Chromosome numbers of afroalpine and afromontane angiosperms

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Chromosome counts are reported for 200 afroalpine species of angiosperms from East Africa and Ethiopia. More than one collection was studied of 116 taxa, in 27 of which intraspecific polyploidy was discovered. Only diploids were recorded in 48.5%, only polyploids in 46.5%, both diploids and polyploids in 5%, which gives an overall polyploidy percentage of 49. This comparatively low figure suggests that the afroalpine flora has been relatively little exposed to major geographical changes in recent geological time. Counts are also reported for 7 afroalpine species of Cyperaceae and for 23 afromontane taxa, none of which are included in the percentage calculations. Taxonomic comments are given for a few genera.

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The afroalpine flora, occurring in isolated enclaves on the upper parts of the high East African and Ethiopian mountains (O. Hedberg 1951, 1957), provides unique opportunities to study speciation in connection with geographical isolation and adaptation to extreme environmental conditions (O. Hedberg 1964, 1969, 1970 a, 1973, 1975 a). Data on chromosome numbers and morphology have often contributed greatly to studies of evolution and speciation, and the percentage of polyploids in a flora may provide useful hints concerning its age and later development. In connection with our current studies on the origin and development of the afroalpine flora and of high mountain floras in general, it was therefore deemed desirable to procure as complete a list as possible of the chromosome numbers of afroalpine vascular plants. Detailed chromosome lists of this kind may also be of considerable interest for studies of generic affinities and angiosperm phylogeny in general (Raven 1975).

The publication has been delayed in the hope of getting the list more complete, but it now seems comprehensive enough to be worth publication. It comprises 182 of the 267 flowering plant species (the Cyperaceae excluded) known to be regular members of the East African afroalpine flora (O. Hedberg 1957), which means a coverage of 68%. We have also included 18 afroalpines from Ethiopia which are not found in East Africa. Only counts on tropical African material are considered. In addition 7 species of Cyperaceae and a few afromontane species (neither of which are considered in the calculation of polyploidy percentage) are included.

Material and methods

Most of the East African material used for this study was collected by O. Hedberg during field trips in 1948 (O. Hedberg 1951), 1967, 1970 and 1973, and by the authors together in 1971 (cf. I. Hedberg 1976). The bulk of the Ethiopian material was assembled by O. Hedberg in 1967 (O. Hedberg 1971) and 1973 (cf. O. Hedberg 1975 a). In order to cover as many species and mountain populations as possible we have tried to get wherever possible both field fixations and seed samples.

All chromosome numbers reported here were counted on somatic mitoses in root tips. Mostly root tip sections were prepared but in some cases squash preparations were used (cf. I. Hedberg 1967, 1970).

The root tips for field fixation were taken from the same specimens that were later put in press as vouchers. Field fixations normally gave only one count per population, whereas we attempted to raise, fix and count 5 specimens from each seed sample. Voucher specimens for the latter consist either of the plants fixed or other specimens raised from the same batch of seeds (when those came into flower) or otherwise of specimens collected in the field from the same population which yielded the seeds. Vouchers of all counts are kept in the Botanical Museum, Institute of Systematic Botany, University of Uppsala (UPS).

The living material was kept in a cool greenhouse in the Botanic Garden of Uppsala University, during summer time in the open under shade. Whereas O. Hedberg has been responsible for most of the collecting and naming of the material, the bulk of the chromosome counts were performed or checked by I. Hedberg, and we are jointly responsible for the discussions and conclusions.

Unfortunately some groups of plants proved very difficult to examine cytologically with the methods employed – the number of counts reported e.g., for *Carex* and *Romulea,* bears little relation to the number of fixations made, and the few and inexact counts of *Alchemilla* have been left out. Such genera evidently demand special techniques.

One important difficulty in studies of polyploidy is to ascertain the basic chromosome numbers. In genera where several counts have been made, it may be reasonable to accept half of the lowest somatic number known as the basic number, but this may need adjustment as more numbers are discovered. Where monographic studies are known to us, we have usually followed the monograph in this respect. Thus *Gladiolus watsonioides* is treated as a diploid with $x = 15$. The basic number of *Cerastium* has earlier been assumed to be 18 (cf. e.g. Blackburn & Morton 1957), but since the somatic numbers 36 and 48 were found in this study in *Cerastium afromontanum* we must assume the basic number to be 6 instead of 18. Grasses like *Deschampsia caespitosa* with the somatic number 26 are treated here as diploids with $x = 13$ even if they must presumably result from secondary polyploidy. This means that the distinction between diploid and polyploid is sometimes rather schematical: *Deschampsia caespitosa* with $2n = 26$ and *Carduus keniensis* with $2n = 34$ are classified as diploids, whereas *Deschampsia flexuosa* with $2n = 28$ and *Carduus chamaecephalus* with $2n = 32$ are treated as tetraploids. But nevertheless this seems to be the most objective manner of classification. Obviously polyploidy percentages should always be taken as approximations only.

Polyploidy percentage

The discovery by Hagerup (1931) that the flora of Timbuctu contained a considerable number of polyploids and his hypothesis that these polyploids have arisen through the influence of climatic extremes stimulated a number of cytologists to explore the frequency of polyploids in other areas. Comparison of their results revealed that at least in NW Europe the percentage of polyploids increases towards higher latitudes (Tischler 1935, Löve & Löve 1943, 1971, Reese 1958). In some instances at least the frequency of polyploidy was also found to increase with altitude on a mountain, as on Mt Bismarck, New Guinea (Borgmann 1964) and on Mt Washington in USA (from c. 45% in the surrounding nemoral flora to 64% in the alpine belt, Löve & Löve 1967). But the snowfen communities of Knutshö, Norway, have a polyploidy percentage of 51 only (Gustafsson 1948), and the nival flora of the Swiss Alps contains barely 56% polyploids (Favarger 1956). Similarly the high mountain flora of the Caucasus contains no more than 49.5% polyploids as against 86% in the Pamir (Sokolovskaja & Strelkova 1962).

To explain the higher incidence of polyploidy towards higher latitudes and (sometimes) altitudes Löve & Löve (1943) suggested that polyploidy may represent an adaptation to a cold climate. This hypothesis was contested by Manton (1950) who considered that polyploidy is not "an adaptation to cold or any other climatic factor but that it is correlated rather with climatic or geographical upheavals however caused ... In a relatively undisturbed flora the incidence of polyploidy may therefore be expected to be low". From a genetical point of view Stebbins (1950) looked upon (allo)polyploidy as "a process which is most effective as a mean of enabling species groups which have reached a certain stage of depletion of their biotypes, and of sharp divergence of specific entities, to adapt themselves to new environmental conditions which arise relatively suddenly. It is much less important in stable environments and in diploid species which are still widespread and rich in ecotypic differentiation". From the point of view of phytogeography, the importance of the polyploidy percentage was formulated by Reese (1958, 1961): "the younger the flora, the higher the percentage of polyploids" (cf. also O. Hedberg 1961).

It was realized at an early stage that the percentage of polyploids may be a crude instrument for comparison of different floras, since the tendency to form polyploids is much higher in some groups than in others; it is usually stronger in monocots than in dicots.

Table 1. Summary of chromosome numbers counted and polyploidy percentage. – Only counts on tropical African material are considered. In calculating the percentage of polyploidy we have counted those species which contain diploid and polyploid strains both under diploids and under polyploids. The total number of afroalpine vascular plant species is probably larger than indicated here, since much has happened both concerning exploration and taxonomic revisional work after the survey in O. Hedberg 1957.

Category	Gramineae	Monocots excl. Cyperaceae	Compositae	Dicots	Angiosperms
Number of species occurring in the East African afroalpine flora	34	53	62	214	267
Number of species in which the chromosome number has been counted	28	42	43	140	182
Per cent species studied	82	79	69	65	68
Number of additional afroalpine species from Ethiopia studied	5	6	7	12	18
Only the diploid number found	6	9	34	88	97
Only one polyploid number found	21	29	13	50	79
Intraspecific polyploidy (diploid + polyploid)	4	5	–	5	10
Intraspecific polyploidy (2 or more polyploid races)	4	5	3	9	14
Percentage polyploids	74	74	32	41	49

But a detailed breakdown of available figures demonstrated that within each of the main families or family groups the same relation exists between latitude and percentage of polyploids (cf. Löve & Löve 1948, Blackburn & Morton 1957, Reese 1957, 1961). A breakdown for monocots and dicots and for the largest family of each in the afroalpine flora is given in Table 1.

In order to improve the usefulness of polyploidy spectra in estimating the age of a flora Favarger (1961) subdivided the polyploids (apart from taxa demonstrating intraspecific polyploidy) in the area into three groups: *paleopolyploids,* of which diploid ancestors and close relatives are unknown and probably extinct; *neopolyploids,* which in the area studied have replaced the diploid race(s) of the same species; and *mesopolyploids,* which can probably be derived from known diploid taxa in the same genus or closely related genera. In a "spectrum of relative age" Favarger groups diploids and paleopolyploids together as an ancient element against a middle-aged element (mesopolyploids) and a recent element (neopolyploids and taxa with intraspecific polyploidy). This method was intended to provide a better measure of the age of the flora than only the percentage of polyploidy. It was later stressed by Reese (1966) than Favarger's age index was not directly comparable to the polyploidy spectrum – instead of giving the age of establishment of a flora it attempted to give the phylogenetic age of it. A tentative attempt to subdivide our polyploids according to Favarger's method proved very difficult, since in order to distinguish between paleopolyploids, neopolyploids and mesopolyploids one must know the flora under consideration and other related floras very well both cytologically and taxonomically. To enforce a distribution of the afroalpine polyploids in this way would have necessitated a number of arbitrary decisions.

Another way of refining the use of polyploidy spectra was applied by Blackburn & Morton (1957) who introduced a *polyploidy index* reflecting also the level of polyploidy of each taxon. That method may obviously be of value in comparing the degree of polyploidy in one family between different geographical areas. But when one is comparing entire floras of widely diverging taxonomic composition it would seem to be less useful.

The polyploidy percentage of 49 obtained in this study (Table 1) is comparatively low – much lower than in the Arctic, and considerably

Table 2. Species displaying intraspecific polyploidy. ++ refer to cases where two ploidy levels were found in one batch of seedlings.

Taxa	Diploid and polyploid	Two different polyploids	Inter-mountain differences	Intra-population differences	References
Poa leptoclada	+	+	.	+	O. Hedberg 1957
Festuca abyssinica	+	.	.	+	
Anthoxanthum nivale	.	+	+	+	I. Hedberg 1976
Koeleria capensis	+	.	.	+	
Deschampsia flexuosa	.	+	+	.	O. Hedberg 1957
Pentaschistis borussica	+	.	.	++	
P. minor	+	.	+	+	
P. mannii	+	.	+	.	
Bromus leptocladus	.	+	.	++	
Luzula campestris var. *gracilis*	.	+	.	++	
Kniphofia snowdenii	+	.	.	+	Janaki Ammal 1950
K. thomsonii	+	.	+	.	
Cerastium afromontanum	.	+	.	+	
Ranunculus volkensii	.	+	+	.	
R. oreophytus	.	+	+	.	
Cardamine hirsuta	+	.	.	.	
C. obliqua	.	+	+	.	Jonsell 1976
Sedum meyeri-johannis	+	.	.	+	
Crassula granvikii	.	+	+	+	O. Hedberg 1957
C. alba	+	.	+	.	
Trifolium burchellianum ssp. *johnstonii*	.	+	.	.	
Callitriche stagnalis	+	.	+	.	
Peucedanum kerstenii	+	.	.	++	
Anagallis serpens ssp. *meyeri-johannis*	+	.	.	+	Taylor 1955
Cotula abyssinica	.	+	+	.	
Senecio johnstonii ssp. *cheranganiensis*	+	.	.	.	
S. schweinfurthii	.	+	.	+	
Guizotia reptans	+	.	+	.	

lower than, e.g., in the alpine belt on Mt Washington and on Mt Wilhelm mentioned above. It is more comparable to values from the high-mountain regions of Caucasus (49.5 %, Sokolovskaja & Strelkova 1962) and to the nival zone in the Swiss Alps (56 %, Favarger 1954). According to the above considerations this indicates that the afroalpine flora like the flora of the Caucasus has been relatively little disturbed by major climatic changes in recent times.

Taxonomic comments

The comparatively large material accounted for in this study enables us to estimate the amount of intraspecific polyploidy in the afroalpine flora. Two or more euploid numbers have been found in 28 taxa (Table 2), which represent 13 % of the total number studied or 24 % of the species from which more than one collection has been counted. In some cases at least there appears to be a difference in ploidy between different mountain populations. This may be compared to 46 cases of intraspecific polyploidy known among the 437 flowering plant species of Greenland (10.5 %; see Jørgensen, Sørensen & Westergaard 1959).

An indication of the frequency of polyploidization is given by the fact that out of 54 sowings in which at least 2 plants were counted 4 gave two different euploid numbers (*Pentaschistis borussica, Bromus leptocladus, Luzula campestris* var. *gracilis* and *Peucedanum kerstenii*).

The cytological data mentioned seem to suggest that differences in ploidy within and between populations may be important in connection with differentiation and speciation, for instance in *Anthoxanthum nivale, Deschampsia flexuosa, Pentaschistis, Ranunculus, Cardamine obliqua, Crassula, Callitriche stagnalis, Cotula abyssinica,* and *Guizotia reptans*.

Occurrence of two or more different chromosome numbers within what is believed to be one taxonomic species gives reason for detailed taxonomic studies to investigate whether the cytological differences are connected with morphological differences permitting taxonomic segregation. Some of the species enumerated in Table 2 have already been thoroughly scrutinized and found to display continuous variation, e.g. *Poa leptoclada, Anthoxanthum nivale, Deschampsia flexuosa, Cardamine obliqua,* and *Anagallis serpens* ssp. *meyeri-johannis* (for references see Table 2). For a few other species taxonomic comments are given below and for those as well as a few others more detailed studies on a larger material are called for.

Pentaschistis. A spontaneous triploid in *Pentaschistis* was reported by O. Hedberg (1952 p. 264) and later identified as *P. mannii* (Hedberg 1957 p. 34). The occurrence of intraspecific polyploidy in this species as well as in *P. minor* and *P. borussica* is confirmed by the counts presented here. We have found no morphological distinctions between the cytotypes in either case. As emphasized by Clayton (1970 p. 124) the genus is insufficiently collected in East Africa for a proper appreciation of variation among the species.

Bromus. The only difference so far discovered between the cytotypes is smaller spikelets in the hexaploid specimen, but in view of the wide and continuous variation described for this species by Clayton (1970 p. 70) this difference appears of no taxonomic value.

Kniphofia thomsonii. No significant morphological differences were discovered between the diploid and tetraploid specimens, nor was the tetraploid in any respect larger than the diploid.

Crassula granvikii. Friedrich (1973 p. 51) reports the number 48 for Ethiopian material of this species and the numbers 32 and 64 for Mt Kenya material of two forms growing together, assigned by him to the closely related species *C. rivularis* (Peter) Hutch. & E. A. Bruce, which was treated by O. Hedberg (1957 p. 100) as a synonym of *C. granvikii*. This variable species would evidently merit a detailed cytotaxonomic study.

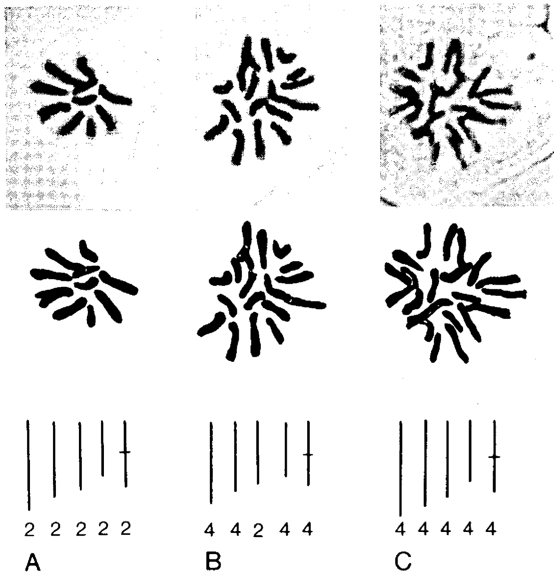

Fig. 1. Chromosome complements in three specimens of *Callitriche* from tropical Africa. – A: 2n = 10 (Hedberg 4234). – B: 2n = 18 (Hedberg 4351). – C: 2n = 20 (Hedberg 5574). – The figures give the number of each chromosome type. × c. 1500.

Crassula alba. Friedrich (1973 p. 58) gives the chromosome number of this species as 14 in material from Cameroons Mt, whereas *C. abyssinica* A. Rich. s. str. from Ethiopia (usually considered synonymous) gave 2n = 28.

Callitriche. As shown in the main list three different chromosome numbers were found within the material. Of those 2n = 10 has been reported earlier in *C. stagnalis* (Jørgensen 1923, Schotsman 1967), *C. obtusangula* (Schotsman 1967) and *C. cophocarpa* (Schotsman 1967); 2n = 20 in *C. stagnalis* (Jørgensen 1923) and in *C. platycarpa* (Schotsman 1967), whereas 2n = 18 is here reported for the first time. Hence the basic number n = 9 is added to the earlier reports from which four (five) basic numbers are known within the genus, viz. 3, 4, 5, (7?), and 19 (Schotsman 1967, who provisionally lists *C. brutia*, 2n = 28, as a diploid).

The chromosome numbers in the present material were counted in paraffin sections which makes the material less suitable for studies of chromosome morphology (cf. I. Hedberg 1970 p. 157). It is, however, possible to distinguish certain types of chromosomes and thus to some extent to compare the different complements (Fig. 1). Obviously they have very much in common. In the diploid (2n = 10) the complement consists of four pairs of subterminals, one pair of which is considerably shorter than the rest, and one pair of medians (or submedians) slightly longer than the shortest subterminals. There are no difficulties in recognizing the two pairs of shorter chromosomes in different sections and it is also possible to distinguish the larger subterminals (Fig. 1A). In the 18-chromosomic specimens as well as in the tetraploid (2n = 20) four short subterminals can easily be recognized and also four medians (or submedians). It seems also possible to group the larger subterminals (Fig. 1 B, C).

Judging from the somatic number the species from Mt Kenya must probably be an allotetraploid arisen from hybrids between species with n = 4 and n = 5, respectively. This assumption is supported by the idiograms though not too much weight should be laid on the differences in length between the larger subterminals. Unfortunately differences in applied technique and illustrations makes it impossible to compare in detail the chromosome complements illustrated by Schotsman (1967) and those illustrated here. The only species with n = 4 so far known is *C. lusitanica*, the complement of which, however, as illustrated by Schotsman, lacks medians or submedians. It is also evident that the complements found in our African material agree much more with that found by Schotsman in *C. obtusangula* (Schotsman 1967 Pl. XIX, III_2:a1) than with those in *C. stagnalis* (Pl. XVIII, III:a–c).

The existence of the somatic number 18 might also explain the origin of the numbers 2n = 28 (*C. brutia*) and 2n = 38 (*C. hamulata*), respectively, since these could then have arisen through hybridization between specimens with n = 9 and with n = 5 and n = 10, respectively, followed by doubling. A fact supporting this hypothesis is that according to Schotsman a certain type of chromosomes is found in both *C. brutia* and *C. hamulata*. This type is said to be a median, longer than the other chromosomes. On the other hand, the medians found by us in the African material are not the largest in the complement, but as pointed out above the length of the chromosomes should be used with great care in comparisons, both within a complement and between different sets.

Because of the limited material available we refrain from taxonomic conclusions, the more so since a comprehensive study of the group is being undertaken by Schotsman. The necessity of a careful cytological investigation of the whole genus in connection with such a study is obvious.

Cotula abyssinica. Our material indicates a very interesting polyploid series with the somatic numbers c. 32, c. 40, 48, and 54. The highest number was found in an ecologically very specialized variety which might prove worthy of a higher rank when more material becomes available (O. Hedberg 1971 p. 119). But between the other three cytotypes no significant morphological differences could be found.

The occurrence of two or more basic chromosome numbers within a genus is an interesting and inspiring challenge for further cytotaxonomic studies. In the afroalpine flora such cases occur in *Deschampsia, Andropogon, Stellaria, Ranunculus, Crassula,* and *Vicia,* each of which must be studied in a wider context.

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List of chromosome numbers

For ease of reference the taxa have been arranged in the same sequence as in O. Hedberg 1957, with additional taxa intercalated in relevant places. Species occurring only at lower levels on the mountains have been marked with an asterisk. + after the species epithet indicates that the chromosome number of the species in question is here reported for the first time. Apart from our own material we have included in this list relevant counts of afroalpine taxa published by other authors. For the survey of polyploidy we have included only counts from the afroalpine flora.

Under references in the list numbers without letters refer to collections by (I. &) O. Hedberg, whereas names of other collectors have been abbreviated as follows: B = S. W. Bie, C = M. J. Coe, C & K = Coe & Kirika, E = J. Eriksson, G = Gower, N = Nelson, T = M. Thulin. Literature references have been abbreviated in the usual manner. Herbarium abbreviations according to Holmgren & Keuken 1974.

