Skene, avstjälpningsplats, »antagelig indslæbt med Bomuld» 18.7. 1937, »fremdrevet til Blomstring i min Have 1.9. 1937», S. Andersen (S.; det. G. Samuelsson: *Pyrethrum Hysterophorus* L., tydligen en lapsus calami, rättad som ovan av E. Asplund).

Carduus personata (L.) Jacq.

Bl Karlskrona, »förvildad» 1890, J. Hamnell (GB; scr. Blom: »på ruderat advent.»; LD)

Crepis zacintha (L.) Babc. (*Zacintha verrucosa* Gaertn.)

Gstr Gävle: Näringen 1929, S. Ahlner (GB, ut *Zacintha verrucosa;* det. C. Blom).

Nils Hylander

Tre växtfynd från Skåne
(Three Plant Finds from Scania)

ABSTRACT. — *Hedera helix* L. var. *hibernica* Kirchner, *Cotoneaster dielsianus* Pritzel, and *Salvia glutinosa* L. have been found during the last decade in Scania (South Sweden). Each taxon has been recorded from one locality. All can be regarded as escaped from cultivation. At present they inhabit rather natural localities. *Salvia glutinosa* is of particular interest because it has become naturalized in a vegetation type which closely agrees with that of its original and natural localities. At present it spreads spontaneously in Mt. Kullen. Only one or a few individuals have been found of the two other taxa. None of the taxa have been reported from Sweden previously.

Tre för Sverige nya taxa presenteras härmed. De odlas stundom som prydnadsväxter och har förvildats. Fyndplatserna utgörs av ganska naturliga lokaler, ej ruderatmark. Alla är belägna i Skåne. Växterna finns fortfarande (1969) kvar på de platser, där de blev funna. Av särskilt intresse är *Salvia glutinosa* L. eftersom den sprider sig spontant och förefaller att bli väl naturaliserad i de skuggiga branter och raviner på Kullen där den observerats. Arten har som det nu synes förutsättningar att bli en ny, »bofast» medlem av vår flora.

Hedera helix L. var. **hibernica** Kirchner. — Skåne, Simris socken, 500 m S Simrislund.

Detta är en kulturform av den vanliga murgrönan. Formen odlas flerstädes i Sydsverige. Förr planterades den ofta på gravar. Den anses härstamma från Irland. Från vanlig murgröna skiljs den lätt genom de stora, mörkgröna bladen. Vid Simrislund växer den i en ung barrträdsplantering. Flera revor klättrar högt upp i träden och marken är delvis täckt av dess löv- och grenverk. Sannolikt utgörs hela »beståndet» av ett stort individ. Det finns anledning att förmoda att växten kommit till platsen med utkastat trädgårdsavfall. Den blev funnen 1964.

Cotoneaster dielsianus Pritzel (det. K.-E. Flinck et B. Hylmö). — Skåne, Gladsax socken, 200 m SÖ stenbrottet i Bäckhalladalen.

Arten sågs i ett individ första gången 1962. Senare har ytterligare två buskar anträffats på hällmarkerna i närheten. Den först påträffade busken växte invid en stengärdesgård. Den föreföll ganska gammal och var omkr. 2 m hög. Den blommar och sätter frukt varje år. De andra buskarna är små och blommar ej. Arten ses stundom i trädgårdar. Från sådana kan den ha spritts med fåglar. Arten har mindre och spetsigare blad än våra vilda arter av släktet.

Salvia glutinosa L. — Skåne, Brunnby socken, Kullen.

Flera individ av arten sågs 1961 nära huvudinfarten till det fridlysta området på Kullen. De hade spontant fröspritts till platsen från en närbelägen villaträdgård, där arten odlades. Sedan dess har arten lyckats sprida sig ytterligare på Kullen. Den iakttogs på tre skilda lokaler 1968. Från den ursprungliga platsen har den spritt sig ned i sydsluttningen och dess individantal har ökat. Den är även sedd i ravinen nära Josefinelust och i en brant SÖ om Barakull. Vid Josefinelust sågs flera exemplar. Arten förefaller helt naturaliserad på dessa lokaler till vilka den sannolikt spritts spontant. Lokalernas vegetation är lik den i artens naturliga biotop. Denna salvia växer vild i Syd- och Centraleuropas bergstrakter. Arten anträffas dessutom flerstädes förvildad och naturaliserad i Mellaneuropa, framförallt i skuggiga rasbranter och raviner, där den växer tillsammans med t.ex. *Agropyron caninum, Epilobium montanum, Festuca gigantea, Geranium robertianum, Lamium galeobdolon, Lunaria rediviva, Melica nutans, Milium effusum, Poa nemoralis* och *Stellaria nemorum*. Dessa utgör ofta artens sällskap på Kullen. Denna *Salvia*-art känns lätt igen på den stora, blekgula kronan, vilken liksom nästan hela plantan är starkt klibbhårig. På Kullen börjar den vanligen att blomma i slutet av juli.

ÖRJAN NILSSON

Botanisk litteratur
(Botanical Literature)

VAN DER PIJL, L.: Principles of Dispersal in Higher Plants. — Springer-Verlag. New York 1969. 154 pp. with 26 figures. Clothbound.

This book can be regarded as a companion volume to the "Principles of pollination ecology" (by FAEGRI and VAN DER PIJL, 1966) which treats the introductory phase in the reproduction of plants. The two books have many parallels in thoughts and construction. The emphasis is on principles and ecology. Both can be regarded as small books of reference because of their great completeness and accurate interpretations. They can also be used as guides to field work and sources of inspiration in further studies.