Taxon	2n	Ploidy	Locality and altitude	Reference
Gramineae				
Andropogon (x = 5, 9)				
amethystinus Steud. +	20	4 x	Galama Mts, 3750 m	4227
lima Stapf +	36	4 x	Mt Elgon, 3560 m	B 66275
			Mt Elgon, 3200 m	4466
Pennisetum (x = 9)				
clandestinum Hochst. ex Chiov.	36	4 x	Kilimanjaro, 2800 m	Tateoka 1965
Pentaschistis (x = 13)				
borussica (K. Schum.) Pilg.	26	2 x	Kilimanjaro, 3800 m, 3150 m	1176, O. Hedberg 1957, Tateoka 1965
	26	2 x	Mt Meru, 3450 m	B 66124: 1, 2, 5
	39	3 x	Mt Meru, 3450 m	B 66124: 4

Taxon	2n	Ploidy	Locality and altitude	Reference
minor (Ballard & C. E. Hubbard) Ballard & C. E. Hubbard +	26	2 x	Mt Elgon, 3800 m	4487
			Mt Kenya, 4250 m	4437
	52	4 x	Mt Kenya, 4350 m	1773, O. Hedberg 1957, Tateoka 1965
mannii Stapf +	26	2 x	Galama Mts, 3750 m	4208
	c. 39	3 x	Aberdare, 3900 m	1538, O. Hedberg 1952, 1957
	52	4 x	Mt Meru, 4560 m	2329, O. Hedberg 1957
trisetoides Pilg. +	26	2 x	Simien, 3600 m	5343
pictigluma (Steud.) Pilg. +	26	2 x	Simien, 4225 m	5440
			Bale Mts, 4050 m	5604
Festuca (x = 7)				
abyssinica Hochst. ex A. Rich. +	14	2 x	Simien, 4100–4200 m	5452, 5445
	28	4 x	Galama Mts, 3750 m	4179
			Bale Mts, 4300 m	5586
			Mt Kenya, 4350 m	1862, O. Hedberg 1957
			Kilimanjaro, 3150 m	Tateoka 1965
			Mt Meru, 3000 m	B 66131
cfr. *abyssinica* Hochst. ex A. Rich.	28	4 x	Simien, 4225 m	5429
pilgeri St.-Y.	28	4 x	Mt Kenya, 4200–4270 m	1901, 1928, O. Hedberg 1957
Poa (x = 7)				
ruwensoriensis (L.) Robyns & Tournay	42	6 x	Galama Mts, 3750 m	4207
			Ruwenzori, 4150 m	402, O. Hedberg 1957
leptoclada Hochst. ex A. Rich.	28	4 x	Mt Kenya, 3100 m	2020, O. Hedberg 1957
	42	6 x	Bale Mts, 4050 m	5595
			Ruwenzori, 3850–4300 m	602, 677, O. Hedberg 1957
			Mt Elgon, 4200 m	886
			Mt Kenya, 4500 m	1757
			Kilimanjaro, 3800–4600 m	1246, 1262, B 05, Tateoka 1965
			Mt Meru, 3150–4200 m	2342, 2406
schimperana Hochst. ex A. Rich.	42	6 x	Galama Mts, 3750 m	4178, 4198
			Bale Mts, 4050–4100 m	5597, 5644
			Muhavura, 3800–4100 m	2079, 2145, 2188
			Ruwenzori, 3850–4150 m	404, 499, 601, 717
			Mt Elgon, 3600 m	983
			Mt Kenya, 3100–4130 m	1780, 1781, 1956, 1965
			Kilimanjaro, 3800 m, 3100 m	1247, Tateoka 1965
kilimanjarica (Hedb.) Markgraf-Dannenb. +	42	6 x	Kilimanjaro, 3800 m	B 02
cfr. *simensis* Hochst. ex A. Rich +	42	6 x	Galama Mts, 3750 m	4209
			Simien, 3720 m	5367
cfr. *pumilio* Hochst. +	42	6 x	Bale Mts, 4300 m	5609
Koeleria (x = 7)				
capensis (Steud.) Nees	14	2 x	Simien, 4100 m	5450
			Galama Mts, 3750 m	4171
			Bale Mts, 4300 m	5585
			Mt Kenya, 3950 m	1873, O. Hedberg 1957
			Kilimanjaro, 3150 m	Tateoka 1965
			Cherangani Hills, 3250 m	Thulin 1970
	28	4 x	Kilimanjaro, 3125 m	B 66188

Taxon	2n	Ploidy	Locality and altitude	Reference
Helictotrichon (x = 7)				
elongatum (Hochst. ex A. Rich.) C. E. Hubbard	28	4 x	Galama Mts, 3750 m	4175
			Kilimanjaro 3120 m, 2900 m	B 66169, Tateoka 1965
milanjianum (Rendle) C. E. Hubbard +	28	4 x	Aberdare, 3200 m	4355
Deschampsia (x = 7, 13)				
caespitosa (L.) Beauv.	26	2 x	Galama Mts, 3750 m	4143
			Simien, 4050 m	5454
			Ruwenzori, 3450 m	363, O. Hedberg 1957
			Mt Elgon, 4000 m	860
flexuosa (L.) Trin. v. *afromontana* C. E. Hubbard	28	4 x	Galama Mts, 3750 m	4193
			Muhavura, 4100 m	2075, O. Hedberg 1957
			Mt Kenya, 3950 m	1840
			Kilimanjaro, 4100 m, 3100 m	1361, Tateoka 1965
	42	6 x	Ruwenzori, 3450 m	389, O. Hedberg 1952
Agrostis (x = 7)				
schimperana Steud.	42	6 x	Mt Elgon, 3200 m	4557
			Kilimanjaro, 3800 m	1248, O. Hedberg 1957, Tateoka 1965
sclerophylla C. E. Hubbard	28	4 x	Mt Kenya, 4350 m	1724, O. Hedberg 1957
taylori C. E. Hubbard	28	4 x	Muhavura, 3730 m	2247, O. Hedberg 1957
kilimandscharica Mez.	28	4 x	Muhavura, 3450 m	2113, O. Hedberg 1957
			Mt Elgon, 3560 m	B 66256
			Aberdare, 3500 m	4331
			Mt Kenya, 3700 m	4436
			Kilimanjaro, 3100 m	Tateoka 1965
quinqueseta (Steud.) Hochst. +	28	4 x	Muhavura, 3730 m	2249
trachyphylla Pilg.	28	4 x	Ruwenzori, 4200 m	412, O. Hedberg 1957
			Mt Kenya, 4200–4350 m	1725, 1768
volkensii Stapf	28	4 x	Aberdare, 3570–3900 m	1543, 1664, O. Hedberg 1957
			Mt Kenya, 4150 m	1907
			Kilimanjaro, 3100 m	Tateoka 1965
			Mt Meru, 3750 m	B 66130
gracilifolia C. E. Hubbard +	28	4 x	Simien, 4100 m	5449
	c. 28	4 x	Mt Elgon, 3200 m	4461
producta Pilg.	28	4 x	Kilimanjaro, 3100 m	Tateoka 1965
Colpodium (x = 4)				
chionogeiton (Pilger) Tzvel.	8	2 x	Mt Kenya, 4250–4450 m	1902, 1759, O. Hedberg 1952, Melderis 1956
			Kilimanjaro, 4830 m, 3800 m	1253, B 35
hedbergii (Meld.) Tzvel.	8	2 x	Simien, 3600–3700 m	5361, 5492
			Bale Mts, 4100–4150 m	5645, 5618
			Mt Elgon, 3580 m	908, O. Hedberg 1952, Melderis 1956

Taxon	2n	Ploidy	Locality and altitude	Reference
Bromus (x = 7)				
leptoclados Nees +	28	4 x	Galama Mts, 3700 m	4235
			Mt Meru, 2400 m	4927: 1, 3, 4, 5
	42	6 x	Mt Meru, 2400 m	4927: 2
			Mt Kenya, 3020 m	4402
Anthoxanthum (x = 5)				
nivale K. Schum.	20	4 x	see I. Hedberg 1976	
	60	12 x	see I. Hedberg 1976	
aethiopicum I. Hedb.	20	4 x	see I. Hedberg 1976	
Cyperaceae				
Scirpus				
setaceus L.	c. 56		Aberdare, 3500 m	4332
Carex				
runssoroensis K. Schum. var. *aberdarensis* Kük.	c. 50		Mt Kenya, 3900 m	4415
conferta Hochst.	c. 52		Mt Elgon, 3560 m	B 66287
	c. 56		Kilimanjaro, 3120 m	B 66164
bequaertii Hochst. ex A. Rich.	c. 58		Mt Kenya, 3400 m	C &K 392: 1
simensis Hochst. ex A. Rich.	c. 70		Aberdare, 3500 m	4330
	70		Cameroons Mt	Morton 1961
fischeri K. Schum.	c. 56		Mt Elgon, 3200 m	4563
	c. 67		Mt Elgon, 3560 m	B 66265: 1
Eriocaulaceae				
Eriocaulon (x = 8)				
schimperi Körn. ex Engl.	c. 80	10 x	Bale Mts, 3950 m	5566
Juncaceae				
Juncus (x = 5)				
dregeanus Kunth	c. 35	c. 8 x	Aberdare, 3300 m	4328
	c. 40	8 x	Mt Elgon, 3200 m	4553
Luzula (x = 3)				
abyssinica Parl.	24	8 x	Galama Mts, 3750 m	4180
			Mt Kenya, 4200 m	1766, Nordenskiöld 1951
			Kilimanjaro, 3800 m	1216, Nordenskiöld 1951
			Mt Meru, 3750 m	B 66129
campestris (L.) DC. v. *gracilis* S. Carter +	24	8 x	Mt Elgon, 3000 m	4571: 2
	c. 30	10 x	Mt Elgon, 3000 m	4571: 4
	42	14 x	Cameroons Mt	Morton 1961
johnstonii Buchenau	42	14 x	Aberdare, 3070 m	1568, Nordenskiöld 1951
			Kilimanjaro, 3350 m	1365, Nordenskiöld 1951

Taxon	2n	Ploidy	Locality and altitude	Reference
Liliaceae				
Kniphofia (x = 6)				
snowdenii C. H. Wright +	12	2 x	Mt Elgon, 3200 m	4467
	18	3 x	Mt Elgon (offspring, cult.)	Janaki Ammal 1950
thomsonii Baker +	12	2 x	Mt Meru, 3450 m	B 66127: 1–5
	24	4 x	Mt Kenya, 3020 m	4398
Iridaceae				
Romulea (x = 9)				
fischeri Pax	74–78	polypl.	Et., Gama Mts, 3300 m	E 417, O. Hedberg 1962 a
	c. 70	polypl.	Mt Elgon, 3350 m	B 66304, Goldblatt 1971
keniensis Hedb.	28–30	polypl.	Mt Kenya, 4000 m	4821
Hesperantha (x = 13)				
petitiana (A. Rich.) Bak. v. *volkensii*	c. 75	6 x	Kilimanjaro, 3120 m	B 66174, Goldblatt 1971
Dierama (x = 10)				
pendulum (L. f.) Bak.	20	2 x	Cherangani Hills, 3240 m	Thulin 1970
			Kilimanjaro, 3000 m	4382
			Tropical Africa	Darlington & Wylie 1955
			Aberdare, 3350 m	5105: 1, 2
Gladiolus (x = 15)				
watsonioides Bak. +	30	2 x	Mt Kenya, 3900 m	4815
			Mt Meru, 3300 m, 3450 m	4761: 2, B 66102
Orchidaceae				
Disa (x = 9)				
stairsii Kränzl. +	36	4 x	Mt Kenya, 3020–3550 m	4400, 4278
Urticaceae				
Urtica (x = 12)				
massaica Mildbr. +	48	4 x	Mt Elgon, 3560 m	B 66282: 1, 2, 3
Polygonaceae				
Rumex (x = 9, 10)				
bequaertii De Wild.	40	4 x	Et., Garamba, 2900 m	E 268, O. Hedberg 1962 a
	c. 40		Cameroons Mt	Morton K 517, Morton 1961
* *ellenbeckii* Dammer	18	2 x	Et., Lake Awasa, 1750 m	E 527, O. Hedberg 1962 a
Oxygonum (x = 13)				
* *sinuatum* (Hochst. ex Steud.) Benth. & Hook. f. +	52	4 x	Kilimanjaro, 1300 m	1117

Taxon	2n	Ploidy	Locality and altitude	Reference
Portulacaceae				
Montia (x = 10)				
fontana L. ssp. *fontana*	20	2 x	Mt Kenya, 3850 m	4310
			Kilimanjaro, 3800 m	B 16
Caryophyllaceae				
Stellaria (x = 9, 13)				
sennii Chiov.	c. 52	4 x	Cherangani Hills, 3150 m	Thulin 1970
			Aberdare, 3000 m	4347
			Mt Meru, 2500 m	4943
* *mannii* Hook. f. +	36	4 x	Et., Arussi, 2400 m	Brink 27:3
Cerastium (x = 6, 13)				
afromontanum Th. Fr. jr. & H. Weim. +	36	6 x	Bale Mts	5523: 1, 2
			Mt Elgon, 3350 m	5073
			Aberdare, 3500 m	5034 A
			Mt Kenya, 3550 m	C & K 390
			Kilimanjaro, 3120–3550 m	B 66157
	48	8 x	Kilimanjaro, 3050 m	B 66241
octandrum Hochst. ex A. Rich. +	52	4 x	Simien, 3720 m	5371
			Bale Mts, 3200 m	5519: 2
			Mt Elgon, 3200 m	4458
Sagina (x = 10)				
abyssinica Hochst. ex A. Rich. ssp. *aequinoctialis* Hedb.	c. 60	6 x	Mt Elgon, 3450 m	220 a, O. Hedberg 1954
			Mt Kenya, 3400 m	C 412
			Kilimanjaro, 3500 m, 4130 m	4370, 1412
			Cameroons Mt	Morton 1961
afroalpina Hedb.	20	2 x	Mt Kenya	Mark 2
			Kilimanjaro, 4600 m	1250
Silene (x = 12)				
burchellii Otth. in DC.	24	2 x	Kilimanjaro, 3700 m	1291, O. Hedberg 1957
			Mt Meru, 3450 m	B 66125
			S. Africa	Nordenstam 1969
Uebelinia (x = 12)				
* *rotundifolia* Oliv. +	48	4 x	Kilimanjaro, 3000 m	4389
* *crassifolia* Th. Fr. jr. +	48	4 x	Cherangani, 3150 m	Thulin 1970
Ranunculaceae				
Delphinium (x = 8)				
macrocentrum Oliv.	16	2 x	Aberdare, 2550 m	Hedberg s.n., O. Hedberg 1957
Anemone (x = 8)				
thomsonii Oliv. +	16	2 x	Mt Elgon, 3500 m	4577
			Kilimanjaro, 3000–3050 m	4384, B 66231

Taxon	2n	Ploidy	Locality and altitude	Reference
Ranunculus (x = 7, 8)				
volkensii Engl.	c. 64	8 x	Mt Elgon, 3600 m	1019, O. Hedberg 1957
	80	10 x	Cherangani Hills, 2550 m	Thulin 1970
	c. 90	polypl.	Mt Kenya, 3000 m	4266
oreophytus Delile	32	4 x	Ruwenzori, 3900 m	507
			Cherangani Hills, 2850 m	Thulin 1970
			Aberdare, 3600 m	1617
			Mt Kenya, 3800–4200 m	1708, 4323
	64	8 x	Kilimanjaro, 3000	4375
* *multifidus* Forsk.	32	4 x	Cherangani, 2850 m	Thulin 1970
stagnalis Hochst. ex A. Rich.	28	4 x	Simien, 3850 m	5466
			Galama Mts, 3750 m	4145
			Mt Elgon, 3600–4000 m	994, 4520, 4482, O. Hedberg 1957
			Kilimanjaro, 4750 m	1256
Cruciferae				
Subularia (x = 7)				
monticola A. Br.	28	4 x	Mt Kenya	1727, 1804, O. Hedberg 1957
			Kilimanjaro	Jonsell 1976
Thlaspi (x = 7)				
alliaceum L.	14	2 x	Simien, 4225 m	5427, Jonsell 1976
Cardamine (x = 8)				
hirsuta L.	16	2 x	Simien, 3750 m	5395, Jonsell 1976
	32	4 x	Cameroons Mt	Morton 1961
obliqua Hochst. ex A. Rich.	36	4 x	Uluguru, 2400 m	Jonsell 1976
	56	7 x	Kilimanjaro, 2500 m	Jonsell 1976
	62		Simien, 3600 m	5348 b, Jonsell 1976
	c. 64	8 x	Bale Mts, 4000 m	5553, Jonsell 1976
	72	9 x	Mt Kenya, 3250 m	Jonsell 1976
			Mt Meru, 2900 m	4742, Jonsell 1976
**africana* L.	16	2 x	Kilimanjaro, 1500 m	4396
			Mt Meru, 2700 m	4741, Jonsell 1976
			Cameroons Mt	Morton 1961
Arabidopsis (x = 5)				
thaliana (L.) Heinh.	10	2 x	Simien, 3700 m	5433, Jonsell 1976
			Mt Kenya, 4000 m	C & K 290
Arabis (x = 8)				
alpina L.	16	2 x	Simien, 4225 m	5431, Jonsell 1976
			Chillalo, 3500 m	Jonsell 1976
			Bale Mts, 4000 m	Jonsell 1976
			Mt Kenya, 3900 m	O. Hedberg 1962 b, Jonsell 1976
			Mt Meru, 2800 m	Jonsell 1976
Oreophyton (x = 8)				
falcatum (A. Rich.) O. E. Schulz	32	4 x	Simien, 4225 m	5435, Jonsell 1976

Taxon	2n	Ploidy	Locality and altitude	Reference
Erophila (x = 8)				
verna (L.) F. Chev. s. lat.	c. 60		Bale Mts, 3950 m	5550, Jonsell 1976
Crassulaceae				
Sedum (x = 8)				
meyeri-johannis Engl.	16–18	2 x	Kilimanjaro, 3550 m	B 66221: 1, 2
	c. 44	6 x?	Kilimanjaro, 3800 m	B 10: 1, 2, 3
Crassula (x = 7, 8)				
granvikii Mildbr.	32	4 x	Bale Mts, 4150 m	5619
			Mt Kenya	Friedrich 1973
			Cherangani Hills, 2500 m	Thulin 1970
			Aberdare	4282
	c. 30		Mt Elgon, 3600 m	1022
	c. 40	5 x	Mt Elgon, 3350 m	B 66317: 2
	48	6 x	Ethiopia	Friedrich 1973
	64	8 x	Mt Kenya	Friedrich 1973
	c. 96	12 x	Mt Kenya	C 1959: 4
alba Forsk. (sub nom. *C. abyssinica* Forsk.)	14	2 x	Cameroons Mt	Friedrich 1973
(sub nom. *C. alba*)	28	4 x	Ethiopia, Dire Dawa	Friedrich 1973
Leguminosae				
Trifolium (x = 8)				
cryptopodium Steud. ex A. Rich. +	48	6 x	Bale Mts, 3950 m	5570
	c. 48		Mt Elgon, 3200 m	4456
burchellianum Ser. subsp. *johnstonii* (Oliv.) Gillett +	c. 48	6 x	Aberdare, 3200 m	4305
	96	12 x	Kenya, Kitale	Pritchard 1962, Britten 1963
acaule Steud. ex A. Rich.	16	2 x	Galama Mts, 3750 m	4126
			Trop. Africa	Frahm-Leliveld 1969
			Mt Elgon, 4000 m	4481
rueppellianum Fres.	16	2 x	Galama Mts, 3700 m	4237
			Kenya, Kitale	Pritchard 1962, Britten 1963
spananthum Thulin	16	2 x	S. Ethiopia	Thulin 1976 b
tembense Fres.	16	2 x	Mt Elgon, 3200 m	4457
			Kenya, Molo	Pritchard 1962
			Tanganyika, Mbulu	Pritchard 1962, Britten 1963
* *steudneri* Schweinf.	16	2 x	Et., Gibbi River, 1100 m	E 165(S), O. Hedberg 1962 a
elgonense Gillett +	16	2 x	Simien, 3600 m	5342
Lathyrus (x = 7)				
hygrophilus Taub. +	14	2 x	Mt Elgon, 3450 m	4503
Vicia (x = 6, 7)				
* *hirsuta* (L.) S. F. Gray	14	2 x	Mt Meru, 2450 m	4963
* *sativa* L.	12	2 x	Mt Meru, 2450 m	4964

Taxon	2n	Ploidy	Locality and altitude	Reference
Geraniaceae				
Geranium (x = 14)				
arabicum Forsk.	28	2 x	Kilimanjaro, 3120 m	B 66159: 1
			Galama Mts, 3750 m	4136
			Mt Kenya, 2500 m	4445
			Tanzania, Ngara distr.	Kokwaro 1969
* *ocellatum* Cambess. +	56	4 x	Cameroons Mt	3518 A
Oxalidaceae				
Oxalis (x = 6)				
corniculata L.	24	4 x	Kilimanjaro, 3120 m	B 66155: 1, 2
	c. 24	4 x	Mt Kenya, 2500 m	4441
Euphorbiaceae				
Euphorbia (x = 10)				
wellbyi N. E. Br. +	20	2 x	Mt Elgon, 3400 m	4550
Callitrichaceae				
Callitriche (x = 5, 9)				
stagnalis Scop.	10	2 x	Simien, 3650 m	5485
			Galama Mts, 3800 m	4234
	20	4 x	Bale Mts, 3950 m	5574
	18	2 x	Aberdare, 3000 m	4351
	18	2 x	Mt Kenya, 3020 m	4403
Malvaceae				
Malva (x = 7)				
verticillata L.	c. 76	polypl.	Simien, 3750 m	5476
Hypericaceae				
Hypericum (x = 8, 12)				
keniense Schweinf. +	24	2 x	Mt Elgon, 3200 m	4554
peplidifolium A. Rich. +	16	2 x	Galama Mts, 3750 m	4194
scioanum Chiov. +	16	2 x	Mt Elgon, 3500 m	4502
Violaceae				
Viola (x = 5, 6)				
eminii (Engl.) R. E. Fr. +	c. 72	12 x	Mt Elgon, 3200 m	4556
Onagraceae				
Epilobium (x = 18)				
stereophyllum Fres. +	c. 36	2 x	Galama Mts, 3750 m	4211

Taxon	2n	Ploidy	Locality and altitude	Reference
Umbelliferae				
Anthriscus (x = 8)				
sylvestris (L.) Hoffm.	16	2 x	Mt Kenya, 3350 m	1940, O. Hedberg 1957
Caucalis (x = 11)				
melanantha (Hochst.) Bth. & Hook. f. +	44	4 x	Et., S. Bale, 2000 m	E 386
Haplosciadium (x = 11)				
abyssinicum Hochst. +	22	2 x	Mt Kenya, 4200 m	C s.n., Hedberg 1964 Fig. 75
			Kilimanjaro, 3800 m	B 105
Pimpinella (x = 9)				
kilimandscharica Engl. +	18	2 x	Mt Elgon, 3500 m	4500
Peucedanum (x = 11)				
kerstenii Engl.	22	2 x	Muhavura, 3800 m	2141, O. Hedberg 1957
			Ruwenzori, 3400 m	4895: 1, 2, 3, 4
			Mt Elgon, 3350 m	B 66301: 1, 3, 4
			Kilimanjaro, 3120 m	1206, B 156
	22	2 x	Kilimanjaro, 3850 m	B 66195: 2, 4
	44	4 x	Kilimanjaro, 3850 m	B 66195: 1
volkensii Engl. +	22	2 x	Kilimanjaro, 3800 m	1214
			Mt Meru, 3580 m	B 66138: 1–3
Heracleum (x = 11)				
elgonense (H. Wolff) Bullock +	22	2 x	Mt Elgon, 3500 m	4495
			Mt Kenya, 3800 m	73/06: 1, 2, 4, 5
Hydrocotyle (x = 9)				
monticola Hook. f. +	18	2 x	Mt Elgon, 3900 m	4531
* *mannii* Hook. f. +	18	2 x	Mt Kenya, 2500 m	4443
			Mt Meru, 2500 m	4942
Primulaceae				
Anagallis (x = 11)				
serpens Hochst. ex DC. subsp. *meyeri-johannis* (Engl.) P. Tayl.	22	2 x	Mt Elgon, 3600–3900 m	1040, 1042, O. Hedberg 1957
			Cherangani Hills, 3300 m	Thulin 1970
			Aberdare, 2900–3680 m	1547, 1651
			Mt Kenya, 2500 m	4446
			Kilimanjaro, 3000–3120 m	1329, 4378, B 66152: 1
	c. 64	6 x	Mt Kenya, 3100 m	1968
	c. 66	6 x	Aberdare, 2900 m	1513
	66	6 x	Aberdare, 3500 m	4333
			Mt Kenya, 3020–3350 m	4409, 4273
Ardisiandra (x = 17)				
* *wettsteinii* R. Wagner +	34	2 x	Et., Irgalem, 1800 m	E 619
			Mt Kenya, 3400 m	C & K 407

Taxon	2n	Ploidy	Locality and altitude	Reference
Gentianaceae				
Swertia (x = 10, 13)				
kilimandscharica Engl.	26	2 x	Mt Elgon, 3500 m	4501
			Cherangani Hills, 2850 m	Thulin 1970
			Aberdare, 3500 m	5040 A: 1, 2
			Kilimanjaro, c. 3000 m	4390, B 66248: 1–5
			Mt Meru, 2400–3600 m	4930: 2, 4, 5, B 66136 A: 2, 4
crassiuscula Gilg	20	2 x	Mt Elgon, 3800 m	4486
			Cherangani Hills, 3150 m	Thulin 1970
			Aberdare, 3600 m	1620, O. Hedberg 1957
			Mt Kenya, 3000–4200 m	1831, 4265, 4404, 4420
subnivalis Th. Fr. jr.	26	2 x	Mt Elgon, 3600 m	1018, O. Hedberg 1957
			Mt Kenya, 4130 m	1783
uniflora Mildbr. +	26	2 x	Mt Elgon, 3900 m	4533
volkensii Gilg	c. 26	2 x	Aberdare, 3900 m	1544, O. Hedberg 1957
	26	2 x	Mt Kenya, 4100 m	1787
macrosepala Gilg	26	2 x	Mt Muhavura, 4100 m	2076, O. Hedberg 1957
cfr. *macrosepala* Gilg (vel sp. nov.)	26	2 x	Bale Mts, 4050 m	5600
Boraginaceae				
Myosotis (x = 8, 9)				
abyssinica Boiss. & Reut.	48	6 x	Kilimanjaro, 3050 m	B 66238: 2, 4
			Cameroons Mt	Morton 1961
vestergrenii Stroh	18	2 x	Galama Mts, 3750 m	4141
			Mt Elgon, 3450 m	215, O. Hedberg 1957
			Aberdare, 3500–3600 m	1611, 5036 A: 1–5
keniensis Th. Fr. jr.	18	2 x	Bale Mts, 4000–4200 m	5631 b, 5575
			Mt Kenya, 4300 m	1729, O. Hedberg 1957
Lithospermum (x = 12)				
afromontanum H. Weim. +	24	2 x	Aberdare, c. 3500 m	4286: 1–3, 5048 A: 1–2
			Kilimanjaro, 3050 m	B 66250: 1
Cynoglossum (x = 12)				
* *geometricum* Baker & Wright +	24	2 x	Cameroons Mt, 2750 m	Morton K616, offspring (UPS)
Labiatae				
Salvia (x = 7, 8)				
merjamie Forsk. +	c. 42	6 x	Aberdare, 3300 m	4579: 2, 4
nilotica Juss. ex Jacq.	32	4 x	Mt Kenya, 3100 m	4317, Yakovleva 1933
			Burundi	Lewalle 1618
	30			Delestaing 1954
Satureja (x = 5, 11)				
biflora (Hamilt. ex D. Don) Briq.	30	6 x	Kilimanjaro, 3800 m	1223, O. Hedberg 1957
punctata (Bth.) Briq.	30	6 x	Cameroons Mt	Morton 1962
kilimandschari (Gürke) Hedb. +	22	2 x	Mt Kenya, 3950 m	C & K 270
			Kilimanjaro, 3100–3800 m	B 37: 2–5, 7–9, B 66165: 2, 3, 5

Taxon	2n	Ploidy	Locality and altitude	Reference
simensis (Bth.) Briq. +	22	2 x	Galama Mts, 3750 m	4218: 1–4
pseudosimensis Brenan	22	2 x	Cameroons Mt	Morton 1962
Stachys (x = 23)				
aculeolata Hook. f. +	46	2 x	Galama Mts, 3150 m	4301
			Mt Elgon, 3200 m	4561
			Aberdare, 3150 m	5069: 1, 3
	c. 42		Aberdare, 3500 m	5037 A: 1
Thymus (x = 7)				
schimperi Ronn. +	c. 30	4 x	Galama Mts, 3750 m	4168
Scrophulariaceae				
Celsia (x = 23)				
floccosa Benth. (incl. *C. scrophulariefolia* Hochst. ex A. Rich. and *C. brevipedicellata* Engl.)	46	2 x	Garamba 2900 m	E 292: 3, 4
			E. Trop. Africa	Håkansson 1926
Limosella (x = 10)				
africana Glück	40	4 x	Galama Mts, 3750 m	4134, 4192
			Ruwenzori, 4050 m	416, O. Hedberg 1957
			Mt Elgon, 3580 m	1021
			Mt Kenya	1765
macrantha R. E. Fr.	c. 60	6 x	Kilimanjaro, 4400 m	1343, O. Hedberg 1957
Sibthorpia (x = 9)				
europaea L.	18	2 x	Mt Elgon, 3350 m	O. Hedberg 1975 b
Veronica (x = 8, 9)				
abyssinica Fres.	48	6 x	Mt Kenya, 3400 m	C & K 400
			Kilimanjaro, 3050 m	B 66249: 1, 4, 5
			Cameroons Mt	Morton 1961
gunae Schweinf.	54	6 x	Mt Kenya, 4250 m	1813, O. Hedberg 1957
			Mt Elgon, 3600 m	941
	c. 54	6 x	Galama Mts, 3750 m	4131
glandulosa Hochst. ex Bth. +	c. 52	6 x	Mt Kenya, 3000 m	4405
			Kilimanjaro, 3100 m	B 66156
arvensis L.	16	2 x	Simien, 4225 m	5428
Zaluzianskya (x = 6)				
elgonensis Hedb.	12	2 x	Mt Elgon, 3800 m	4478: 1, O. Hedberg 1970 b
Bartsia (x = 7)				
macrocalyx	c. 28	4 x	Mt Elgon, 3450 m	259, O. Hedberg 1957

Taxon	2n	Ploidy	Locality and altitude	Reference
Selaginaceae				
Hebenstretia (x = 7)				
dentata	14	2 x	Mt Elgon, 3350 m	B 66316: 1–5
			Aberdare, 3000 m	B 66412: 1–5
			Kilimanjaro, 3100 m	B 66167: 1–5
			S. Africa	Sugiura 1939
Rubiaceae				
Anthospermum (x = 11)				
usambarense K. Schum. +	22	2 x	Mt Kenya, 3550 m	C & K 377
			Mt Meru, 3450 m	B 66118: 1–3
Galium (x = 11)				
ossirvaense K. Krause +	22	2 x	Mt Elgon	4476
glaciale K. Krause +	c. 36	4 x	Galama Mts, 3700 m	4236
	c. 44	4 x	Kilimanjaro, 3800	B 115:6
ruwenzoriense (Cort.) Chiov. +	c. 38	4 x	Mt Elgon, 3350 m	B 66334: 1, 2, 4
	38–42	4 x	Mt Meru, 3600 m	B 66142
	c. 36	4 x	Mt Meru, 3250 m	4899: 3–5
Valerianaceae				
Valeriana (x = 7, 8)				
volkensii Engl. +	28	4 x	Mt Elgon, 3300 m	4564
kilimandscharica Engl.	16	2 x	Mt Elgon, 3450–4050 m	210, 961, O. Hedberg 1967
			Mt Kenya, 4200 m	4427
			Kilimanjaro, 3500 m	4368
Dipsacaceae				
Dipsacus (x = 9)				
pinnatifidus Steud. ex A. Rich. +	18	2 x	Galama Mts, 3500 m	4187
			Kilimanjaro, 3050 m	B 66255: 1–6
Scabiosa (x = 8)				
columbaria L.	16	2 x	Mt Elgon, 3200 m	4468
Campanulaceae				
Campanula (x = 7)				
* *edulis*	56	8 x	Asella, 2700 m	Thulin 1976 a
			Ngorongoro, 2200 m	Thulin 1976 a
	c. 56		Mt Meru, 2450 m	4735: 1, 2
Wahlenbergia (x = 7)				
krebsii Cham. ssp. *arguta* (Hook. f.) Thulin	14	2 x	Asella, 2300 m	Thulin 1975
			Mt Kenya, 2800 m	Thulin 1975
			Kilimanjaro, 2850 m	Thulin 1975
			Mt Meru, 2500 m	4689

Taxon	2n	Ploidy	Locality and altitude	Reference
pusilla Hochst. ex A. Rich.	14	2 x	Mt Chilalo, 2900 m	Thulin 1975
			Aberdare, 3500 m	5028 A: 1, 2
			Kilimanjaro, 3500 m	Thulin 1975
			Mt Meru, 3450 m	Thulin 1975
Canarina (x = 17)				
* *abyssinica* Engl.	34	2 x	Mt Elgon, cult	O. Hedberg 1961
* *eminii* Aschers. ex Schweinf.	34	2 x	Mt Elgon, cult	O. Hedberg 1961
Lobelia (x = 6, 7, 13)				
* *aberdarica* R. E. Fr. & Th. Fr. jr.	28	4 x	Mau Range, 2700 m	1076
			Cherangani, 2850 m	Thulin 1970
* *bambuseti* R. E. Fr. & Th. Fr. jr. +	28	4 x	Mt Kenya	C 1960 s.n.
deckenii Schweinf. +	28	4 x	Kilimanjaro, 3100–3800 m	B 66229: 1, 4; 18: 1, 2, 6, 9
burtii E. A. Bruce	28	4 x	Mt Meru, 3200 m	2404, O. Hedberg 1967
keniensis R. E. Fr. & Th. Fr. jr. +	28	4 x	Mt Kenya	C & K 363
rhynchopetalum +	c. 28	4 x	Galama Mts, 3750 m	4191
telekii Schweinf.	c. 28	4 x	Mt Elgon, 4000 m	861, O. Hedberg 1967
			Kenya	Mabberley 1974
wollastonii E. G. Bak.	c. 28	4 x	Ruwenzori, 4150 m	400, O. Hedberg 1967
lanuriensis De Wild. +	c. 28	4 x	Ruwenzori	4891: 2, 5
minutula Engl. +	12	2 x	Aberdare, 3200 m	4350
lindblomii Mildbr. +	26	2 x	Mt Elgon, 3500 m	4499
	c. 26	2 x	Aberdare, 3550 m	4275
Monopsis (x = 7)				
stellarioides Urb. var. *schimperana* (Urb.) E. Wimm.	28	4 x	Mt Elgon, 3600 m	909 (offspring), O. Hedberg 1957
Compositae				
Dicrocephala (x = 9)				
alpina R. E. Fr. +	18	2 x	Galama Mts, 3750 m	4213, 4221
			Kilimanjaro, 3000–3125 m	4385 and offspring (3 plants)
				B 66191: 3, 4
Conyza (x = 9)				
subscaposa O. Hoffm. +	18	2 x	Mt Kenya	N s.n.
ruwenzoriensis (S. Moore) R. E. Fr. +	c. 54	6 x	Mt Elgon, 3500 m	4491
	c. 54	6 x	Aberdare, 3350 m	4580: 3
variegata Sch. Bip. ex A. Rich. +	18	2 x	Galama Mts, 3750 m	4197
Helichrysum (x = 7)				
odoratissimum (L.) Less.	c. 14	2 x	Mt Meru, 3450 m	B 66115: 1
	14	2 x	S. Africa	Nordenstam 1969
cymosum (L.) Less. ssp. *fruticosum* (Forsk.) Hedb. +	14	2 x	Mt Kenya	N s.n.
citrispinum Delile v. *hoehnelii* (Schweinf.) Hedb. +	14	2 x	Kilimanjaro, 3550 m	B 66210: 1–4

Taxon	2n	Ploidy	Locality and altitude	Reference
newii Oliv. & Hiern. +	14	2 x	Kilimanjaro, 3125–3800 m	B 66185: 2; 15: 1, 2
amblyphyllum Mattf. +	14	2 x	Mt Elgon, 3200 m	4454
chionoides Philipson +	14	2 x	Mt Kenya, 3600–4200 m	4435, 4802 (offspring, 2 plants)
meyeri-johannis Engl. +	14	2 x	Kilimanjaro, 3000 m	4386
formosissimum (Sch. Bip.) Sch. Bip. ex A. Rich. +	14	2 x	Mt Elgon, 3550 m	B 66261: 1
			Aberdare, 3500 m	5050 A: 3, 4
guilelmii Engl. +	14	2 x	Mt Meru, 3450 m	B 66112: 1, 3, 5
globosum Sch. Bip. ex A. Rich. (syn. *Gnaphalium schultzii* Mendonça)	14	2 x	Galama Mts, 3750 m	4152
			Cherangani Hills, 2650 m	Thulin 1970
* *foetidum* (L.) Moench	28	4 x	Cameroons Mt, 2600 & 2750 m	Morton K 566, 636
Stoebe (x = 8)				
kilimandscharica O. Hoffm. +	16	2 x	Mt Elgon, 3200 m	4551
Anthemis (x = 9)				
tigreensis J. Gay ex A. Rich.	18	2 x	Galama Mts, 3750 m	4229
			Mt Kenya	Turner & Lewis 1965
Cotula (x = 8, 9)				
cryptocephala Sch. Bip. ex A. Rich. +	c. 80	10 x	Simien, 3750 m	5477
			Mt Elgon, 3800 m	4515
abyssinica Sch. Bip. ex A. Rich. var. *abyssinica* +	c. 32	4 x	Mt Elgon, 3350 m	B 66305: 4
	c. 40	5 x	Aberdare, 3550 m	4296
	48	6 x	Mt Kenya, 2500 m	4440
var. *sessilis* Hedb. +	54	6 x	Galama Mts, 3750 m	4204
Artemisia (x = 9)				
afra Jacq. ex Willd.	18	2 x	Mt Elgon, 3200 m	4552
			Mt Elgon	Kawatani & Ohno 1964
Cineraria (x = 10)				
grandiflora Vatke	40	4 x	Mt Kenya, 3000 m	4397
			Mt Kenya	Turner & Lewis 1965
			Kilimanjaro, 3000–3125 m	4388; B 66181: 2–4
Senecio (x = 10)				
johnstonii Oliv.				
ssp. *elgonensis* (Th. Fr. jr.) Mabberley +	100	10 x	Mt Elgon, 3900 m	4534
* ssp. *cheranganiensis* (Cotton & Blakelock) Mabberley	c. 80	8 x	Cherangani, 2700 m	Thulin 1970
	20	2 x	Cherangani, 3300 m	Mabberley 1971
keniodendron R. E. Fr. & Th. Fr. jr. +	100	10 x	Mt Kenya, 4200 m	5017
mattirolii Chiov.	20	2 x	Ruwenzori, 4000 m	730 (offspring), O. Hedberg 1967
mattirolii Chiov. × *transmarinus* S. Moore	20	2 x	Ruwenzori, 4200 m	726 (offspring), O. Hedberg 1967

Taxon	2n	Ploidy	Locality and altitude	Reference
transmarinus v. *sycephyllus* (S. Moore) Hedb.	20	2 x	Ruwenzori, 3400 m	357 (offspring), O. Hedberg 1967
sotikensis S. Moore +	40	4 x	Mt Elgon, 3200 m	4453
purtschelleri Engl. +	40	4 x	Mt Kenya, 3950 m	C & K 277
			Kilimanjaro, 3550–3800 m	B 3: 1, 2, 4; B 7: 1, 2; B 13: 5; 66209: 2, 3; G 1959: 1
telekii (Schweinf.) O. Hoffm. +	20	2 x	Kilimanjaro	G 1959: 2
			Mt Meru, 3450 m	B 66101: 2
meyeri-johannis Engl. +	20	2 x	Kilimanjaro, 3600 m	4361
jacksonii ssp. *caryophyllus* (Mattf.) Hedb. +	20	2 x	Mt Elgon, 3400 m	4541
keniophytum R. E. Fr. +	20	2 x	Mt Kenya, 3850 m	4314, N s.n.
* *trichopterygius* Muschl. & Hiern. +	40	4 x	Aberdare, 3200 m	4352
schweinfurthii O. Hoffm.	c. 180	18 x	Mt Meru, 3450 m	B 66115: 1, Afzelius 1949
	c. 160	16 x	Mt Meru, 3450 m	66108: 3
	c. 140	14 x	Kilimanjaro, 3550 m	66220: 2
chillaloensis Cufod. +	40	4 x	Galama Mts, 3750 m	4214
cyaneus O. Hoffm. +	20	2 x	Kilimanjaro, 3125	B 66184: 1, 2, 3, 5
			Kilimanjaro	4570: 1, 2
unionis Sch. Bip. ex A. Rich. +	20	2 x	Galama Mts., 3750 m	4160
aff. *unionis* Sch. Bip. ex A. Rich.	40	4 x	Simien, 3650 m	5425: 1, 2, 3, 4
schultzii Hochst. ex A. Rich.	40	4 x	Simien, 3650 m	5488
nanus Sch. Bip. +	40	4 x	Bale Mts, 4100 m	5639
Euryops (x = 10)				
brownei S. Moore	c. 20	2 x	Aberdare, 3700 m	1550, O. Hedberg 1967
dacrydioides Oliv. +	20	2 x	Kilimanjaro, 3500 m	4369
prostratus B. Nord. +	20	2 x	Bale Mts, 4200 m	5615
Haplocarpha (x = 9, 15)				
rueppellii (Sch. Bip.) Beauverd	30	2 x	Galama Mts, 3750 m	4140
			Bale Mts, 4100 m	5621
			Cherangani Hills, 2850 m	Thulin 1970
	c. 30	2 x	Mt Kenya	N s.n.
schimperi (Sch. Bip.) Beauverd +	36	4 x	Galama Mts, 3750 m	4225
Guizotia (x = 15)				
reptans Hutch.	30	2 x	Aberdare, 3500 m	4329
	c. 60	4 x	Cherangani, 2850 m	Thulin 1970
Carduus (x = 8, 17)				
chamaecephalus (Vatke) Oliv. & Hiern. +	32	4 x	Mt Kenya, 4300 m	4425
			Mt Kenya, 4200 m	N s.n.
keniensis R. E. Fr. +	34	2 x	Mt Elgon, 3300 m	4575: 1, 3, 4, 5; B 66307: 1, 3, 4
**nyassanus* (S. Moore) R. E. Fr. +	34	2 x	Kilimanjaro	B 66192: 2–5
* *afromontanus* R. E. Fr. +	32	4 x	Mt Kenya	4835: 1–3

Taxon	2n	Ploidy	Locality and altitude	Reference
Dianthoseris (x = 4)				
schimperi Sch. Bip. ex A. Rich. +	8	2 x	Simien, 4225 m	5436
			Mt Kenya, 3800–4200 m	4817, N s.n.
Crepis (x = 4)				
oliverana (Kuntze) C. Jeffrey +	8	2 x	Mt Meru, 3450 m	B 66109: 1–3
cfr. *xylorhiza* Babc. +	8	2 x	Simien, 3600 m	5360
carbonaria Sch. Bip. +	8	2 x	Aberdare, 3500 m	5052 A: 1, 2, 3, 5
suffruticosa Babc.	8	2 x	Mt Meru, 3800 m	Babcock 1947
Erigeron (x = 9)				
alpinus L. s. lat.	18	2 x	Galama Mts, 3750 m	4155
			Bale Mts, 3950 m	5554: 1, 2, 4, 5

Typification of Iris heylandiana Boiss. & Reut.

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Iris heylandiana Boiss. & Reut. is lectotypified and a new description of the taxon is given.

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Boissier (1882) described *Iris heylandiana* using as syntypes the specimens Olivier s.n., between Mosul and Baghdad (G) and Kotschy 307, between Diarbekir and Mardin (G). Dinsmore (1934) referred his specimen 21512 (BEI) to *I. heylandiana*. Mouterde (1966) considered Gombault 5769 (Herb. Leb. National Res. Counc.) to be this taxon. Recently, Chaudhary et al. (1976) cited a collection from NE Syria as *I. heylandiana* (?).

The author has had the opportunity of examining practically all the material cited by different authors as *I. heylandiana* from NE Syria and S Turkey. Boissier's syntypes are two entirely different taxa. Kotschy 307 is essentially the same as described by Foster (1890) as *I. gatesii*, a well-known taxon. Olivier's sheet does not match any other taxon known and is here selected as the type specimen of *I. heylandiana*.

Another enigmatic taxon is *I. maculata* Baker (1876). The sheet believed to be the original material (fide Brian Mathew, Kew) is in a poor state. Although the specimen (Aucher–Eloy–Berbier d'Orient 2136 (K); not 7136 as reported by Dykes 1912) looks very much like the type of *I. heylandiana*, it is difficult to say with certainty that the two are conspecific. With the exact locality unknown for this specimen and the condition of the material too poor for a definite determination it does not seem advisable to consider *I. heylandiana* to be synonymous with *I. maculata*.

Dinsmore 21512 cited by Dinsmore as *I. heylandiana* is neither this taxon nor *I. gatesii*. The material is apparently identical with that reported by Chaudhary et al. (1976) as *I. heylandiana* (?) from Darbassyeh, NE Syria. Nor is Gombault 5769 from near Ras-Al-Ain, cited by Mouterde (1966), *I. heylandiana*. The latter sheet has the name *I. gombaultii* written on it in Dinsmore's hand. Study of fresh material from the above two locations is essential to assign these specimens their taxonomic status.

A description of the lectotype of *I. heylandiana* is given here.

Iris heylandiana Boiss. & Reut.

Boiss. & Reut. 1882, in Boiss., Fl. Orient. 5: 130–131 (p. p.); non Dinsmore 1934, nec Mouterde 1966, nec Chaudhary et al. 1976. – Orig. coll.: Iraq, between Mosul and Baghdad, Olivier s.n. (G lectotype).

Plants about 40 cm tall. Rhizome not known. Leaves 7, 1.0–1.2 cm wide, up to 20 cm long, falcate to strongly arched, completely or partly enclosing the peduncle. Stem leaf one, the node visible between the basal leaves or not. Flowers up to 15 cm tall from base of the valves, c. 9 cm wide; peduncle 11–14 cm; valves tightly clasping or only slightly inflated; ovary c. 2.5 cm long with a stalk 5 mm long; perianth tube about 2.5 cm long. Falls c. 6.5 cm long, 3.5 cm wide; beard linear of rather long, mamillate–papillate (not echinate), clavate hairs. Standards erect, c. 7 cm long, 4 cm wide, laterally reflexed.

Anthers c. 2 cm long; filaments 1 cm long. Style branches c. 4.5 cm long, 2 cm wide or less, rather oblique (like in *I. auranitica* Dinsm.), wider than the combined width of the two lobes. Pollinator tunnel open ventrally. Pod not known.

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Amphicarpy and variability in Pisum fulvum

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Amphicarpy in *Pisum fulvum* Sibth. & Sm. is basically genetically determined but shows variation among populations. The potential for developing subterranean flowers may appear also in normally non-amphicarpic populations. However, inherent phenological differences among populations affect occurrence and extent of formation of subterranean fruits. The degree of amphicarpy may also be influenced by growth conditions. Amphicarpy is negatively correlated with aerial vegetative growth and fruit yield; it is of obvious adaptive value in some habitats. *P. fulvum* is predominantly autogamous. Some characters apparently lacking ecological significance are strikingly constant within populations and seem to be distributed at random among populations. These characters show no correlation with amphicarpy. Amphicarpy in *Pisum* seems to be a relatively young phenomenon. The amphicarpic form series is taxonomically regarded as a variety. Its morphology, phenology, distribution and ecology are described.

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Pisum fulvum Sibth. & Sm. is an East Mediterranean plant, occurring in Israel, Jordan, Lebanon, S and W Syria, Cyprus and S Turkey (Gruenberg-Fertig 1966). Like many other annual legumes in this region, it is a very polymorphic species, showing a wide range of variability in several morphological characters. Variability was found to occur between populations, and sometimes also within populations.

The amphicarpic form, described as var. *amphicarpum* Warb. & Eig (Warburg & Eig 1926), is of particular biological and ecological interest. From present records, this form is fairly frequent in Israel (Zohary 1972, Mattatia 1976), rare in Syria and Lebanon (Mouterde 1970), and not known from the other parts of the distribution area of the species. In the morphology and biology of the subterranean reproductive organs, amphicarpy of *P. fulvum* closely parallels the same phenomenon in two other legumes from this region, i.e., *Vicia sativa* ssp. *amphicarpa* (Plitmann 1973, Mattatia 1976) and *Lathyrus ciliolatus* (Mattatia 1977). However, it differs from the latter in two major respects: (1) Amphicarpic and non-amphicarpic forms cannot be distinguished by any definite diagnostic character, apart from amphicarpy itself. They differ only in some quantitative characters, which fall within the general range of variability of the species. (2) Amphicarpy was described to occur to a varying degree in different populations of *P. fulvum*. This feature was originally pointed out by Warburg & Eig (1926) as "different grades" of amphicarpy, and is also reflected from the data of Ben-Ze'ev & Zohary (1973), who described among the lines of *P. fulvum* "small amphicarpic type", "large, slightly amphicarpic type", "nonamphicarpic type" etc. This variability may lead to the impression that amphicarpy in this species is not constant and a facultative character. Thus Zohary (1937) maintained that amphicarpy in *P. fulvum* is not constant and depends on growth conditions, such as the depth of germination, and therefore concluded that the amphicarpic form cannot be considered as a taxonomic unit. Hylander (1946), on the other hand, cited Samuelsson's view, that there was no need for naming an amphicarpic variety, as *P. fulvum* seems to be always amphicarpic.

The aim of the present study was to examine the constancy of amphicarpy in *P. fulvum* and the variation of this character, as related to the pattern of variation of other morphological characters. The study is based on field observations throughout the distribution area of the species in Israel and on plants grown in an experimental plot in the Department of Botany, the Hebrew University, Jerusalem.

The amphicarpic form of Pisum fulvum

A general description of *P. fulvum* appears in several East Mediterranean floras (e.g. Davis 1970, Post 1932, Zohary 1972). The following is a complementary description of the amphicarpic form.

Amphicarpic plants of *P. fulvum* produce, in addition to the aerial shoots, subterranean stolons, bearing flowers and fruit. The stolons develop from the cotyledonary buds, from axillary buds at the nodes of the subterranean part of the main axis, between the cotyledons and ground level, and sometimes also from basal nodes of aerial shoots lying on the ground; they are achlorophyllous, sub-terete, simple or 1–2-branched, up to 20 cm long, bearing at their nodes small laciniate scales. Growth of the stolons is diageotropic to slightly plagiogeotropic; the growing apex is recurved, thus protected from mechanical damage while penetrating the soil. The subterranean flowers are cleistogamous, resembling floral buds, reduced in size, 6–9 mm long, but they always contain all the floral organs as the aerial flowers. The corolla is colourless, or sometimes the standard is slightly tinged with pink to orange, due to some penetration of light to the upper soil layer. The subterranean pods are usually smaller than the aerial ones, or sometimes approaching them in size, 10–20(–25) mm long, containing 1–3(–4) seeds, which are on the average slightly larger than the aerial ones. The valves are relatively thin and indehiscent, in accordance with their dispersal ecology, sometimes splitting along the sutures, but not twisting.

The somatic chromosome number in amphicarpic lines was found to be $2n=14$ (aceto-orcein root-tip squashes), which confirms previous counts in *P. fulvum* in general (Fedorov 1969, Ben-Ze'ev & Zohary 1973).