The author of the present book has often preferred to illustrate the different types of dispersal with examples from tropical floras. The reader often finds much enjoyment because of the interesting and uncommon examples which are presented in an attractive and personal way. VAN DER PIJL has been professor at the University of Indonesia on Java and has got a long and deep experience of the vegetation in the Tropics. He is a biologist particularly interested in the cooperation between animals and plants from an ecological point of view, which he has demonstrated in many works. He has also been engaged in the ecological aspects of flower and fruit evolution. In the present book one chapter is devoted to the evolution of dispersal organs. Another chapter deals with the relation between the flowers and the seeds and fruits with particular attention to their ecology and the interaction between fruit and flower on morphological basis. One chapter treats establishment in connection with dispersal in different environment and its synecological aspects. The examples come mainly from field studies, whereas herbarium or desk ecology is neclected.

One of the introductory chapters deals with the classification of dispersal and its terminology. On the whole the book is a rich source of terms. Sometimes the reader can be confused of the multiplicity which may complicate the reading of separate chapters.

The types of dispersal by different agents are described and exemplified. On a ecological and functional background there is a typological classification of the fruits. The concise descriptions maintain contact with current taxonomy, and there is not merely an enumeration of different mechanisms. The general question whether form or function is primary is sometimes taken under consideration but mainly the bounds with the biotic or abiotic environment are emphasized. According to the author the seeds dominate functionally in dispersal during an initial phase. Later they are replaced by fruits.

A particular chapter is devoted to the dispersal and ecological development in *Leguminosae*. This group is well suited for an inquiry into the dispersal ecology behind seeds and fruits and their development. It is here almost isolated from other processes because the flowers are mainly entomophilous and in most groups very uniform and because their ovary is simple and rather uniform.

The last chapter deals with man and plants and man's rôle in dispersal. Particular attention is given to the weeds and their colonizing and aggressiveness. Their occurrence is usually determined by establishment under agricultural conditions. The weeds often posses a certain genetic make-up suited to their special requirements, e.g., an abundant seed production often in combination with autogamy, fast dispersal and a short life.

The book is provided with a valuable bibliography.

Örjan Nilsson

Erdtman, G.: Handbook of Palynology. Morphology. Taxonomy. Ecology. An Introduction to the Study of Pollen Grains and Spores. — Munksgaard, Copenhagen 1969. 486 pp., 125 plates, and 50 illustrations in the text. Clothbound. Price 180 Danish Crowns.

For many years professor Erdtman (E.) has stand out as one of the leading personages in palynology. He has reached a deep experience and an unusually profound insight into the subject. Recently he retired from his office as director of the Palynological Laboratory in Solna (Sweden), an institution which he has founded and developed. E. and his Laboratory have gained an international distinction. The Laboratory has got, through his agency, an unique collection of spore and pollen preparations and photo-micrographs and a very extensive library. Grana Palynologica, the first palynological periodical, was started by E. in 1954. Through a great output of scientific works E. has given valuable contributions to the palynology. He has devoted a particular interest to the terminology in morphological descriptions of pollen grains and their use in taxonomy.

In the present book E. has gathered his experiences in palynology and with the aid of some collaborators produced a work which certainly for long time may serve as a book of reference and textbook in the study of pollen grains and spores. Everyone who intends to make deeper studies in palynology has much to assimilate from this book. The book can be regarded as an international and widened version of "Introduktion till palynologin" (Erdtman 1963, in Swedish). Most of the different parts of palynology are treated in the many-sided book. The main point is on basic palynological research with particular attention to morphology and taxonomy. The ecological aspects and pollen analysis are also emphasized. The strictly palaeobotanical part of palynology is somewhat more superficially treated. In the book there are also some useful chapters dealing with the technical and methodical aspects on the study of pollen grains. A long chapter is devoted to other microfossils than pollen which may occur in palynological preparations. Perhaps this chapter falls somewhat outside the scope of the book but is nevertheless valuable. The book is very richly and instructively illustrated.

The book can be divided into two main parts, a text part (pp. 21—246) and an illustrated one (pp. 247—469). The first part is devoted to three different subjects, morphology, taxonomy, and ecology. As a third part the extensive appendices may be regarded.

The morphological part of the book deals with the descriptive morphology of pollen grains. Particular attention is given to the NPC-system. This system describes the aperture condition of the pollen grains by means of a three-figured code. The system has been worked out by E., and it will probably be of much value in the days of computor treatment of palynological data. In an appendix there is a glossary of used terms which might have been connected with the morphological chapter. This chapter is followed by some illustrations (plates 1—13). These are accompanied by descriptions which intend to show how pollen descriptions can be worked out.

The taxonomical part of the book informs about the use of pollen morphological facts in the delimitation of taxa of various rank, viz., orders, families, and genera. The infraspecific variation in pollen morphology is also dealt with whereas the intraspecific divergences in different genera are omitted or only briefly treated. An interesting chapter is devoted to the pollen morphology of several angiosperm families (pp. 96—112). They are briefly described and information is given on particularly interesting families and about those in which further studies are needed.

Among the appendices one presents the Palynological Laboratory in Solna, its collections and service-organization and how different scientists can make use of them. One appendix deals with photo-micrography and another with the methodics in making preparations.

In the illustrated part of the book there are several illustrations accompanied with some questions concerning the morphology of the reproduced pollen grains. These questions have the intention to stimulate and inform the reader at the study of the figures.

Örjan Nilsson

Lunds Botaniska Förening 1969

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