Variation in amphicarpy

Field studies and examination of available herbarium material (HUJ), have shown a wide range of variation in the occurrence and in the degree of development of subterranean reproductive organs, from well-developed stolons, flowers and fruits, to their complete absence. For simplicity, the various forms were classified into four categories: (1) Amphicarpic plants, with well-developed stolons and mature subterranean fruits at the time of maturation of the aerial fruits. (2) Plants with scanty and late development of subterranean organs. At the time of maturation of the aerial fruits, few minute floral buds or flowers could be found in the ground, borne on very thin and short stolons, or sessile in the axils of the cotyledons or scales on the main axis. Since this late development does not result in the formation of mature fruits, from the functional point of view these cases cannot be regarded as truly amphicarpic. (3) Plants with some fruits borne on short, small-leaved basal branches near ground level, sometimes partly hidden among plant debris and stones. Generally these basal pods develop from cleistogamous flowers and are sometimes intermediate between aerial and subterranean pods. This condition, termed as "sub-amphicarpic", may be regarded as transitional between basicarpy and amphicarpy. (4) Plants that according to present evidence have no subterranean stolons, flowers and fruits.

The distinction between these categories is not always clear-cut, and there are sometimes transitions between them. Thus in non-amphicarpic populations single plants were found to be "subamphicarpic" or to have single lately-formed subterranean buds. In some cases it is difficult to decide whether a partly exposed basal pod developed originally in the ground or whether it was covered after anthesis. Variation was also observed in the amphicarpic type. The number of subterranean fruits may be small (1–2), or greater (up to 10). In general, judging by the extent of development of the stolons and the number of subterranean fruits, the expression of amphicarpy is weaker than in the amphicarpic *Vicia* and *Lathyrus* (Mattatia 1976).

Distribution and ecology

The general distribution of *P. fulvum* in Israel is mainly in the Mediterranean phytogeographical territory (Zohary 1972), with some extensions to the Irano-Turanian territory in sub-Mediterranean bathas at the margins of the Samarian and Judean Deserts (Fig. 1). *P. fulvum* occurs in rather diffuse populations in open formations like batha, at the edges of fallow and cultivated fields, and sometimes at margins or clearings of garigue and maquis. Whereas there appears to be no clear pattern in the distribution of the non-amphicarpic forms, it seems from the present evidence that the amphicarpic populations are concentrated in the higher mountainous parts of the distribution area of the species: in the Judean Mts, mainly at the higher altitudes, around Bethel, Jerusalem and Hebron, in Samaria, Mt Gilboa, the Upper Galilee and Mt Hermon. In those regions the amphicarpic plants often grow in grazing areas. They thrive particularly in rocky slopes, in gravelly soils and stony habitats, such as gravel heaps and stony edges of terraces. Under such conditions, density in amphicarpic populations is locally higher than in non-amphicarpic ones. This is due to the fact that a considerable number of plants originate from subterranean fruits, which are topochorous and synaptospermous dispersal units. Owing to the amphicarpic habit, the populations persist in the same microhabitat year after year.

The breeding system

Like *P. sativum* (Hayward 1938) and the wild species of peas (Ben-Ze'ev & Zohary 1973), *P. fulvum* is predominantly autogamous. This was repeatedly confirmed by bagging of floral buds, which yielded mature pods and highly germinable seeds. The flowers are sometimes reduced in size, and then may be cleistogamous. Even in chasmogamous flowers, the anthers usually dehisce prior to anthesis. However, as indicated by the general pattern of variation, allogamy may also take place occasionally.

According to Ben-Ze'ev & Zohary (1973), vigorous and fully fertile hybrids were obtained by crossing amphicarpic and non-amphicarpic lines, though no information is provided on the inheritance of amphicarpy in the hybrids obtained.

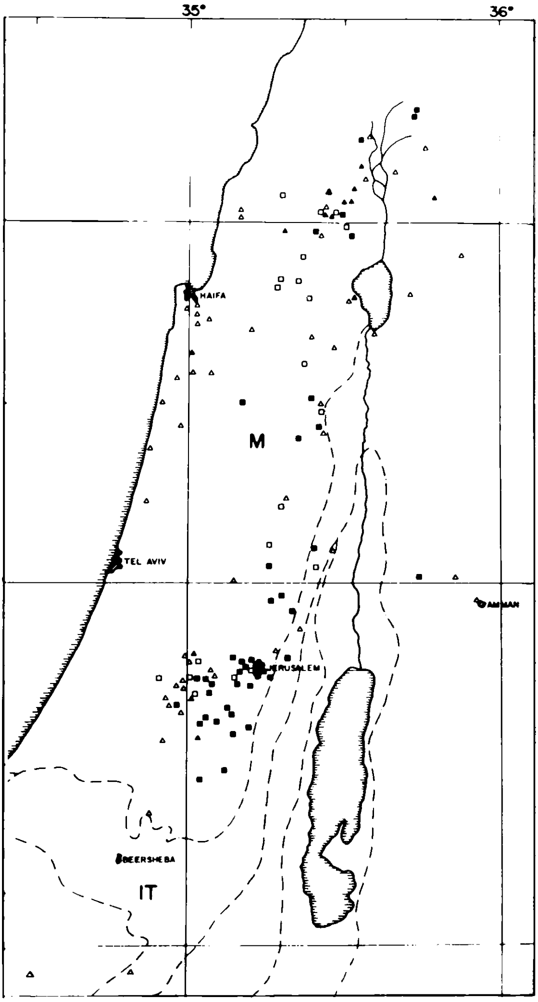

Fig. 1. Populations of *Pisum fulvum* in Israel examined with reference to amphicarpy. – Filled squares: amphicarpic. Unfilled squares: late subterranean flowering. Filled triangles: sub-amphicarpic. Unfilled triangles: Not amphicarpic by present evidence.

Constancy of amphicarpy

In order to study the constancy of amphicarpy and the relationships between it and other morphological characters, the following experiments have been carried out. Plants of ten different populations, five amphicarpic and the rest of the other types, were grown under equal conditions in Jerusalem. Scarified seeds, collected in the natural habitats, were sown at a depth of 4–5 cm in beds of terra-rossa mixed with polyuritan crumbs. In eight cases parallel experiments have been carried out on terra-rossa covered with a layer of limestone gravel. These conditions

Table 1. Differential characters of two populations of *Pisum fulvum*. 1: Jerusalem, Neve Sha'anan. 2: Mt. Carmel, Nahal Kelah.

Character	1	2
Habit	plants few-branched; branches 10–30(–50) cm	plants many-branched; branches 25–75(–100) cm
Margins of leaflets	incised; lobes round-elongate, 3–5 mm	serrate; teeth small, acute
Average length of flowers	1.2–1.3 mm	1.4–1.5 mm
Colour of seeds	orange-brown to light brown	dark brown, punctate
Amphicarpy	present	absent

imitate natural habitats of the amphicarpic form. The plants were grown outdoors under natural conditions. About half of the plants of each group were taken out at the time of ripening of the aerial fruits for examination of subterranean organs, and the rest were examined after withering.

Plants from one amphicarpic population and one non-amphicarpic population were grown for three successive generations. A comparison of some characters of the mother-populations, which proved to be constant during the course of the experiment, is given in Table 1. Some parameters concerned with amphicarpy are compared in Table 2.

The experimental plants generally conformed with the mother-populations in the occurrence and in the extent of development of subterranean reproductive organs. In some cases, plants from populations that have been regarded by field observations as non-amphicarpic or subamphicarpic, developed in the ground minute stolons with few floral buds or small flowers (Fig. 2E), which, however, did not form mature fruits due to their late development.

Observation on the ontogeny and phenology of plants from amphicarpic lines has shown that the development of stolons starts approximately at the time of secondary branching of aerial shoots, about 3–5 weeks after the emergence of the seedling (Fig. 2A). At this time, elongation of the main axis is slowed down or has ceased. The rate of vegetative growth is generally slower than in non-amphicarpic plants growing under the same conditions. Subterranean floral buds could be observed in January and February, approximately at the time of differentiation of aerial buds, or in some cases even earlier. At the onset of aerial flowering, usually during March–April, developing fertilized ovaries and young fruits were observed in the ground. Flowers which develop later in the season may wither before maturing fruits. These facts point out the significance of the phenology and time factor and their influence on differences in amphicarpy between populations.

In the two populations compared in Tables 1 and 2, flowering of the amphicarpic plants started 1–2 weeks earlier than in the non-amphicarpic ones. Their flowering season was markedly shorter, so that fruit maturation was earlier. This is in correlation with the differences in the extent of vegetative growth prior to anthesis, and is well reflected in the fruit yield.

Table 2. Comparison of parameters of two populations of *Pisum fulvum*, as in Table 1. 1 is amphicarpic and 2 is non-amphicarpic. Results for two years of cultivation under equal conditions are compared (mean values of 6 plants in 1973, 12 plants in 1974; standard errors of most means given).

Parameter	1973		1974	
	1	2	1	2
Longest branch (cm)	43.5 ± 2.5	74.5 ± 5.1	44.3 ± 3.3	105.2 ±4.7
Number of aerial pods	17.0 ± 2.2	53.7 ± 7.1	20.0 ± 3.7	90.5 ±9.4
Dry weight of aerial organs (g)	4.301	9.526		
Cumulative length of stolons (cm)	65.7 ± 5.3	5.3 ± 1.0	46.0 ± 4.1	10.2 ± 4.1
Dry weight of stolons and subterranean reproductive organs (g)	0.388 ± 0.07	0.036 ± 0.01	0.313 ±0.07	0.017 ± 0.004
Number of subterranean pods	6.8 ± 1.1	0	4.0 ± 0.8	0
Total number of fruits	23.8	53.7	24.0	90.5

Some variable characters

Plant habit and yield. Although generally described as 15–30 cm (Zohary 1972) or 60 cm high (Mouterde 1970), plants may reach the height of 1 m. The extent of branching is also very variable. As in most annuals, variability in these characters is largely phenotypic. However, despite the wide range of variation, it has been repeatedly observed, both in the field and in the experiments, that the extent of vegetative growth is negatively correlated with amphicarpy. The same applies to the average number of flowers and fruit yield (Table 2).

Leaves. Apart from variation in size and in length of petiole and tendrils, which is mostly phenotypic, there is marked variation in the shape and indentation of leaves, which cannot be related to growth conditions or to geographical distribution. Margins of leaflets may be serrate or crenate to incised, with teeth of varying shape and size, from minute to 3–5 mm long. Generally there is uniformity in this character within a population, or sometimes two leaf types may occur together in one population, e.g., in an amphicarpic population from Jerusalem plants having either serrate or incised leaflets (var. *incisum* of Post 1932) occurred in approximately equal ratios. This was constant in two successive generations of cultivation. The plants of both leaf types were equally amphicarpic (Fig. 2 B–D).

Size of aerial flowers. Size varies in the range 10–17 mm. Flowers tend to be smaller at the beginning and end of the flowering season and under limiting conditions, and in extreme cases they may be cleistogamous. Differences between populations were constant but for such phenotypic variation. At least in some cases, small average flower size was found to be correlated with amphicarpy (Table 1).

Colour of flowers. Colour varies from brownish to yellowish orange. Within a certain range of phenotypic variability, colour is constant and usually similar in a given population. Sometimes more than one colour type may occur, e.g., in the population mentioned above, a light yellowish orange corolla was coupled with incised leaflets, and a darker orange corolla with serrate leaflets. In other cases colour was not correlated with any particular character.

Pigmentation of seeds. In the literature the seeds are invariably described as velvety-black (Post 1932, Zohary 1972). However, in some of the populations examined, seeds were orange-brown or light brown, seldom dark brown and punctate (Table 1). In two amphicarpic populations, both aerial and subterranean pods had light brown seeds. This fact and the constancy studies indicate that seed colour does not depend on growth conditions. In other cases amphicarpic plants had the typical black seeds.

It may be summarized that, of the characters studied, plant height, the extent of vegetative growth and fruit yield are correlated with amphicarpy, whereas leaf shape and pigmentation of flowers and seeds are randomly distributed among populations and are not correlated with any of the other characters studied.

Discussion

Experiments and observations have shown that amphicarpy in *Pisum fulvum* is genetically constant, although not uniform in degree in different lines. However, there are certain requirements for its full expression, and like other genotypical characters it can be modified by growth conditions. Much of the variation in amphicarpy encountered in natural habitats can be attributed to edaphic conditions, which affect the immediate environment of the subterranean reproductive organs. The soil is a rather unusual medium for development of buds and flowers and for processes like anthesis and fruit maturation. Therefore, even small changes in the edaphic conditions can be expected to affect the expressivity of amphicarpy.

The potential of forming subterranean floral buds and cleistogamous flowers under suitable conditions is of a rather wide occurrence in this predominantly autogamous species, which shows a tendency to cleistogamy also in aerial flowers. This potential is related to the hypogeal germination and to the fact that the cotyledonary and other axillary buds of the main axis are subterranean. Sporadic development of one of these buds, as described above, was also observed in some non-amphicarpic species of *Vicia* and *Lathyrus* (Mattatia 1976). It can be expected to occur at random in any of the species of the Vicieae with the above-mentioned

Fig. 2. Plants of *Pisum fulvum* grown under equal conditions in Jerusalem in constancy experiments. – A: 30-day-old seedlings, at the beginning of development of the subterranean stolons. – B: Comparison of leaf indentation in two biotypes of an amphicarpic population (Jerusalem, Giv'at-Ram). – C–D: Subterranean organs (right) and fruiting aerial branches (left) of the two biotypes as in Fig. B (aerial and subterranean pods

characters. However, there are two main requirements in order that such a development will result in amphicarpy: (1) that hypogeal branches will continue to develop but will remain subterranean; and (2) that the development of the subterranean organs will keep pace with that of the corresponding aerial organs and not lag behind it.

Amphicarpy probably involves more fundamental differences than the mere potential to develop subterranean buds. It is well known that in hypogeal seedlings (e.g. of *Pisum sativum,* Hayward 1938), development of the normally dormant cotyledonary buds into branches may be induced by decapitation. Such branches, however, grow vertically or obliquely to emerge from the ground as ordinary leafy shoots. In amphicarpic plants development of subterranean buds, including the cotyledonary buds, proceeds normally, without interference with the hormonal system by decapitation. This fact and the reduced growth of the main axis and more decumbent habit of amphicarpic plants suggest that in them apical dominance is less pronounced and that amphicarpy probably involves differences in the hormonal system. The latter point is suggested also by the diageotropic growth of the stolons.

The phenological aspects are also very important. The observations indicate that differences in the degree of amphicarpy depend largely on the time of differentiation of the subterranean reproductive organs and the onset of flowering and fruit-set, in relation to the life span of the plant. The formation of a subterranean branch or a floral bud late in the season should not be considered as amphicarpy, as it does not result in the maturation of fruits.

The pattern of variation of morphological characters in *P. fulvum* is characteristic of populations of predominantly inbreeding species with occasional outcrossing, as repeatedly described in annual legumes (Stebbins 1957, Heyn 1971). Successive autogamous generations bring about the establishment of characters in local biotypes, while occasional allogamy may lead to a burst of new variability. This breeding system makes possible the sympatric differentiation of new forms (Ehrendorfer 1968), while the strong tendency to autogamy and cleistogamy serves as effective means for reproductive isolation. Characters such as the indentation of leaves or the pigmentation of seeds, cannot be correlated with any ecological factor or with any other morphological character and seem to have no evident adaptive importance. This may explain their random distribution among populations. Amphicarpy, on the other hand, definitely has ecological significance, as it implies a diversification in the modes of reproduction and dispersal ecology. This involves a change of strategy in the allocation of resources. The formation of a whole system of non-photosynthetic subterranean stolons, specialized for reproduction only, comes at the expense of the photosynthetic system. It results in a reduced rate of vegetative growth and consequently in reduction of the total biomass and fruit yield of the amphicarpic plant as compared with the non-amphicarpic one (Table 2). Such changes certainly affect the competitive ability of the plants. Under suitable conditions, the successful formation of subterranean fruits is advantageous, as it assures the perpetuation of the amphicarpic population in a particular microhabitat from year to year. This is particularly so under conditions that may present some dangers to the aerial flowers and fruits (Warburg & Eig 1926). In such cases amphicarpy can be regarded as a very safe investment in a microhabitat which has proved to be suitable for the completion of life cycle of this particular biotype in the preceding season (cf. Zohary 1937, Koller & Roth 1964). Therefore the establishment of this character can be expected to be favoured by selection, despite the reduction in plant material and fruit yield associated with it. On the other hand, the formation of subterranean organs under conditions that will not permit their complete course of development to mature fruits will not contribute to survival and therefore represents a waste of resources. In such cases it can be expected that amphicarpy will tend to be gradually eliminated by selection. This can explain the distribution of amphicarpic populations in the mountainous region in gravelly soils and stony habitats. These types of habi-

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before full maturation). – E: Comparison of plants of two populations, amphicarpic (left) and non-amphicarpic (right), as in Tables 1 and 2 (photographed in May, towards the end of the growing season).

tats can be regarded as the ecological niches of the amphicarpic plants, since the conditions prevailing in them, namely good drainage and ample aeration in the soil, enable amphicarpy and its ecological advantages to be fully expressed.

The facts that amphicarpy in *P. fulvum* is less pronounced and more variable than in the amphicarpic *Vicia* and *Lathyrus* (Mattatia 1976) may suggest that amphicarpy is a relatively young phenomenon in this species and still in the process of evolution and establishment by occasional hybridization and selection. The absence of a reproductive barrier between amphicarpic and non-amphicarpic lines (Ben-Ze'ev & Zohary 1973) strengthens this view.

The present study supports the taxonomic treatment of the amphicarpic form of *P. fulvum* as a variety (Warburg & Eig 1926). The same view is held by Ben-Ze'ev & Zohary (1973) on cytological evidence. However, the criterion for the amphicarpic variety should be the constant formation of mature fruits in the ground. Plants with late subterranean flowering should be excluded, although it is admitted that such a criterion, which incorporates phenological data, may involve practical difficulties.

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Polytretus reinboldii, a rare brown alga in culture (Ectocarpales, Sorocarpaceae fam. nov.)

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Polytretus reinboldii (Reinke) Sauvageau has shown a direct type of life history through several generations under various sets of culture conditions. The best development of erect filaments is obtained at low temperature (4–5°C), while higher temperature (15°C) strongly inhibits the formation of erect filaments and also affects their morphology. There is not an opening at each loculus along the surface of the plurilocular sporangium as previously assumed, but Reinke's sporangium must be considered a sorus of sporangia. The taxonomic position is rather close to the genera *Hummia* and *Sorocarpus*. A new family, Sorocarpaceae, is proposed to contain these three taxa, all of which have true hairs and sympodial branching.

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Reinke (1892) described this species as *Ectocarpus reinboldii,* based on material from Heligoland. Sauvageau (1900) changed the generic name to *Polytretus* with a reference to Reinke's illustrations, which show each loculus along the surface of the sporangium with an opening and also show true phaeophycean hairs. He considered the genus to form a connecting link between the Ectocarpaceae on one side, and the Sphacelariaceae, Cutleriaceae, and Tilopteridaceae on the other.

P. reinboldii seems to be a fairly rare alga with a limited distribution. Outside the type locality it has only been reported by Parke & Dixon (1968), Rosenvinge & Lund (1941), and Wærn (1958) from Great Britain, Denmark, and Sweden, respectively.

Material and methods

Polytretus reinboldii with plurilocular sporangia was collected by Tyge Christensen, growing on hand-sized stones at a depth of approximately 3 m at the island of Hirsholmen, NE of Frederikshavn, Denmark, on 8 March 1973. Unialgal cultures were established by pipetting germlings from crude cultures. The culture medium was a modification of Provasoli's ES (cf. Nielsen 1972), with an addition to the initial cultures of germanium dioxide to prevent growth of diatoms. The light source was Philips fluorescent tubes, warm white 29. The following sets of culture conditions have been used: (1) 4°C, 1100 lx, 16h light/8h dark (LD); (2) 4°C, 420 lx, LD; (3) 15°C, 2400 lx, LD; (4) 15°C, 690 lx, LD; (5) 5°C ± 2.5°C, 2500 lx, 8h light/16h dark (SD).

Results

Swarmers from the plurilocular sporangia are of normal phaeophycean type with a long anterior and a short posterior laterally inserted flagellum. Copulation has not been observed; after a period of swimming the swarmers round off and germinate unipolarly (Fig. 2A). The eyespot is visible in the initial stages of germination either in the rounded cell or in the germ-tube (Fig. 2A, arrows). By further vegetative growth a prostrate, uniseriate, branched system arises (Fig. 2B), which remains sterile under all conditions tested. Older prostrate systems are composed of roundish cells (Fig. 2C). At conditions 3 and 4 the plants mostly remain at this stage, eventually forming a hemispherical cushion. Only few erect filaments have been observed in this

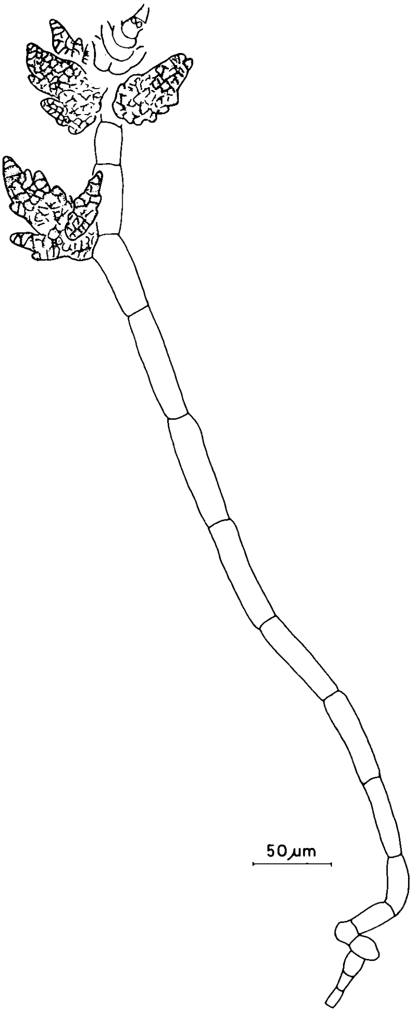

Fig. 1. Short, unbranched erect filament of *P. reinboldii* with apical, sessile sori; few such filaments develop at sets 3 and 4 conditions.

case, in a reduced form, few-celled, without vegetative laterals, developing normal sporangia at their tips (Fig. 1).

At sets 1, 2, and 5 vigorous growth of erect filaments occurs. These filaments are initially unbranched terminated by a phaeophycean hair. By sympodial branching the hair is pushed into a seemingly lateral position (Fig. 2D–F). The laterals formed may continue the vegetative growth (Fig. 2E) or may immediately form sporangia (Fig. 2F). At sets 1 and 2 the plants appear as small delicate bushes, while they have relatively fewer laterals at set 5. Their growth is diffuse intercalary.

The reproductive body of this species is called a plurilocular sporangium by Reinke (1892), his Pl. 41 Fig. 12 showing each loculus along the surface of the sporangium with an opening. A closer study has shown, however, that these are rather complex structures, better interpreted as sori. The initials may be few-celled laterals (often 3–6 cells), which are transformed in their entirety into sessile sori by numerous subdivisions (Fig. 4A), or they may be longer with transformation of the apical cells and subsequent development of laterals from some of the stalk-cells (Fig. 4B, C) giving a cluster of sori. Some of the initial divisions in the young sorus are longitudinal (Fig. 4E, arrows), and it must be assumed that several such divisions may occur in each link. At a later stage of development each link of the sorus is subdivided into well-separated clusters of cells (Fig. 4D), and at maturity each cell cluster is often prolonged into a tooth-like structure (Fig. 4G) representing the top of one sporangium with an apical opening through which the swarmers are released (Fig. 4H). Consequently, Reinke's plurilocular sporangium must be interpreted as a chain with each link being a whorl of sporangia. It is obvious that the longitudinal divisions in the sorus initial are often most frequent in the lower cells, which gives the sorus a conical outline as seen in Fig. 4G. Intercalary sori have been observed under set 5 conditions. As seen in Fig. 4F the apical and some lateral cells of the young sorus fail to form sporangia, and are instead prolonged into short, branched vegetative filaments. Further, the sori developed at SD are often longer and more slender with only initial development of whorled sporangia (Fig. 5). Unilocular sporangia-like and ascocyst-like cells as illustrated by Rosenvinge & Lund (1941) have never been observed in culture.

Discussion

The culture conditions tried in this study show that higher temperature (15°C) exerts a strong inhibitory effect on formation of erect filaments. This is in perfect agreement with the occurrence of *Polytretus* in nature, where it has been

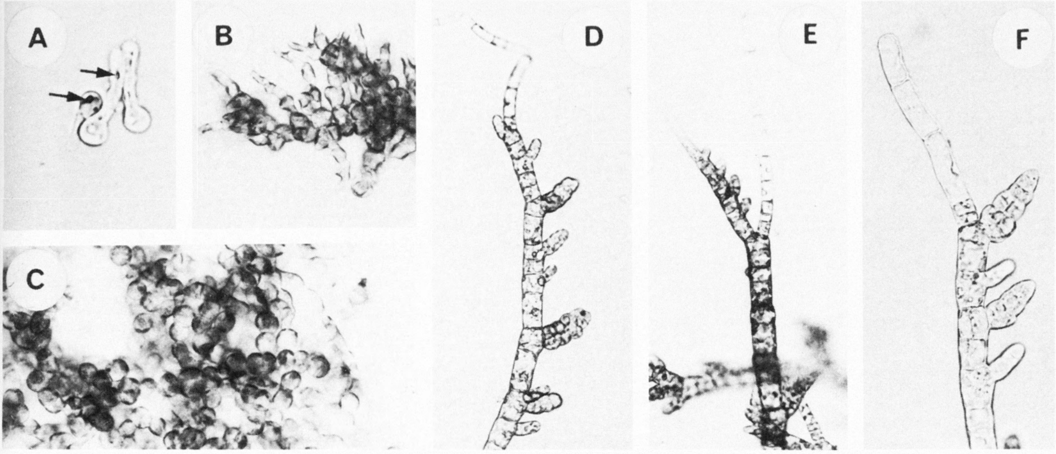

Fig. 2. Germination and sympodial branching of *P. reinboldii* in culture. – A: Germinating swarmers with still visible eye-spots (arrows). × 600. – B: Part of young, prostrate system. × 150. – C: Part of older prostrate system of roundish cells. × 150. – D: Initial stage of sympodial branching; the hair is in a subapical position. × 150. – E: Later stage of sympodial branching, the terminal hair is now in a seemingly lateral position. × 150. – F: Sympodial branching followed by immediate transformation of the lateral to a sorus. × 250.

found from March to June (I have no dates for the finds in Great Britain).

Rosenvinge & Lund (1941) mention that several of the sporangia found in Danish material from nature are actually chains of sporangia thus rather similar to those obtained under set 5 conditions, but they maintain that each loculus along the surface has an opening. I have found in all cases that several loculi have an opening in common, thus forming a sporangium together. The sori formed in culture may be very complex. Material from nature obviously often shows fewer loculi and no tooth-like prolongations deeming from illustrations in literature.

Basing on the sporangia Sauvageau (1900) suggested a connection from the Ectocarpaceae to the Sphacelariaceae, Cutleriaceae, and Tilopteridaceae through *P. reinboldii*. This connection seems not quite evident, as these taxa are widely separated from *Polytretus* by apical and trichothallic growth, respectively, and by the fact that the individual sporangium

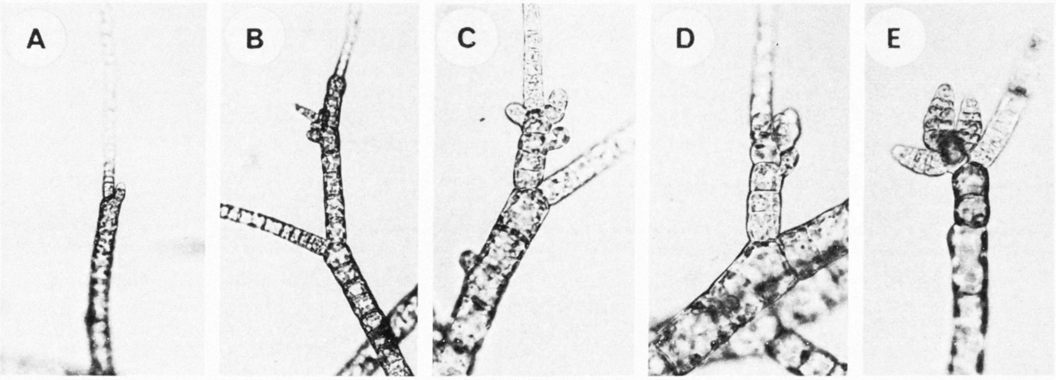

Fig. 3. Sympodial branching and sporangia development of *Sorocarpus micromorus* in culture. – A, B: Initial and later stages of sympodial branching (cf. Fig. 2D–F). × 150. – C–E: Development of sporangia from short laterals, often several from the same supporting cell (cf. Fig. 4B). × 250.

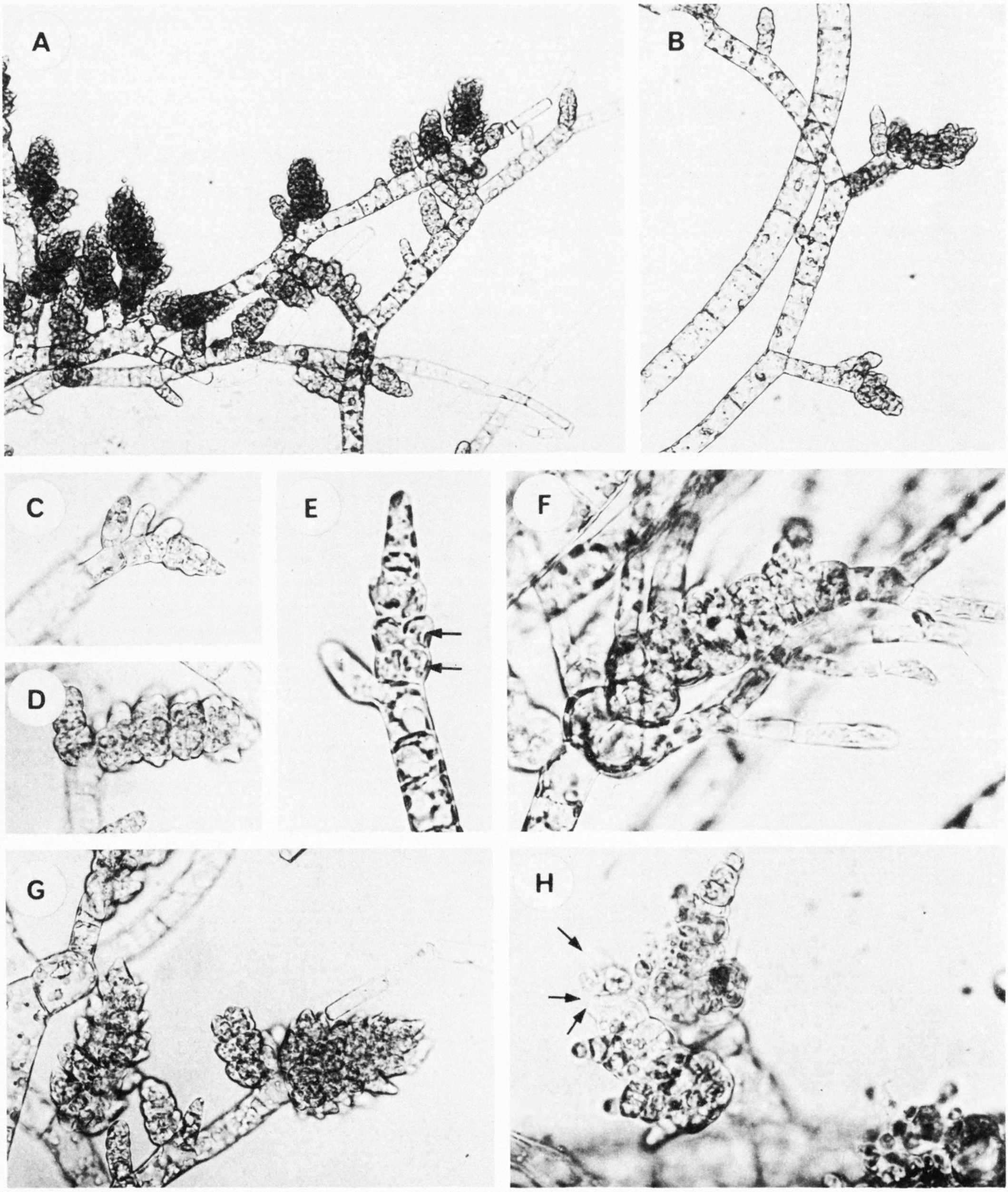

Fig. 4. Sporangia formation of *Polytretus reinboldii* in culture. – A: Mostly sessile sori on erect filaments. × 150. – B: Stalked sori and further development of sori from laterals of higher order. × 150. – C: Detail of stalked sorus with development of sporangia initials from the stalk-cells. × 250. – D: Each link subdivided into well-separated clusters of cells. × 250. – E: Longitudinal divisions (arrows) in the basal cells of an initial sorus. × 600. – F: Intercalary sorus formed under set 5 conditions. × 500. – G: Mature sori of conical outline with the individual sporangia prolonged into tooth-like structures. × 250. – H: Partly empty sori. Three openings of sporangia are indicated by arrows. × 500.

of *Polytretus* agrees with those of other members of Ectocarpales in principle.

In modern systematic treatments such as that by Christensen (1966) *Polytretus* is still included in the Ectocarpaceae together with genera without true hairs. There seems, however, to be particularly close relations with the genera *Sorocarpus* and *Hummia.*

The generic name *Hummia* needs a few comments. It was proposed by Fiore (1975) to replace *Farlowiella* Kornmann (Kuckuck 1956), which is said to be a homonym of *Farlowiella* Saccardo (1883). However, the name published by Saccardo (1883) is *Farlowia,* which was later changed to *Farlowiella* Saccardo (1891 p. 1100). In the same paper Fiore says that *Hummia onusta* (Kütz.) Fiore is the gametophytic generation of *Stictyosiphon subsimplex* Holden, which makes *Hummia* superfluous. Either this is bad nomenclature or Fiore should have mentioned the possible connection with *Stictyosiphon* with more reservation.

Polytretus, Sorocarpus and *Hummia* all have true phaeophycean hairs and all show sympodial branching. Further, the development of their sporangia is in principle the same. I have previously reported on the life history of *Sorocarpus micromorus* (Bory) Silva in culture (Pedersen 1974), though without giving detailed illustrations of sympodial branching and sporangia development. Fig. 3 shows sympodial branching (Fig. 3A, B) and young sporangia (Fig. 3C–E) of *S. micromorus*. There is a striking similarity to *P. reinboldii* (Fig. 2 D–F).

The sporangia formation of *Hummia* is also restricted to certain parts of laterals. As to possible unilocular sporangia there are only doubtful reports by Rosenvinge & Lund (1941) and Takamatsu (1936) for *Polytretus* and *Sorocarpus,* respectively. *Hummia, Polytretus,* and *Sorocarpus* are of course closely related to other hair-bearing genera that do not exhibit sympodial branching, such as *Protectocarpus* and apparently also *Kuckuckia*. However, in my opinion the sympodial branching is a specialized character. Also the sporangia formation, restricted to laterals, is more specialized compared e.g. with *Protectocarpus,* in which most of the cells of the erect filaments are potential sporangia. Consequently, I find it necessary to separate the genera *Polytretus, Sorocarpus,* and *Hummia* from the Ectocarpaceae and refer them to a separate new family, Sorocarpaceae, defined by the presence of true hairs and sympodial branching.

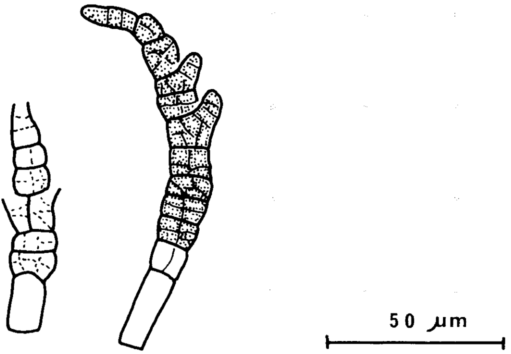

Fig. 5. One empty and one mature sorus composed of sporangia in chains with incipient development of sporangia in whorls (cf. empty sorus). Set 5 conditions.

Sorocarpaceae fam. nov.

Fila erecta a filis repentibus orta primum simplicia, quidque pilo vero terminatum, inde sub pilis ramigera sympodia ita formantia. Sori sporangiorum plurilocularium e ramulis orti, aut omnibus ramulorum cellulis subdivisis aut nonnullis in statu vegetativo manentibus, quoque sporangio ostio unico terminali aperto. Sporangia unilocularia vix formata. Genus typificum: *Sorocarpus* N. Pringsheim, 1863, p. 12, pl. 3A, Fig. 1–8.

Erect filaments initially unbranched with a terminal true hair, showing sympodial branching. Sori of plurilocular sporangia are formed by complete transformation of laterals or certain parts of laterals, each sporangium with a terminal opening. Unilocular sporangia hardly formed.

Acknowledgements. I am grateful to Tyge Christensen for the material of *P. reinboldii,* critical reading of the manuscript, and the Latin diagnosis.

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Two conspicuous desmids from Amazonas

Kuno Thomasson

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Two new species of desmids from the Amazonas area, namely *Micrasterias foersteri* and *Cosmarium kostei,* are described, and their phycocoenosis is analyzed.

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Some time ago the rotatorian specialist Walter Koste sent me photomicrographs of two curious desmids, both of which were unknown to me. There is quite a number of papers on Brasilian desmids but in some way these two have hitherto escaped observation. Both were frequent in a sample, which Dr Koste kindly placed at my disposal. The sample is labelled as follows:

GOB-13-75. Region Nhamundá, Probe Nr. 3, Terra Santa. Überschwemmte Wiese, sehr flach, 0,5–1,5 m, sehr viel Wasserpflanzen. 4. 7. 75. pH 5,4, µS 12, Sichttiefe 1,40 m. Netzprobe, die Maschenweite 100 µm. Leg. Gerd O. Brandorff, Max-Planck-Institut für Limnologie, Abt. Tropenökologie, Plön. Das Material wurde mit Hilfe des Instituto Nacional de Pesquisas da Amazônia (INPA), Manaus gesammelt.

Cosmarium kostei Thom. sp. nov. – Fig. 1 C–E, 4

Cosmarium maximum; medium profunde constrictum incisura acutangula mox valde ampliata, apex complanatus, laevis, anguli apicales protracti, 1–3-cuspidati. Membrana crassa, porosa. Cellula 180–210 µm long., 140–163 µm lat. Iconotypus fig. nostra 1 E. Habit.: Brasilia, Amazonas.

The plant is biradiate; the semicells are in front view cup-shaped with mamillate corners. The apex is straight or slightly convex, the sinus is acute, and the thick cell wall is porous. It looks like a huge *Staurodesmus subpygmaeus* v. *spiniferus* (Scott & Grönbl.) Teil. Actually my first impression was that it might belong to the genus *Staurodesmus* because in the first studied specimens the corners terminated in a small spine. However, it soon turned out that there were mostly two spines, rarely three. The mamillate corners with spines might be interpreted as short processes, and if so, it would be natural to refer this plant to the genus *Staurastrum*. Furthermore, its relationship to *Cosmarium* might be considered; in e. g. *C. securiforme* v. *brasiliense* Grönbl. the radii of semicells are also drawn out into a kind of process. Of course, the shape is entirely different. The systematic position of this conspicuous plant thus remains somewhat uncertain. Most likely it is a *Cosmarium*.

Micrasterias foersteri Thom. sp. nov. – Fig. 1 A–B, 2, 3 A–E

Species magna, paululo latior quam longior; sinus apertus profundus; semicellulae 5-lobatae, omnis lobus lateralis incisione aperta invicem divisus. Semicellulae in medio processibus mammillatis ornatae. Cellula 200 µm long., 210–230 µm lat. Iconotypus fig. nostra 1 B. Habit.: Brasilia, Amazonas.

Contrary to the previous plant this one has a very complicated shape. On the whole it looks like an ordinary *Micrasterias*. The lateral lobes of order III are divided into a pair of lobes of order IV, one of which points, as a rule, outwards from the cell surface. There are two long mamillate processes on both sides of the isthmus; these are also directed outwards from

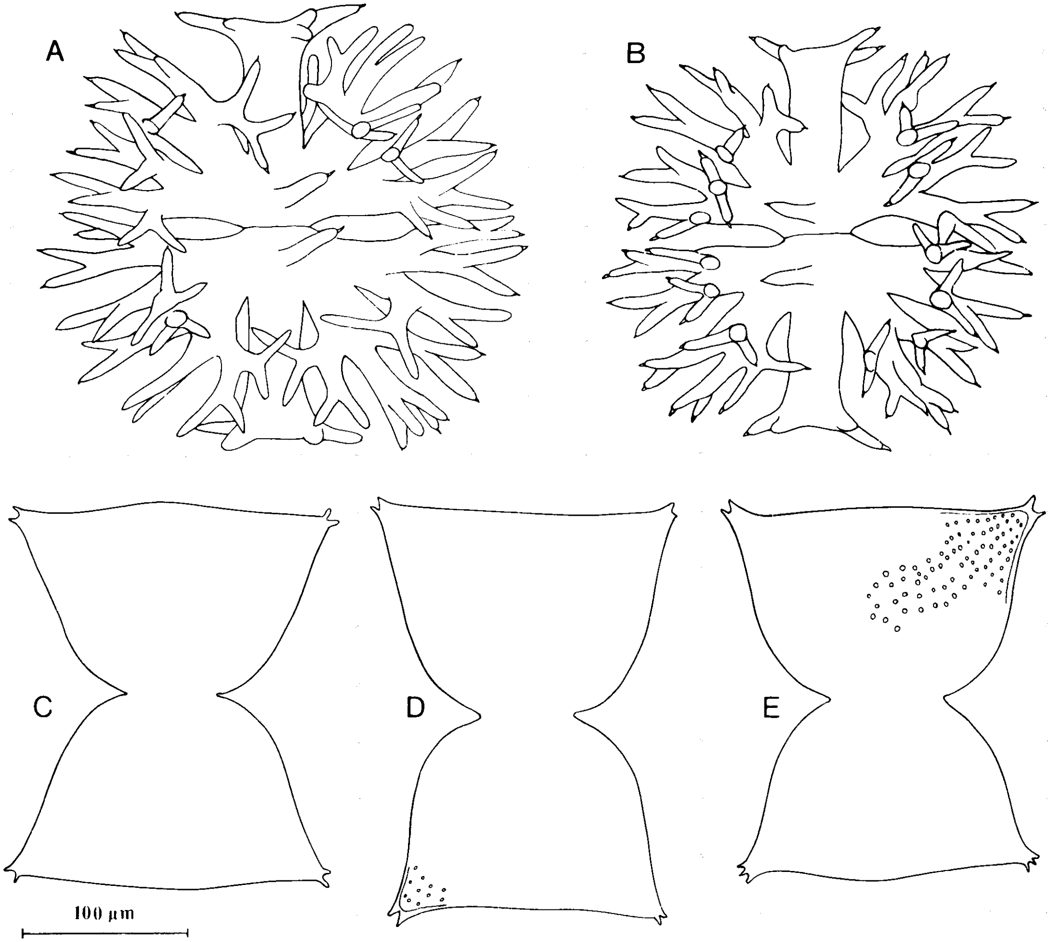


Fig. 1. A–B: *Micrasterias foersteri.* – B: Iconotype. – C–E: *Cosmarium kostei.* – E: Iconotype.

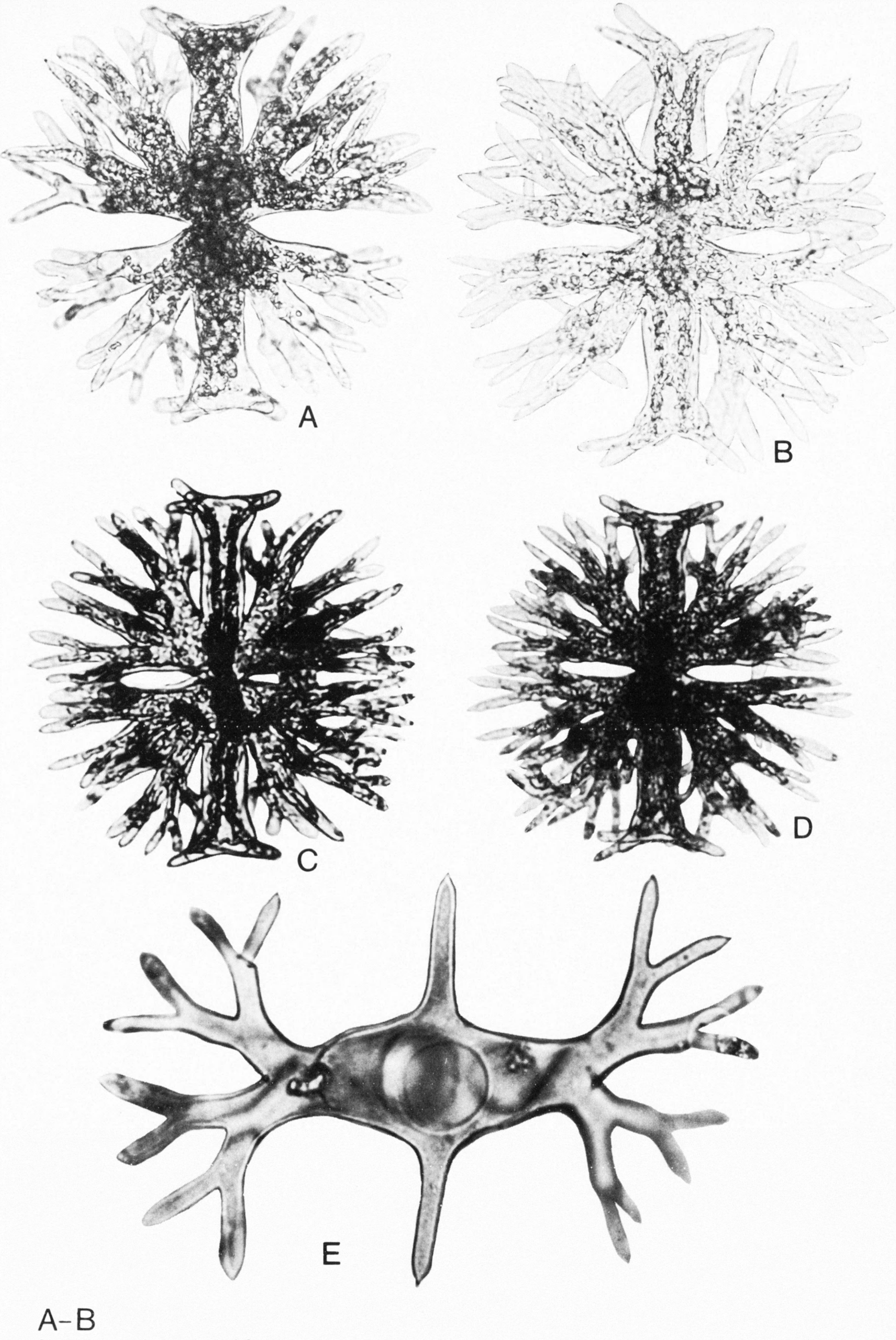
the cell surface. The mamillate drawn-out corners of polar lobes are double. The taxonomic problem with this curious plant is whether it is a *Micrasterias* or belongs to the genus *Allorgeia.* I consider it belongs most probably to the genus *Micrasterias*.

The sample, which was really a mini-sample of only about 3–5 mm^3, at first glance seemed to contain a few dozen taxa only. However, after some weeks of study, the occurrence of a considerable number of taxa was established. They are listed below in order to give some idea of the phycocoenosis in this kind of habitat. There are at least 50 more taxa, mainly diatoms, which I have not been able to identify.

Cyanophyta

Chroococcus dispersus (Keissl.) Lemm.
Cylindrospermum sp.
Gomphosphaeria lacustris Chod.

Fig. 2. A–E: *Micrasterias foersteri.* – A–D: Front view. – E: Basal view of semicell showing lateral lobes, and the mamillate projections on each side. – A–B × 300.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A–B
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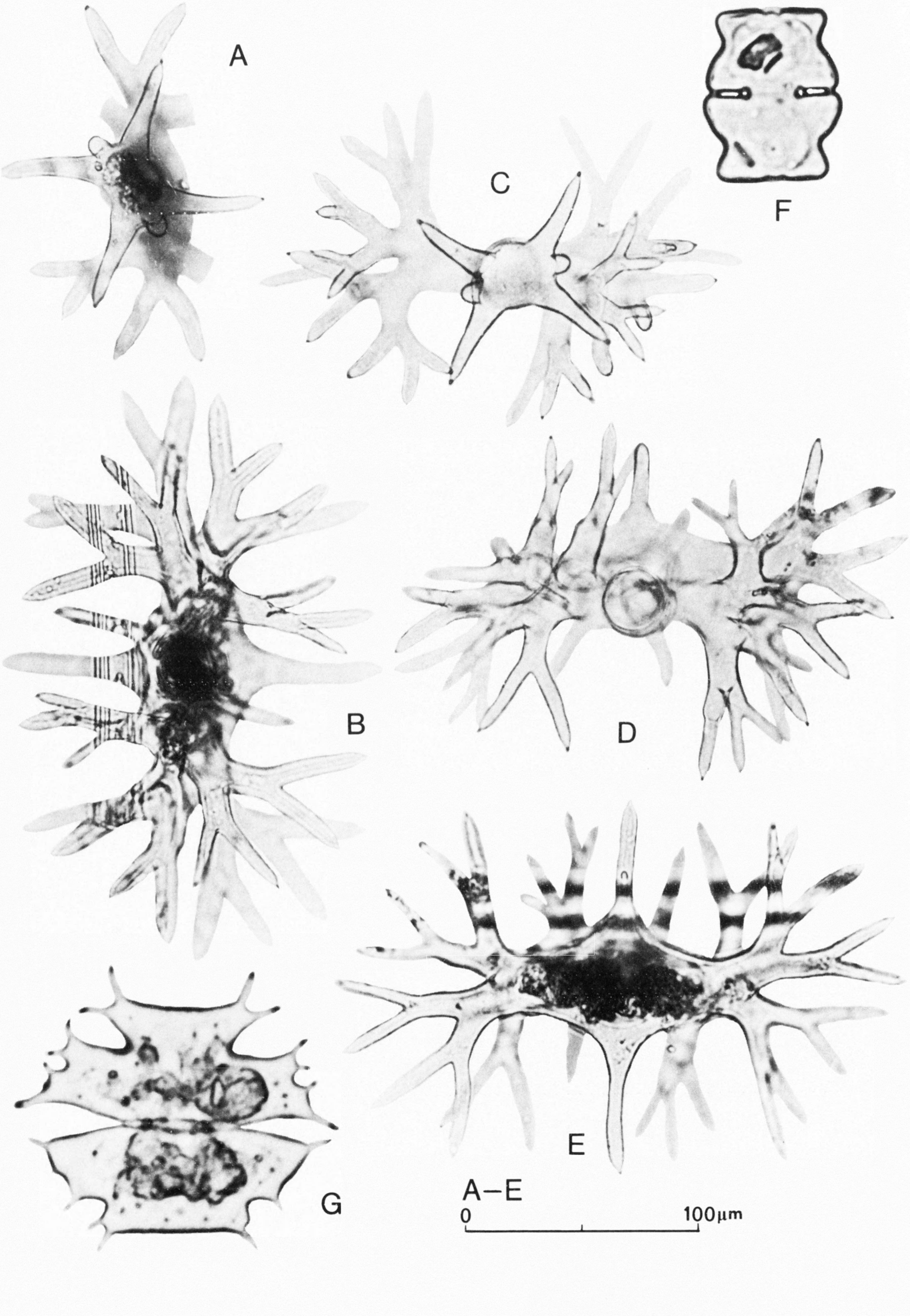
100 µm


A
C
F
B
D
E
G
A–E
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Merismopedia glauca (Ehr.) Näg.
Oscillatoria limnetica Lemm.

Pyrrhophyta

Peridinium gatunense v. *madagascariense* (Lef.) Lef.
Peridinium sp.

Chromophyta

Chrysophyceae

Dinobryon bavaricum Imh.
D. cylindricum Imh.
D. sertularia Ehr.
Epipyxis alpina Hill. & Asm.
E. proteus (Wisl.) Hill. & Asm.
Mallomonas splendens (G. S. West) Playf.
Mallomonas sp.
Synura uvella Ehr.

Bacillariophyceae

Actinella guianensis Grun.
A. mirabilis Grun.
Melosira granulata (Ehr.) Ralfs
Rhizosolenia eriensis H. L. Smith
R. longiseta Zach.
Surirella sp.
Synedra acus Kütz.

Euglenophyta

Euglena sp.
Phacus curvicauda Swir.
Phacus sp.
Trachelomonas spinosa Stok.
T. volvocina Ehr.

Chlorophyta

Volvocales

Eudorina elegans Ehr.

Chlorococcales

Ankistrodesmus falcatus (Corda) Ralfs
Botryococcus braunii Kütz.
Coelastrum cambricum Arch.
Crucigeniella apiculata (Lemm.) Kom.
Dictyosphaerium pulchellum Wood
Dimorphococcus lunatus A. Br.
Oocystis sp.
Pediastrum boryanum (Turp.) Menegh.
P. tetras (Ehr.) Ralfs
Scenedesmus brasiliensis Bohl.
S. denticulatus v. *gracilis* Playf.
S. ecornis (Ralfs) Chod.
S. ecornis v. *disciformis* Chod.
S. quadricauda (Turp.) Bréb.
Selenastrum bibraianum Reinsch
Tetraedron caudatum (Corda) Hansg.
Treubaria setigera (Arch.) G. M. Smith

Chaetophorales

Chaetosphaeridium pringsheimii Kleb.

Zygnematales

Closterium closteroides (Ralfs) Luis & Reet.
C. closteroides v. *intermedium* (Roy & Biss.) Ruz.
C. costatum Corda
C. costatum v. *subtumidum* Racib.
C. gracile Bréb.
C. macilentum Bréb.
C. porrectum v. *borgei* (Borge) Först.
C. setaceum Ehr.
C. turgidum Ehr.
C. venus Kütz.
Pleurotaenium coronatum (Bréb.) Racib.
P. coronatum v. *fluctuatum* W. West
P. elatum (Turn.) Borge
P. elatum v. *alternans* (Nordst.) Grönbl.
P. minutum v. *latum* Kais.
P. subcoronulatum (Turn.) W. & W.
P. truncatum (Bréb.) Näg. – Long. 480 μm, lat. 75 μm.
P. truncatum v. *attenuatum* Krieg. – Long. 480 μm.
P. verrucosum (Bail.) Lund.
Docidium baculum Bréb.
D. hexagonum (Børg.) Krieg.
D. undulatum Bail.
Triploceras gracile Bail.
T. gracile v. *bidentatum* Nordst.
Ichtyocercus longispinus v. *amazonensis* Först.
Tetmemorus granulatus Bréb.
Euastrum abruptum Nordst.
E. bahiense f. *minor* Thom. n. f. – Euastrum forma ornatuque speciei simile, sed multo minus. Long. 25 μm.
E. biocellatum Scott & Croasd.
E. ciastonii Racib. – Cf. *E. flammeum* v. *subkalimantanum* Först.
E. ciastonii v. *apertisinuatum* Scott & Presc.
E. confusum Först.
E. cuspidatum Wolle
E. didelta v. *quadriceps* (Nordst.) Krieg. – Fig. 6 J; long. 100 μm. This plant resembles in shape *E. brasiliense* v. *convergens* Krieg. However, there are three large protuberances just above the isthmus. The semicells are stouter than in typical *E. didelta* v. *quadriceps*.
E. engleri Schmidle

Fig. 3. A–E: *Micrasterias foersteri*. – A: Vertical view, apical lobe. – B: Vertical view, upper lateral lobes. – C: Vertical view, apical lobe. – D: Vertical view, upper lateral lobes. – E: Vertical view, lower lateral lobes. – F: *Euastrum gessneri* v. *laticeps* forma. – G: *Micrasterias* sp.

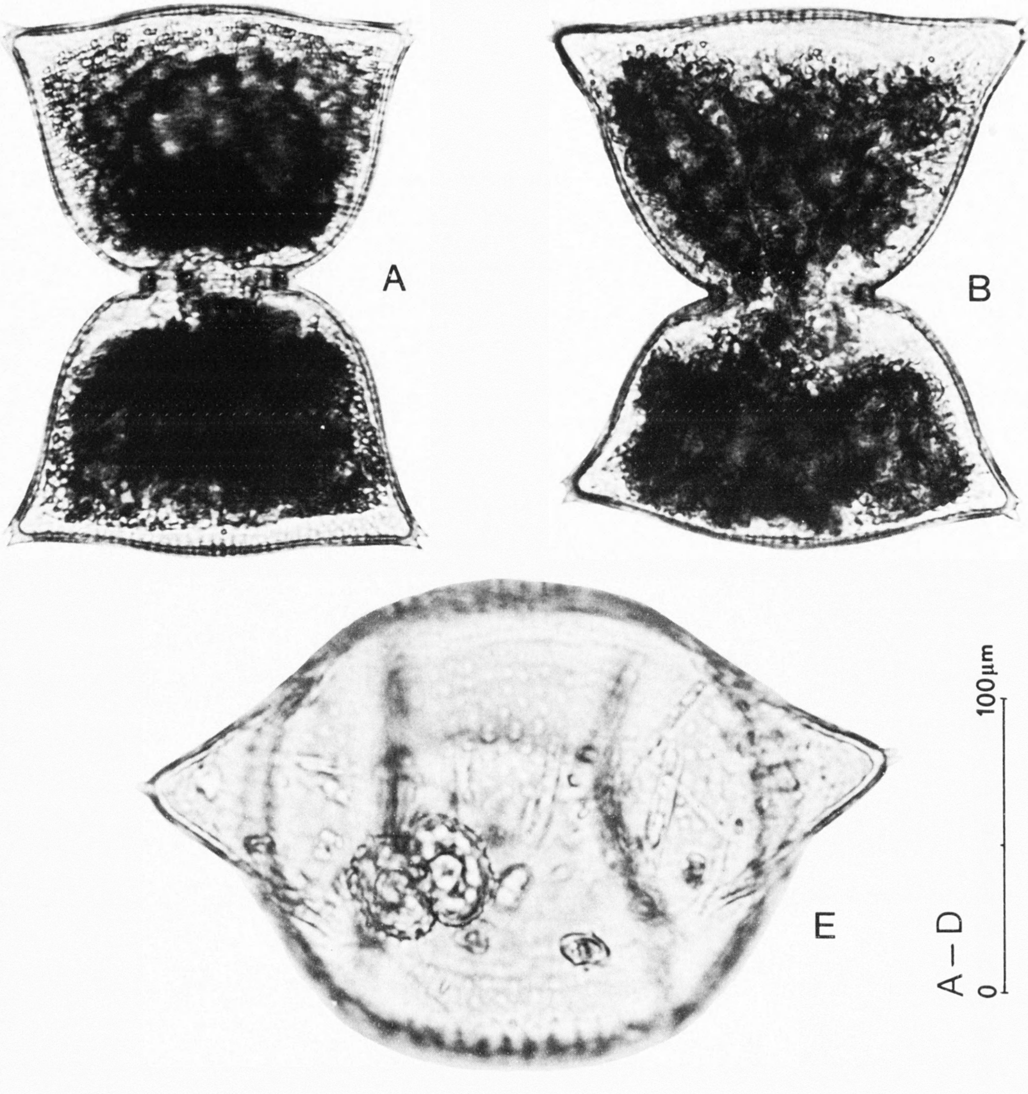
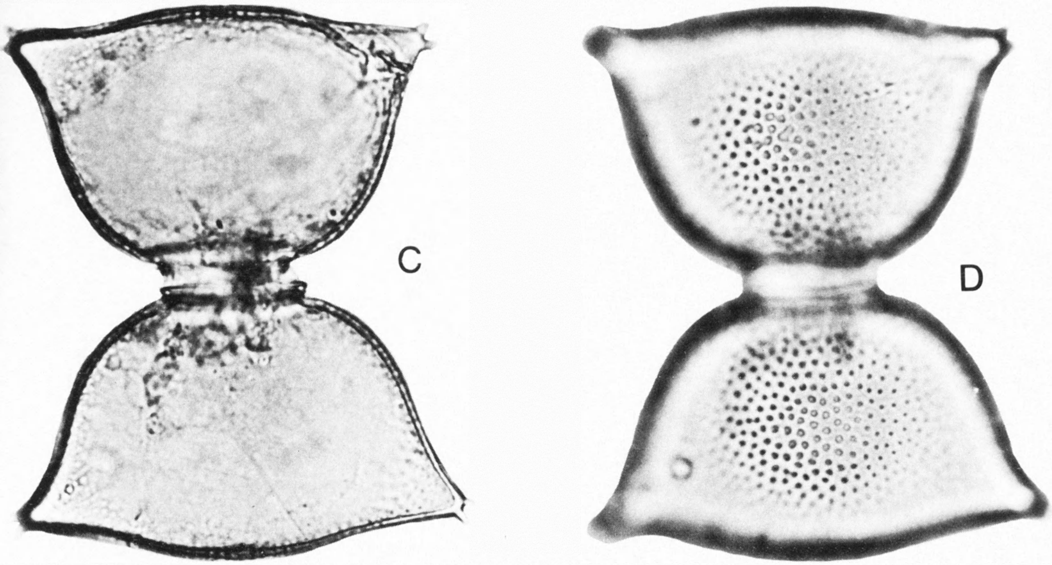


Fig. 4. *Cosmarium kostei*. A–D: Front view. – E: Vertical view.

E. evolutum (Nordst.) W. & W.
E. evolutum v. *glaziowii* (Børg.) W. & W. – Long. 56 μm.
E. evolutum v. *perornatum* Scott & Croasd.
E. flammeum v. *subkalimantanum* Först.
E. foersteri Scott & Grönbl.
E. gemmatum Bréb.
E. gessneri v. *laticeps* Scott & Prescott forma – Fig. 3 F. This is a small form, the length being only 28 μm, breadth 24 μm. It resembles *E. subincisum* Reinsch forma depicted by Krieger (1932) which is, however, a smaller plant.
E. humbertii v. *brasiliense* Krieg.
E. humbertii v. *brasiliense* f. *goyazense* Först. – Long. 28 μm, lat. 18 μm.
E. humerosum v. *evolutum* Krieg.
E. informe Borge – Long. 30 μm.
E. obesum Josh.
E. oculatum v. *cyclopicum* Först.
E. oculatum v. *suboculatum* Borge



E. paulense f. *caicarense* Först.

E. pinnatum Ralfs – Fig. 5 A–D. There are a number of figures of *E. humerosum* v. *evolutum* Krieg. which closely resemble *E. pinnatum*. However, the lateral supraisthmal protuberances are different.

E. platycerum v. *eximium* f. *clausum* Grönbl. & Scott – Fig. 5 E–I. Many morphae, formae, and varieties of *E. platycerum* Reinsch have been described. The taxonomical value of many of these taxa is doubtful. The morphological variation within the present population has been illustrated by Fig. 5 G–I.

E. pirassunungae Borge

E. quadrilobatum Scott & Grönbl. – Long. 23.5 μm, lat. 16 μm.

E. sinuosum Len.

E. sublobatum v. *kriegeri* f. *rotundatum* Först.

E. sublobatum v. *notatum* Grönbl. – With a granule just above the isthmus on each side.

E. subtrilobatum v. *gibbosum* Först.

E. umbonatum (W. & W.) Schmidle

E. validum W. & W.

Micrasterias alata Wall.

M. arcuata Bail.

M. arcuata f. *gracilis* W. & W.

M. decemdentata (Näg.) Arch. – Fig. 6 D. This plant is similar to the one designated as *M. decemdentata* in Borge (1918 Fig. 5: 22), later transferred to *M. abrupta* by Krieger (1939 p. 37). A rather similar plant has been figured by Krieger (1939 Fig. 104: 10) as *M. decemdentata*. For *M. abrupta* see West & West (1896 Fig. 14: 13–16), compare also Fig. 3: 10–12 and 4: 4–5 in Förster (1963).

M. depauperata v. *kitchellii* (Wolle) W. & W.

M. foersteri Thom.

M. foliacea Bail.

M. radiata v. *gracillima* G. M. Smith

M. radiata v. *groenbladii* Croasd.

M. radiosa v. *ornata* f. *elegantior* G. S. West

M. truncata f. *gibbosa* Thom. – The description of this taxon in Thomasson (1971) was not illustrated with a side view. Such a figure is given here (Fig. 5 J).

Micrasterias sp. – Fig. 3 G. Long. 36 μm, lat. 52 μm. This small *Micrasterias* is probably related to *M. abrupta* W. & W. However, having seen only two specimens I prefer to leave its taxonomic position open.

Actinotaenium cucurbitinum (Biss.) Teil.

A. globosum (Bulnh.) Teil.

A. peniomorphum v. *latius* (Scott & Presc.) Först.

A. turgidum v. *ligatum* (W. & W.) Teil. – Fig. 6 E–F represents an interesting morpha. The length of the plants is 100 μm, and the diameter 50 μm.

Cosmarium connatum Bréb.

C. contractum Kirchn.

C. costatum v. *subtumidum* Racib.

C. denticulatum v. *rotundatum* Lütkem.

C. denticulatum v. *rotundatum* f. *mediolaeve* Först.

C. depressum v. *elevatum* Borge

C. cf. *exasperatum* Josh.

C. furcatum Först.

C. geminatum v. *scottii* Först. – Long. 28 μm, lat. 30 μm.

C. groenbladii Thom.

C. isthmium v. *brasiliense* Grönbl.

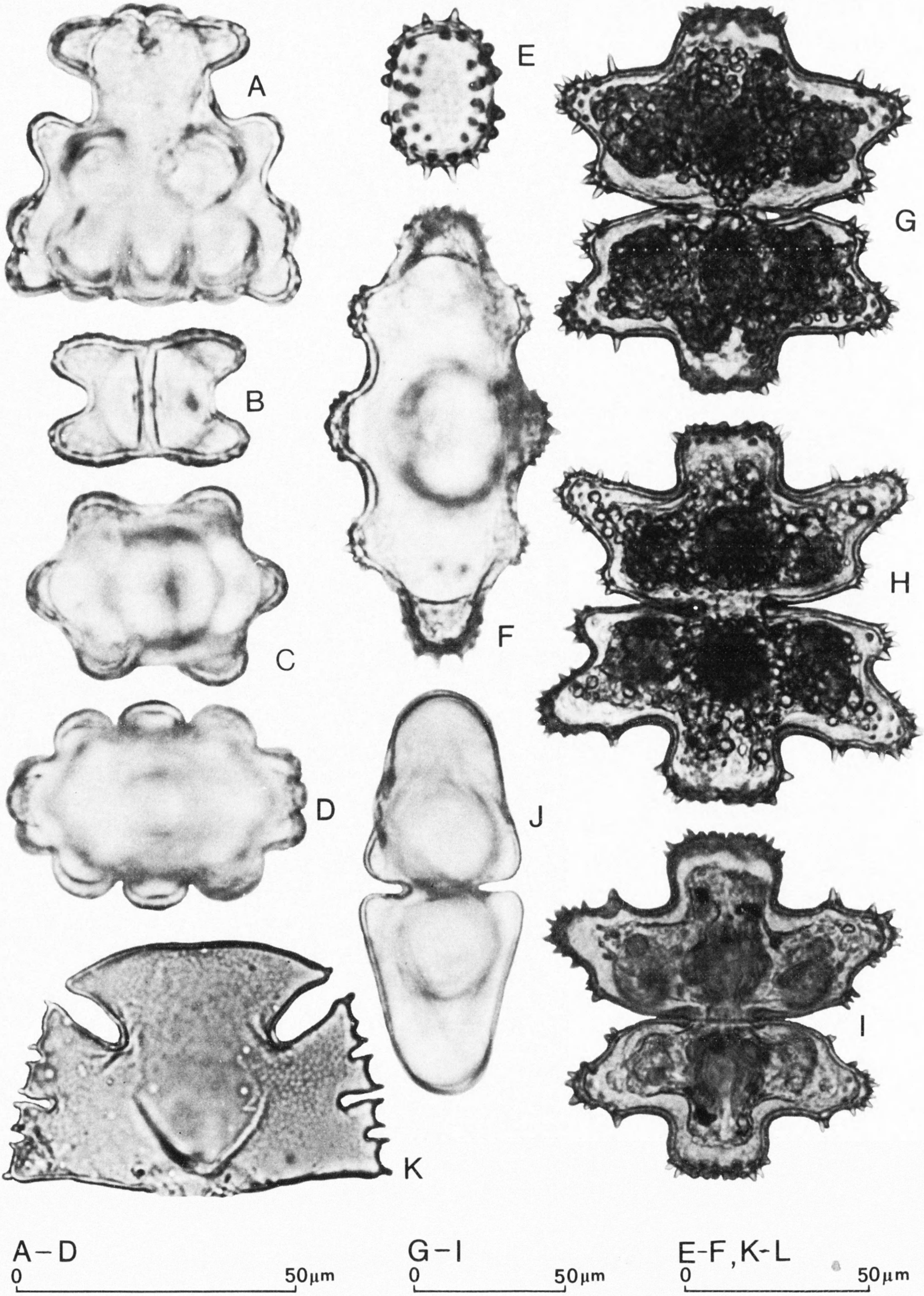
C. kostei Thom.

C. lagerheimianum (Turn.) Scott & Presc. – Long. 96–120 μm, lat. 68–72 μm.

C. lagoense Nordst. – Incl. v. *amoebum* Först., long. 38(42) μm, lat. 28 μm.

C. lagoense v. *cornigerum* Nordst. – Syn. *C. lagoense* v. *octastichum* Först.

C. latipyramidatum v. *trapeziforme* Thom. var. nov. –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A – D
0
50µm
G – I
0
50µm
E-F, K-L
0
50µm

Long. 85–90 µm, lat. 65–70 µm. Semicellulae trapeziformis, angulis acutirotundatis, membrana dense porosa. Iconotypus fig. nostra 6 G.

C. moniliforme v. *pseudofuellebornii* Först.

C. monomazum v. *dimaziforme* Grönbl.

C. notochondrum W. & W. forma – The papillae are more like spines than in plants depicted by West & West and there is one protuberance on each side of the sinus.

C. ocellatum Eichl. & Gutw.

C. ornatum v. *pseudolagoense* Först.

C. patelliforme Borge – Fig. 6 H, I. Long. 108–116 µm, lat. 62–64 µm. These plants are a little smaller than those described by Borge (1903). However, the similar *C. contractum* v. *maximum* W. & W. is considerably smaller. I am not convinced about the taxonomic value of the apical depression mentioned by Borge.

C. polymorphum v. *groenbladii* Först. – Long. 26.5 µm, lat. 22 µm.

C. portianum Arch.

C. pseudoconnatum v. *borgei* Först.

C. pseudomagnificum v. *brasiliense* Först. – Long. 70–72 µm. This variety resembles *C. margaritiferum* v. *brasiliense* Först. One should always carefully consider the ornamentation of the cell wall.

C. pseudopachydermum Nordst. forma

C. pseudopyramidatum v. *borgei* Krieg. & Gerl. – Long. 88 µm.

C. pseudotaxichondrum v. *longii* (Tayl.) Scott

C. redimitum Borge

C. regnesii v. *productum* W. & W.

C. scrobiculosum Borge – The plants are a little smaller than those described by Borge (1903): Length 60 µm, breadth 40 µm. See also Fig. 139 in Grönblad (1945).

C. spinuliferum W. & W. – Long. 32 µm, lat. 26 µm.

C. subpraemorsum Borge – Long. 60 µm, lat. 40 µm.

C. trilobulatum v. *minutum* Först.

C. zonatum v. *subcylindricum* Grönbl. & Scott – Fig. 6 C. Long. 54–64 µm.

Xanthidium armatum (Bréb.) Rabenh.

X. armatum v. *circumornatum* Först.

X. fragile Borge

X. mamillosum (Grönbl.) Först.

X. multituberculatum Först. forma – With a large protuberance on each side of the isthmus.

X. regulare v. *asteptum* Norst. – Borge 1918 Fig. 3: 31.

X. regulare v. *pseudoregulare* (Borge) Bic. & Carv.

X. regulare Nordst. forma – Förster 1964 Fig. 27: 1.

Arthrodesmus borgei Thom.

A. impar v. *centrispinum* Scott & Grönbl.

A. longispinus Borge – This taxon was described by Borge (1903 Fig. 3: 35). Since then a number of plants of different shape have been lumped under that name. Fig. 6 A, B shows what this taxon should be like.

A. octocornis Ehr.

A. westii (W. & W.) Först. – Long. 40 µm, lat. 72 µm.

Staurodesmus calyxoides v. *marthae* (Grönbl.) Teil.

S. ceratophorus (Nordst.) Först.

S. cornutus (Wolle) Teil.

S. hebridarus v. *brasiliensis* Först. fac. 3 – Long. 40–44 µm.

S. incus (Bréb.) Teil. forma – Teiling 1967 Fig. 5: 5.

S. leptodermus v. *ikapoae* f. *elongatus* Grönbl. & Scott – Long. 42(96) µm.

S. mamillatus (Nordst.) Teil.

S. maximus (Borge) Teil. forma – Förster 1969 Fig. 30: 1.

S. minutissimus (Reinsch) Teil.

S. o'mearae (Arch.) Teil.

S. patens (Nordst.) Croasd.

S. phimus (Turn.) Thom. – Förster 1974 Fig. 8: 18.

S. psilosporus (Nordst. & Löfgr.) Teil. forma – Förster 1964 Fig. 25: 6–7.

S. validus (W. & W.) Thom.

S. wandae v. *pseudopterosporus* (Först.) Teil.

S. wandae (Racib.) Bourr. forma – Five-radiate, somewhat larger than those described by Raciborski. Spines considerably longer, length of cells 44 µm, with spines 88 µm.

Staurastrum binum v. *inaequale* Grönbl. & Croasd. – Long. 48(92) µm, lat. 28(80) µm. There are seven long upper spines and the same number of shorter and thinner lower spines which are directed towards the isthmus.

S. bituberculatum Först. – Long. 48–60 µm, lat. 40 µm.

S. brachiatum Ralfs

S. boergesenii v. *elegans* Borge

S. brasiliense Nordst.

S. brasiliense v. *porrectum* Borge

S. capitulum v. *tumidiusculum* (Nordst.) W. & W.

S. cerastes v. *pulchrum* Scott & Grönbl. – Long. 48(92) µm, lat. 28(80) µm. Most likely the plant described by Grönblad (1945) as *S. submanfeldtii* v. *convergens* is closely related to *S. cerastes* v. *pulchrum*.

S. circulus Grönbl.

S. columbetoides v. *basiaculeatum* Scott & Presc.

S. columbetoides v. *ginzbergeri* (Grönbl.) Scott

S. cosmaroides Nordst. – Long. 74 µm.

S. cosmaroides v. *tropicum* (Lagerh.) Borge – This plant is identical with the one figured in Bicudo 1969 Fig. 199. The size is: length 78 µm, breadth 40 µm. It is abundant in the sample.

S. diptilum Nordst.

S. elegantissimum v. *brasiliense* f. *triradiatum* Först. – Syn.: *S. oxyacantha* v. *majus* Scott & Grönbl. forma in Thomasson (1971).

S. elongatum v. *amazonense* Scott & Grönbl.

S. glabribrachiatum Först.

S. grallatorium v. *brasiliense* (Grönbl.) Först. – Syn.: *S. saltans* v. *brasiliense* Grönbl.

S. hystrix v. *brasiliense* Grönbl.

S. hystrix v. *floridense* Scott & Grönbl.

S. inconspicuum Nordst.

S. irregulare W. & W.

S. jurucuiense Thom.

Fig. 5. A–D: *Euastrum pinnatum*. – A: Front view. – B–D: Vertical views. – E–I: *Euastrum platycerum* v. *eximium* f. *clausum*. – E: Apex in vertical view. – F: Basal view. – G–I: Front views. – J–K: *Micrasterias truncata* f. *gibbosa*. – J: Side view. – K: Front view.

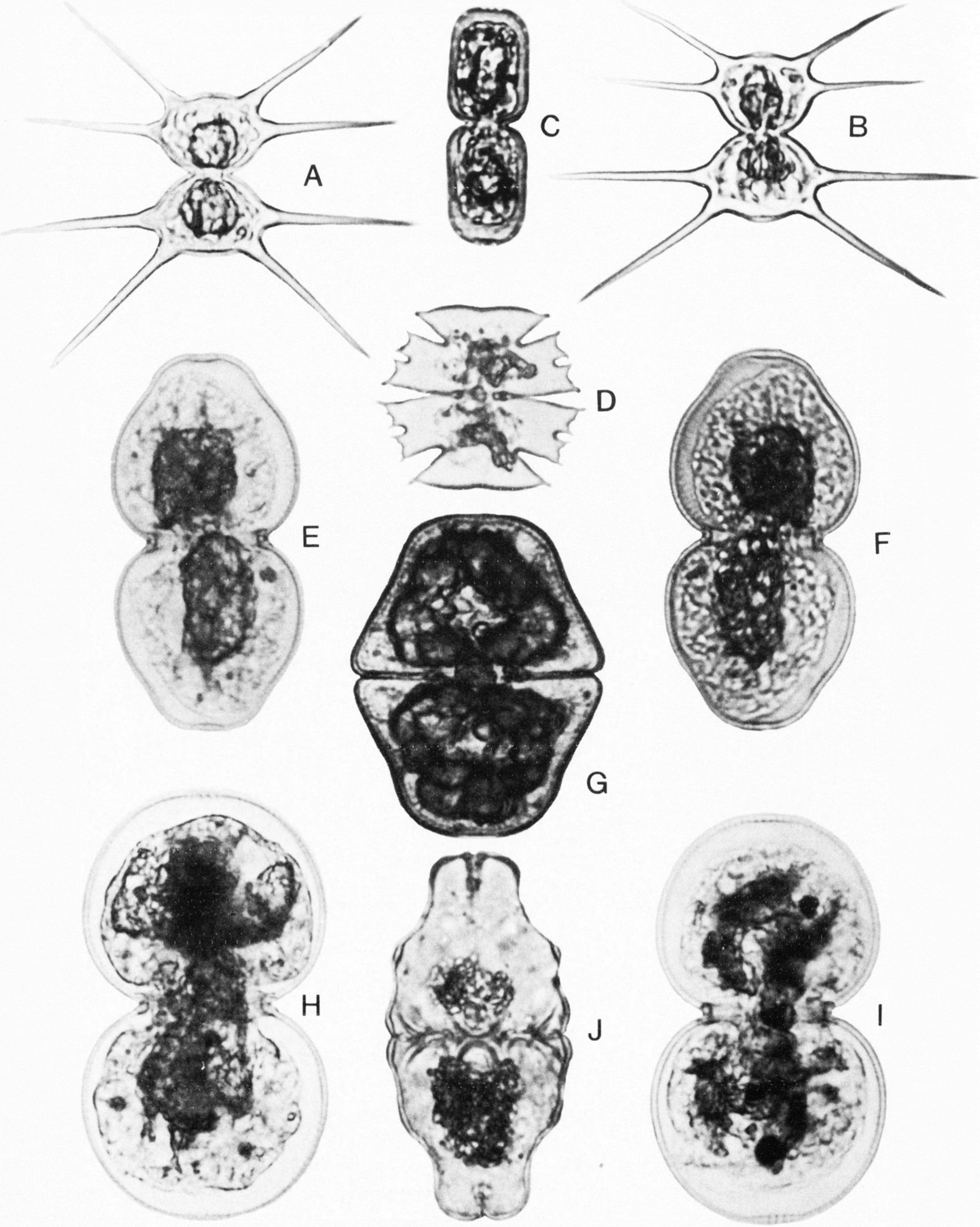

Fig. 6. A–B: *Arthrodesmus longispinus*. – C: *Cosmarium zonatum* v. *subcylindricum*. – D: *Micrasterias decemdentata*. – E–F: *Actinotaenium turgidum* v. *ligatum*. – G: *Cosmarium latipyramidatum* v. *trapeziforme*, iconotype. – H–I: *Cosmarium patelliforme*. – J: *Euastrum didelta* v. *quadriceps*.

S. laevispinum Biss. – Long. sine proc. 12 µm.
S. leptacanthum Nordst.
S. leptocladum v. *cornutum* Wille
S. leptocladum v. *insigne* W. & W.
S. longipes v. *evolutum* f. *gracillius* Först.
S. minnesotense Wolle
S. novae-caesareae v. *brasiliense* (Grönbl.) Först.
S. octoverrucosum v. *brasiliense* Först.
S. orbiculare v. *depressum* Roy & Biss. forma – Förster 1969 Fig. 33: 4.
S. penicilliferum Grönbl.
S. pseudozonatum v. *minutum* f. *rectum* Först.
S. quadrangulare v. *contectum* (Turn.) Grönbl. – Long. 20–22 µm.
S. rotula Nordst.
S. royi Turn.
S. spiculiferum Borge
S. stelliferum v. *evolutum* Thom.
S. tectum v. *ayayense* Grönbl.
S. teliferum v. *groenbladii* Thom.
S. tentaculiferum Borge
S. tetracerum Ralfs
S. trifidum v. *inflexum* W. & W.
S. trihedrale Wolle – The observed plant is similar in shape to the one figured by West & West (1896 Fig. 16: 29), being somewhat larger: length 54 µm, breadth 40 µm.
S. vestitum v. *subanatinum* W. & W.
S. wolleanum v. *brasiliense* Scott & Grönbl.
S. xiphophorum Grönbl. – Abundant.
S. zonatum Børg. – The specimens in this sample are 40–42 µm long, the breadth is 52 µm, the ornamentation of the apex is similar to the specimen figured by Grönblad (1945 Fig. 300). The plants are 5-radiate.
S. zonatum f. *elongata* Grönbl. – Long. 30(48) µm, 4-radiate.
Spondylosium panduriforme f. *limneticum* (W. & W.) Teil.
S. rectangulare f. *majus* Scott & Grönbl.
Sphaerozosma laeve (Nordst.) Thom.
Desmidium baileyi f. *tetragonum* Nordst.
D. curvatum Nordst.
D. cylindricum Grev.
D. elegans (Racib.) Grönbl.
D. gracilipes (Nordst.) Lagerh.
Bambusina longicollis (Nordst.) Grönbl.
Phymatodocis alternans Nordst.
P. nordstedtiana Wolle
Hyalotheca dissiliens (J. E. Smith) Bréb.

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Notice for the exchange of duplicate voucher material

S. H. Sohmer

The Herbarium of the University of Wisconsin-La Crosse has been the base for a number of floristic projects including a detailed project dealing with Navigation Pool 8 of the Upper Mississippi River. This area consists of that portion of the Upper Mississippi River and its flood plain impounded behind Lock and Dam No. 8 at Genoa, Wisconsin, and extending 47.5 km or 23.3 river miles, north to Lock and Dam No. 7 at Dresbach, Minnesota.

Two major series of collections have been made in this area; one series vouches for a study of the vascular flora and its succession on dredge material (material dredged from the navigation channel and piled along the edge of the channel) and the other vouches for a study dealing with the flora and phytosociology of all other sites, both aquatic and terrestrial, in this area. The total number of collections come to nearly 6000 numbers and over 20,000 specimens.

The first set of these collections will remain at UWL to vouch for these studies. I would like to distribute the duplicate sets for exchange to herbaria that will maintain these collections. The specimens have been identified, often by specialists of particularly difficult groups, and will be provided with 100% rag, heavy, detailed specimen labels with separate map labels that will pinpoint exact locations within the Navigation Pool. Individual arrangements can be made and we are rather open to exchange possibilities for this material. Please contact Dr S. H. Sohmer, Director, Herbarium, University of Wisconsin, La Crosse, Wisconsin 54601, USA.

Vesiculomyces Hagström gen. nov. segregated from Gloeocystidiellum (Corticiaceae)

Elisabeth Hagström

Hagström, E. 1977 04 15: Vesiculomyces Hagström gen. nov. segregated from Gloeocystidiellum (Corticiaceae). *Bot. Notiser 130:* 53–54. Stockholm. ISSN 0006-8195.

The new monotypic genus *Vesiculomyces* is described to accommodate *V. citrinus* (Pers.) Hagström (≡ *G. citrinum* (Pers.) Donk). A distribution map of this species is given.

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An investigation of the Nordic species of the genus *Gloeocystidiellum* Donk is being undertaken by the author. As a first result a new genus is here described to accommodate *G. citrinum* (Pers.) Donk, a species that deviates in several important characters from other species of *Gloeocystidiellum*.

Vesiculomyces Hagström gen. nov.

Fructificatio resupinata, effusa, albida–citrina–flavida, in vivo plus minusve tuberculata; systemate hyphali monomitico; hyphis tenuiter tunicatis, septatis non fibulatis, 1.5–3.5 µm latis; gloeocystidiis vesicularibus, demum apicaliter tubiformibus sinuosisque, quae in solutione sulphovanillini non tinguntur, 30–150 × 10–22 µm; basidiis flexuoso-cylindricis, 4-sterigmatibus, 23–75 × 4.5–8 µm; sporis subglobosis, tenuiter tunicatis, glabris, amyloideis, apiculo prominenti, 5.0 × 4.8 µm vel 4.9 µm diam.

Typus generis *Vesiculomyces citrinus* (Pers.) Hagström comb. nov. (≡ *Thelephora citrina* Pers., Mycol. europ. 1: 136 (1822).

Fructifications resupinate, effused, white to yellow, when fresh more or less tuberculose. Hyphal system monomitic, of thin-walled hyphae that are septate but not fibulate, 1.5–3.5 µm diam. Gloeocystidia without positive reaction to sulfo-aldehydes, terminal, bladder-like, later apically winding and tube-formed, 30–150 × 10–22 µm. No other sterile hymenial elements present. Basidia flexuous-cylindrical with 4 sterigmata, 23–75 × 4.5–8 µm. Spores subglobose, thin-walled, smooth, amyloid, with a prominent apiculus, 5.0 × 4.8 µm or 4.9 µm diam.

The generic name is derived from *vesicula* = small bladder, and *myces* = fungus, referring to the shape of the gloeocystidia.

Discussion

The main difference between *Vesiculomyces* and *Gloeocystidiellum* is the reaction of the gloeocystidia to sulfo-aldehydes. All species of *Gloeocystidiellum* s. str. show a positive reaction, the gloeocystidia becoming dark coloured in the test. There are some other characters contributing to make *V. citrinus* distinct from all species of *Gloeocystidiellum* viz. the lack of clamps, the almost spherical spores and the long and narrow basidia. Taken together these characters make *Vesiculomyces* stand out as a well delimited taxon. The segregation of *Vesiculomyces* allows a more precise circumscription of *Gloeocystidiellum* which can be described as having amyloid spores, gloeocystidia with positive reaction to sulfo-aldehydes but lacking acanthohyphidia and other hymenial elements characteristic of the genus *Aleurodiscus* Rabenh.

Amyloid spores is a very important character for the classification of species and genera of resupinate Basidiomycetes. Besides in *Gloeocy-*

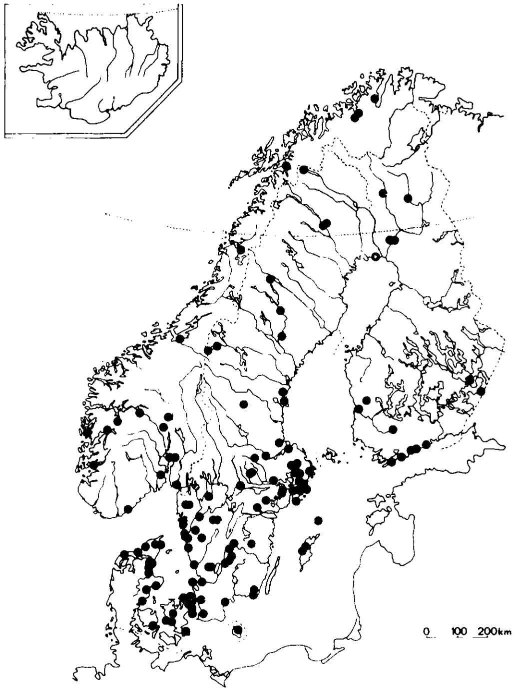

Fig. 1. *Vesiculomyces citrinus*. Known distribution in Northern Europe.

stidiellum and *Aleurodiscus* such spores are found in the related genera *Laxitextum* Lentz and *Scytinostromella* Parm., which differ from *Vesiculomyces* in having ornamented spores. Amyloid spores are also found in *Irpicodon* Pouz., in *Melzericium* Hauersl. and in *Amylocorticium* Pouz. However, these three genera are easily separated from *Vesiculomyces* by lacking gloeocystidia, possessing clamps and having spores of quite different shapes. *Melzericium* besides has pleurobasidia. Some other species with such basidia, in the genera *Xenasmatella* Oberw. and *Pseudoxenasma* Larss. & Hjortst., have amyloid spores as well. In Stereaceae such spores are found in most genera, for example *Stereum* Pers. per S.F. Gray, *Amylostereum* Boid. and *Xylobolus* Karst., but these differ in other respects. The stereoid genus *Laurilia* Pouz. (Echinodontiaceae) with amyloid, ornamented spores is in many respects different from *Vesiculomyces*.

The natural relationships between *Vesiculomyces* and other genera within Corticiaceae and consequently its place within the family are obscure, as is very often the case among the resupinate Basidiomycetes. The similarities with *Gloeocystidiellum* and *Aleurodiscus* may or may not be an indication of real affinity. *V. citrinus* is rather similar to the phlebioid fungi in hymenial configuration, having narrow basidia standing in a dense palissade. For practical reasons it is probably best to leave it in the vicinity of *Gloeocystidiellum*.

During the investigation of *Vesiculomyces citrinus* special attention has been given to intraspecific variation. Variation in colour, structure, thickness and size of the fruitbodies, the nature of hyphae, gloeocystidia, basidia and spores have been thoroughly studied. Preferences to different substrates have been considered. *V. citrinus* is clearly a uniform taxon. All available Nordic collections of *V. citrinus* from the following herbaria have been examined: GB, UPS, S, C, O, TRH, H, L, Lars Arvidsson, John Eriksson, Nils Hallenberg, Kurt Hjortstam, Åke Strid and Stellan Sunhede. The known distribution is shown in Fig. 1. Despite the bias resulting from over- and undercollecting it can be claimed that the fungus is more common in the southern parts of the investigated area.

The most common substratum for this species is decayed wood of coniferous trees lying on the ground. In the southern parts of the investigated area some 80% of the material has been found on coniferous wood and the corresponding number for the northern parts is somewhat higher. *Picea abies* seems to be the most common substrate according to the labels on the collections. *Pinus* is also often reported as a host. Some finds have been made on *Juniperus*, and a few other conifers have also occasionally been noted. At least seven genera of deciduous trees may serve as substratum, viz., *Betula*, which is quite common, *Alnus, Salix, Fagus, Populus, Quercus* and *Sorbus*. *V. citrinus* has also been found growing on mosses, on dead *Lenzites* and on soil. Detailed information and a list of the material studied will be included in a stencilled report to be published at the Botanical Department, University of Göteborg.

Acknowledgements. I am indebted to my supervisor, Dr John Eriksson, for valuable help with the present paper, and to Professor Åke Fridh for correcting the Latin.

Pardinae, a new section of Bomarea (Alstroemeriaceae)

Magnus Neuendorf

Neuendorf, M. 1977 04 15: Pardinae, a new section of Bomarea (Alstroemeriaceae). *Bot. Notiser 130:* 55–60. Stockholm. ISSN 0006-8195.

A new section of *Bomarea,* sect. *Pardinae,* is described. It is characterized by auriculate pollen grains and white petals. The section comprises two species: *B. pardina* Herb. and *B. ceratophora* sp. nov. *B. pardina* is distributed in the Andean region from Peru to S Colombia. *B. ceratophora* is known from the E slopes of the Andes of the provinces Tungurahua and Pastaza in Ecuador.

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The genus *Bomarea* (Alstroemeriaceae) was established by Mirbel in 1804 and comprises now about 100 species. However, this figure is very unreliable because of the lack of a modern revision. The genus is closely related to *Alstroemeria* L. but separated by the actinomorphic (sometimes slightly zygomorphic) flowers, the straight filaments and the leathery or somewhat fleshy mature capsules or berry-like fruits. *Alstroemeria* has zygomorphic flowers, curved filaments and dry capsules.

Bomarea is generally subdivided into three subgenera: *Wichuraea, Sphaerine* and *Bomarea* (Baker 1888). The largest of these, subgenus *Bomarea,* on which I am preparing a monograph, is usually split up into four groups of species, classified sections by Killip (1936). The principles of the division of subgenus *Bomarea* seem quite artificial, however, and make some obviously closely related species fall into different sections. A modern revision will entail a different grouping within the subgenus *Bomarea*. Two closely related species, one of which is described in the present paper as new to science, have characteristic pollen grains, quite different from those in other species of the genus. These two species constitute a natural group and warrant recognition as a separate section, *Pardinae.*

Sect. **Pardinae** Neuend. sect. nov.

Type species: *Bomarea pardina* Herb.

Inflorescentia thyrsus condensatus, cymulis unifloris ad quadrifloris. Segmenta perianthii inaequalia. Petala alba maculis fuscoviolaceis vel atroviolaceis. Pollinis grana auricula utraque parte sulci ornata.

Vines. Stems to 10 m long, glabrous. Inflorescence a condensed thyrse composed of one- to three- or rarely four-flowered cymules (Fig. 1). The youngest shoot-generation of the cymule always stunted (Fig. 2). Pedicels bracteate. Petals exceeding the sepals with about 1 cm, white to whitish grey, internally with numerous dark violet spots. Pollen grains with an auricle at each end of the sulcus (Fig. 3).

Two species belong to this section. The geographical distribution comprises Peru, Ecuador and southernmost Colombia, with a concentration to the Andean region in the N half of Ecuador.

Key to the species

Sepals without horn .... 1. *B. pardina*
Sepals with a 0.6–0.8 cm long, curved horn just below the apex .... 2. *B. ceratophora*

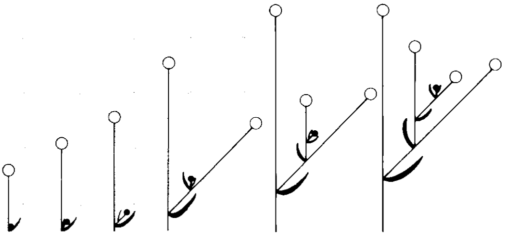


Fig. 1. *Bomarea pardina.* – Different cymule-types, youngest shoot-generation (flower) stunted. Length of axis enlarged.

1. **Bomarea pardina** Herbert – Figs. 4, 5 A–C

Bomarea pardina Herbert 1837 p. 120 – Orig. coll.: Hall 19 (K holotype).

Bomarea lyncina Herbert 1837 p. 398 – Orig. coll.: Mathews 1668 (K holotype).

Bomarea brachypus Kränzlin & Sodiro 1907 p. 40 – Orig. coll.: Sodiro 176/15 (B), Lehmann 7784? (B).

Bomarea grandiceps Kränzlin & Sodiro 1907 p. 40 – Orig. coll.: Sodiro 174/16 (B).

Bomarea pulchella Sodiro 1908 p. 55 – Orig. coll.: Sodiro 11/905 (cf. below).

Bomarea venusta Sodiro 1908 p. 55 – Orig. coll.: Sodiro 7/907 (cf. below).

Bomarea falcata Sodiro 1908 p. 56 – Orig. coll.: Sodiro s. n. (cf. below).

Illustrations: Herbert 1837, Pl. 14 fig. 1 (inflorescence) and Pl. 46 fig. 1 (as *Bomarea lyncina* Herb., part of inflorescence, leaf).

Stem rather slender, voluble, generally 3–5 m long, sometimes up to 10 m, glabrous. *Leaves* ovate to narrowly ovate, generally 6–13 cm long, 3–5 cm wide, cuspidate to acuminate at apex, obtuse at base, glabrous above, densely pilose to ± glabrous beneath. *Petioles* 0.5–1.5 cm long, with a flattened narrow margin. *Bracts* sessile, or with a short untwisted petiole, narrowly ovate, 1.0–2.5 cm long, 0.3–1.5 cm wide, acute to obtuse at apex, slightly puberulous. *Cymules* 10–30(–40), one-, two-, three- or rarely four-flowered, pedicels ± pilose, primary pedicels 1.0–1.5(–2.5) cm long. *Bractlets* ovate to narrowly ovate, 0.5–2.0 cm long, 0.3–0.6 cm wide, obtuse at apex, slightly puberulous. *Sepals* narrowly obovate to narrowly elliptic (Fig. 5 A, C), (3.6–)4.0–5.0(–5.8) cm long, 0.7–1.1(–1.4) cm wide, externally red and slightly puberulous, internally pale pink, often with a distinct boss 1–2 mm high c. 0.5 cm below the apex. *Petals* cuneate, unguiculate (Fig. 5 A–C), (4.0–)4.8–6.0(–6.8) cm long, 1.2–1.8(–2.0) cm wide, white to whitish grey, with reddish mid-nerve, internally with numerous, rather large, elliptic, dark violet spots on the lamina, externally with a few small spots at the margin. *Filaments* filiform, generally 0.5–1.0 cm shorter than the petals. *Anthers* elliptic, 0.6–0.8 cm long. Pollen grains (95–)110–120 μm long, with auricles (Fig. 3), flesh-coloured to pale violet. *Ovary* turbinate to subglobose, ± densely pilose. *Style* as long as the stamens, glabrous. Stigma branches c. 3 mm long. *Fruit* unknown.

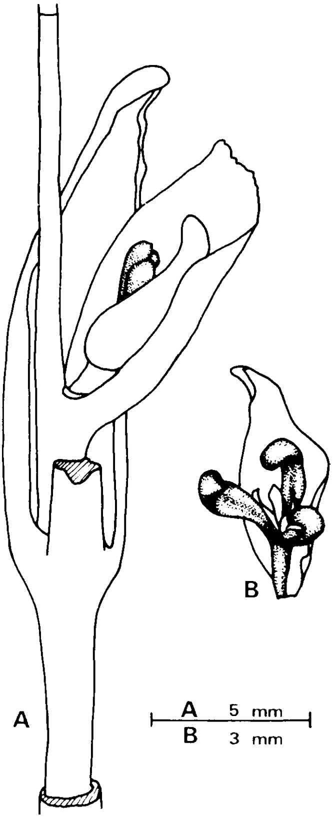


Fig. 2. *Bomarea pardina.* – A: Two-flowered cymule with a third stunted flower (flowering pedicels and bract removed) (Hitchcock 21174). – B: Stunted, bracteate flower (André 3787).

Representative specimens. Colombia. Putumayo: Valle de Sibundoy, in the vicinity of Sibundoy, c. 2250 m, 10–11.XII. 1942, Schultes & Smith 3091 (US) – *Ecuador. Carchi:* Road Tulcán–Maldonado, c. 13 km SE of Maldonado, c. 2600 m, 1.III. 1974, Harling & Andersson 12337 (GB) – *Pichincha:* San Ignacio, km 23 on road Aloag–Sto. Domingo, 2000 m, 4.III. 1967, Sparre 14691 (S) – *Napo:* Near Archidona, 19.IV. 1935, Mexía 7254 (UC) – *Pastaza:* Mera, 1160 m, 28.XII. 1958, Harling 3741 (S) – *Bolívar:* Below San Jacinto de la Unión, ca 2300 m, 15.VIII. 1939, Asplund 8323 (S).

Bomarea pardina is rather uncommon in mountain rain forest and edge vegetation from 550 to 3000 m. The geographical distribution coincides with that of the section. Forty-seven collections have been examined. A list of investigated specimens is kept at the Botanical Museum, Göteborg.

Despite a rather large intraspecific variation, which probably depends on the large vertical distribution, *B. pardina* is very characteristic with the white, richly spotted petals, shorter unhorned sepals and auriculate pollen grains.

The pubescence of the lower leaf surface varies from densely pilose to more or less glabrous, and the cymules can be either one-, two-, three- or rarely four-flowered. A few of the inflorescences examined have both one- and two-flowered cymules. The leaves vary rather much in shape and size. The bracts and bractlets are longer and narrower in a compact inflorescence than in a lax one. In most of the collections from low elevations in eastern Ecuador, the sepals are wider (1.3–1.4 cm, Fig. 5 C) than in the material from the rest of the distribution area (0.7–1.1 cm, Fig. 5 A). The cymules in collections from low elevations (500–1000 m) bear at least two, often more, flowers, while one-flowered cymules prevail at high altitudes.

The type of *B. lyncina,* from Peru, (all other types mentioned are collected in the Andes of the N part of Ecuador), has three-flowered cymules and rather small leaves, which are almost glabrous beneath. The type of *B. pardina* has one-flowered cymules and the lower leaf surface is pilose. The type of *B. brachypus* agrees very well with that of *B. pardina*. Kränzlin's comment that the inflorescence of *B. brachypus* is quite different from that of *B. pardina* is not correct. Concerning *B. grandiceps,* Kränzlin states that it has very little similarity to *B. pardina,* with which Sodiro had identified it. This is rather confusing, since the types agree very well. The only dissimilarity is that *B. grandiceps* has longer leaves with the lower surface only slightly pilose. Also *B. pulchella* is similar to *B. pardina* with the exception that the leaves are glabrous. Sodiro placed *B. pulchella* under the heading "Umbella simplici", but remarked that the pedicels are sometimes two-flowered. *B. venusta* and *B. falcata,* placed by Sodiro in the group "Umbella composita", also agree well with *B. pardina,* but have two- to three-flowered cymules and glabrous leaves. *B. falcata* was separated from *B. venusta* by its proportionately longer leaves.

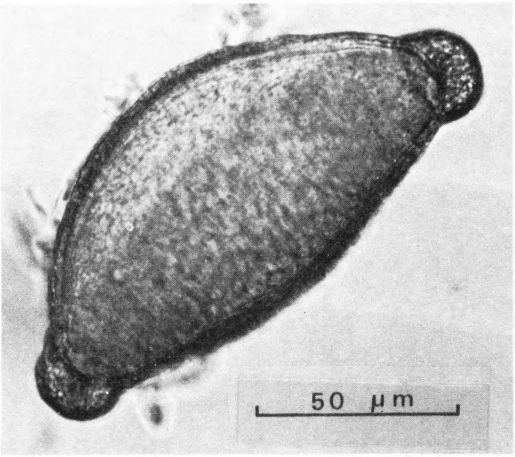


Fig. 3. *Bomarea pardina.* – Pollen grain (Harling 3741).

I have only seen fragments of the types of *B. pulchella, B. falcata* and *B. venusta,* brought from the Sodiro herbarium in Quito to herbarium US by Mrs Mexía in 1934. Part of Sodiro's herbarium was sold to Herbarium Darwinion probably between 1924 and 1926, but the major part of Sodiro's original collections is still in Quito (Acosta-Solís 1969). It was earlier kept in Colegio San Gabriel, but is now placed in Bibliotheca Arvelio Espinoza. Since the material there is packed up and in no order it is unavailable. In Universidad Central, Quito (Q), one of Sodiro's duplicate collections is kept. The sect. *Pardinae* is represented here only by one specimen, labelled *B. grandiceps* (L. Andersson pers. comm.). Since there are no Sodiro collections at all at Universidad Católica in Quito (QCA), the types of *B. pulchella, B. falcata* and *B. venusta* are probably to be found in Bibliotheca Arvelio Espinoza.

From the material studied I do not believe that much importance should be attached to the difference in number of flowers per cymule and

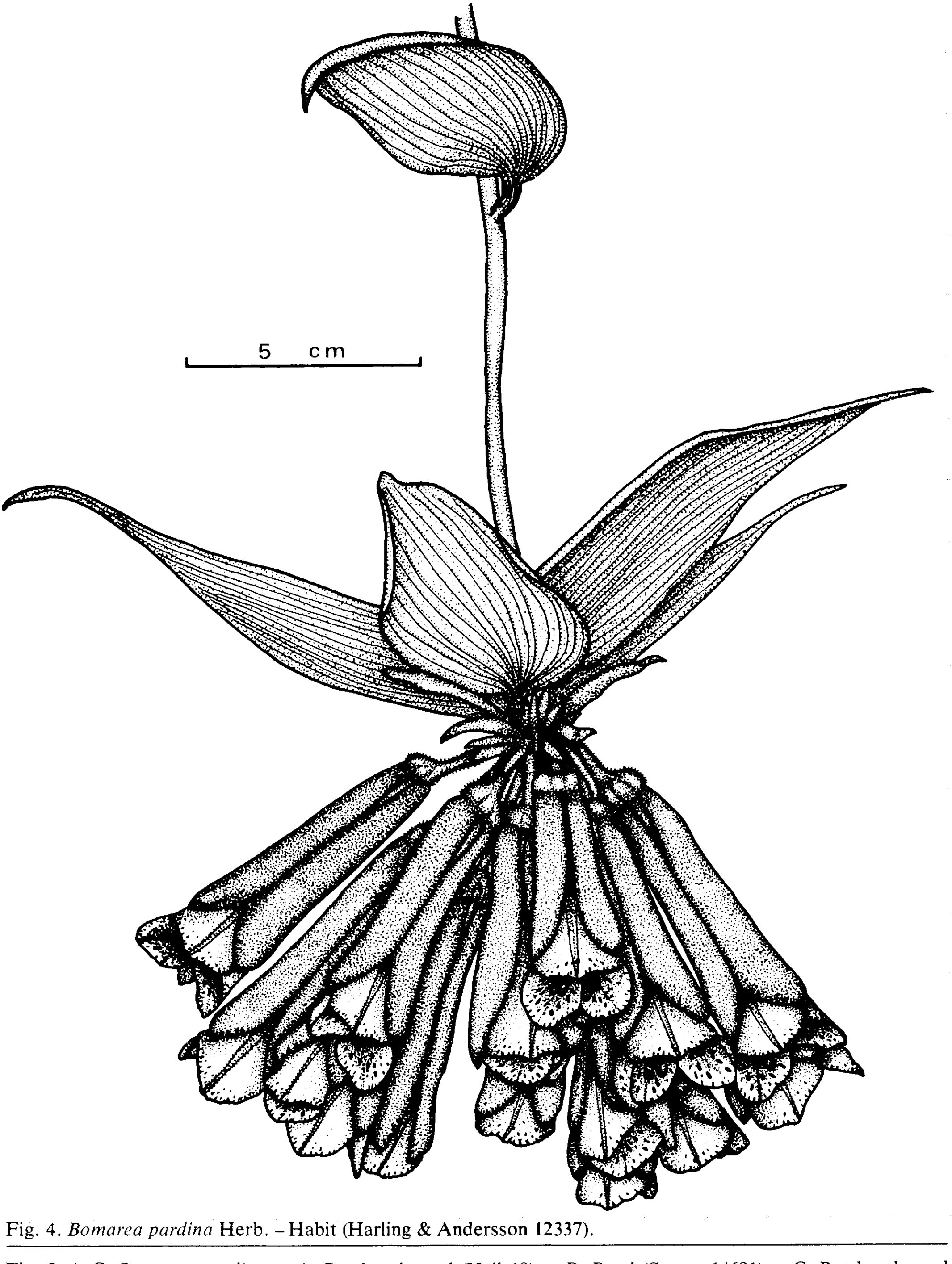
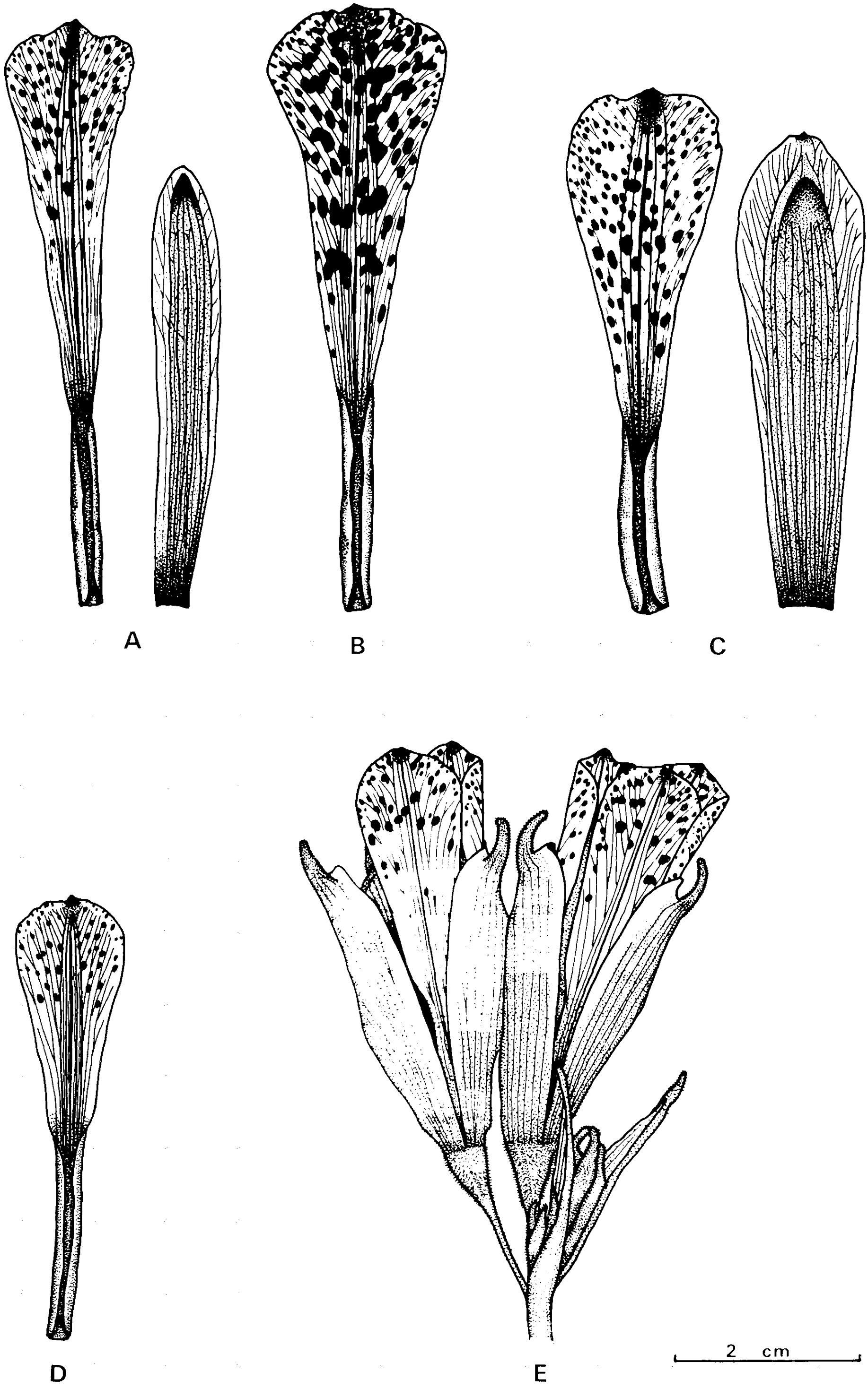


Fig. 4. *Bomarea pardina* Herb. – Habit (Harling & Andersson 12337).

Fig. 5. A–C: *Bomarea pardina*. – A: Petal and sepal (Hall 19). – B: Petal (Sparre 14691). – C: Petal and sepal (Mexía 7254). – D–E: *Bomarea ceratophora*. – D: Petal (Lugo 144). – E: Two-flowered cymule (Asplund 18550).


A
B
C
D
E
2 cm

the varying pubescence of the leaves. The highly variable species *B. pardina* could perhaps be divided into two or more subspecies, but more collections must be available before definite conclusions can be drawn.

2. **Bomarea ceratophora** Neuend. sp. nov. – Fig. 5 D–E

Orig. coll.: Asplund 18550 (S).

Bomareae pardinae Herb. affinis, differt foliis comparate angustioribus, 10–16 cm longis, 2–3 cm latis, subtus in nervis dense pilosis, floribus, si mediam magnitudinem respicias, minoribus, sepalis cornu crasso, curvo, 0.6–0.8 cm longo, paulo infra apicem instructis, petalis spathulatis, 4.5–4.9 cm longis, 1.2–1.4 cm latis, pollinis granis minoribus, 85–95 μm longis.

Stem slender, voluble, 3–4 m long, glabrous. *Leaves* narrowly ovate, 10–16 cm long, 2–3 cm wide, cuspidate at apex, obtuse at base, glabrous above, pilose on the nerves beneath. *Petioles* 1–1.5 cm long. *Bracts* sessile or with a short, untwisted petiole, narrowly ovate, 3–5 cm long, 0.5–1 cm wide, acute to obtuse at apex, slightly puberulous to ± glabrous. *Cymules* 15–50, two- or three-flowered, pedicels slightly pilose to ± glabrous, primary pedicels 2–3 cm long. *Bractlets* narrowly ovate, 1.7–3 cm long, 0.4–0.6 cm wide, slightly puberulous. *Sepals* narrowly obovate to narrowly elliptic, 3.3–4.0 cm long, 0.6–0.9 cm wide, with a 0.6–0.8 cm long, curved horn 2–3 mm below the apex (Fig. 5 E), externally light red and slightly puberulous, internally whitish. *Petals* spathulate, unguiculate (Fig. 5 D–E), 4.5–4.9 cm long, 1.2–1.4 cm wide, white with reddish mid-nerve and dark violet spots on both sides. *Filaments* filiform, as long as the petals or somewhat shorter, glabrous. *Anthers* elliptic, 0.5–0.7 cm long. Pollen grains (75–)85–95 μm long, with auricles, flesh-coloured. *Ovary* semiglobose to turbinate, ± densely pilose. *Style* as long as the petals, glabrous. Stigma branches 3–4 mm long. *Fruit* unknown.

Specimens studied. Ecuador. Tungurahua: Vicinity of Río Pastaza at Río Topo, 1240 m, 13.IX. 1933, Diels 1007 (B) – Colonia México, III. 1969, Lugo 652 (GB) – *Pastaza:* Mera, 1100 m, 21.XI. 1955, Asplund 18550 (S) – Mera, 1100 m, 26.VII. 1968, Lugo 144 (GB).

Bomarea ceratophora is known from the E slopes of the Andes in the central part of Ecuador. It is climbing in mountain rain forest.

B. ceratophora is closely related to *B. pardina,* but separated by the long horns on the sepals and the spathulate petals. Furthermore the flowers are generally smaller and the leaves longer and proportionally narrower.

Acknowledgements. I am indebted to Dr U. Eliasson for much advice and valuable criticism. I am also grateful to Professor G. Harling and Mr L. Andersson for help in various ways, and to Professor Åke Fridh for his help with the Latin diagnosis.

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Contribution to the Taraxacum flora of Nordrhein-Westfalen

Carl Ingemar Sahlin

Sahlin, C. I. 1977 04 15: Contribution to the Taraxacum flora of Nordrhein-Westfalen. *Bot. Notiser 130:* 61–70. Stockholm. ISSN 0006-8195.

The following new species are described: *T. distantijugum* Sahlin, *T. eudontum* Sahlin, *T. oinopopodum* Sahlin, *T. semicurvatum* Öllg., *T. virellum* Hagl. ex Sahlin and *T. fridenii* Sahlin, all belonging to sect. *Taraxacum*.

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During 1969–1975 I have had the opportunity of studying the *Taraxacum* flora of Nordrhein-Westfalen and of making six excursions in the area. About 140 species were found and determined. I estimate this figure to be equivalent to 40–50% of the total number of species in the area.

The most common species are *T. alatum* Lindb. fil., *T. ancistrolobum* Dt., *T. atrovirens* Dt., *T. exsertum* H., v. S. & Z., *T. hamatiforme* Dt., *T. lamprophyllum* M. P. Chr. and *T. pannucium* Dt. *T. alatum* is distributed throughout Europe. Five (excepting *T. exsertum*) have a suboceanic distribution in northern Europe and may be expected in such a list for Nordrhein-Westfalen. The *Taraxacum* flora of suboceanic Europe is well-known from the works of H. Dahlstedt, J. L. van Soest and his collaborators, M. P. Christiansen, and others. The majority of the species were identified without difficulty.

T. exsertum is a good example of a smaller group, which has a Dutch-German distribution, following the big rivers upstream from the Rhine Delta, with a slight extension to the sides. A second group of less common species enters Nordrhein-Westfalen from the southwest, extending to northern or central France. Finally, there is also an eastern element, a group of species especially found in the Sauerland. In these three geographical groups there remains a few undescribed species. I have chosen six of them to be treated here. All belong to the section *Taraxacum* (syn. *Vulgaria* Dt.)

My own collections (abbreviated CIS) are kept in my private herbarium. The voucher specimens of J. L. van Soest (abbreviated v. S.) are deposited in Rijksherbarium at Leiden (L).

T. distantijugum Sahlin sp. nov. – Fig. 1

Holotypus: Germany, Nordrhein-Westfalen, Kreis Meschede: a lay-by 4 km N of Meschede at the road to Lippstadt, 12.V. 1972 Sahlin (S).

Planta sat gracilis, 10–12 cm alta. *Folia* elliptica, gramineo-viridia, 3–4-juga, parce araneosa–sugglabra. Lobi laterales distantes, anguste deltoides–lineares, patentes–leviter retroversi, dorso sat recto et dentibus paucis tenuissimis et singulis robustis praeditis, in margine inferiore non raro denticule unico instructis, in apicem subsensim angustati. Lobus terminalis magnus et sagittatus, saepius in uni vel utroque latere semel aut bis profunde incisus, in apicem apiculatum, plerumque integer. Interlobia longa et angusta, plerumque integra vel interdum dentibus singulis instructa, vulgo piceimarginata–piceimaculata. Petiolus sat angustus, aeque ac dimidia–praecipua pars nervi mediani lucide rubro-violaceus. *Scapi* foliis superantes, ± roseocolorati et parce araneosi. *Involucrum* sat parvum, ad 15 mm altum, sat obscure viride, basi ovata. Squamae exteriores linearis, 1.5–2 mm latae et 8–10 mm longae, patentes, rubrocoloratae, in apicem sat sensim attenuatae, conspique marginatae. *Calathium* aureum. Ligulae marginales extus stria cano-violacea coloratae. Ligulae interiores apicibus non raro purpurascentibus. Antherae polliniferae.

Fig. 1. *Taraxacum distantijugum* Sahlin. Holotypus.

Stigmata sicca sat atra. *Achenium* parvum c. 2.6 mm longum (pyr. incl.), superne spinulosum caeterum tuberculatum et laeve, in pyramidem c. 0.3 mm longam, brevissimam conicam et sat abrupte abiens.

T. distantijugum is easy to recognize. Its leaves are particularly characteristic with their more or less black-violet coloured interlobes, the long and narrow lobes with few large teeth on the distal margin and the large incised terminal lobes. *T. distantijugum* does not seem to have any close relatives.

This species apparently represents the eastern element in the *Taraxacum* flora of Nordrhein-Westfalen. I have not seen the species in the western part of Germany or in France, but in Austria:

Austria. Burgenland: Leithagebirge, Kaisersallé at the road to Kaisersteinbruch, 15.V. 1976 CIS.

T. eudontum Sahlin sp. nov. – Fig. 2

Holotypus: The Netherlands, Zuid-Holland: Hazerswoude, Dorp 7.V. 1973 Sahlin & van Soest (S).

Planta mediocriter alta. *Folia* suberecta, oblongo-

Fig. 2. *Taraxacum eudontum* Sahlin. Holotypus.

lanceolata, sat laete viridia, araneosa, 5–7-loba. Lobi laterales sat approximati, non raro alternatis, superiores basi lata, deltoides, dorso ± convexo vulgo dente unico et robusto lobo ± parallelis praedito, in apicem saepe abrupte abeuntes et basi eiusdem interdum geniculata, apice sat longo, acutiusculo, patente–leviter retroverso et circa medium saepe ± dilatato, in margine inferiore ad basin apicis dente unico et robusto armifero; inferiores angustiores deltoides–falcati, in dorso sat crebre denticulatis–integro. Lobus terminalis sat parvus, hastato-triangularis, integer, supra lobulos basales interdum leviter incisum vel contractum, acutum. Anguli loborum obtusi vel interdum sat orbiculati et plicati. Petiolus angustus, pallidus; nervus medianus apicem versus leviter vinosus. *Scapi* foliis superantes, sub involucri ± floccosi, virescenties. *Involucrum* mediocre, ad 20 mm altum, sat atroviride. Squamae exteriores lanceolatae–late lanceolatae, 3–4 mm latae, 9–12 mm longae, arcuato-patentes, conspique marginatae, mucronatae, supra canescens saepe rubrocoloratae; interiores 2.5–3 mm latae. *Calathium* luteum, subradians. Ligulae marginales subtus stria cano-violacea coloratae. Ligulae interiores apicibus purpurascentibus. Antherae polliniferae. Stigmata sat lutescentia–virescentia. *Achenium* stramineum, c. 3.7 mm longum (pyr. incl.), vix 1 mm latum, superne spinulosum inferne parum rugosum–fere laeve, in pyramidem 0.5 mm longam, late conicam sensim abiens.

The geniculate lobes with the large tooth in the lower margin and the pallid petioles of *T. eudontum* are reminiscent of some of the species related to *T. undulatum* Lindb. fil. & Markl. Thus the species has been confused with *T. sinuatum* Dt. (1925). The petioles of the latter are, however, more or less red, often bright red. Its lobes are mostly deltoid and largely dentate. The terminal lobe of the outer leaves is small and triangular, that of the inner leaves long, broad and ovately triangular with a broad and more or less obtuse apex.

There are two forms of *T. sinuatum*. The second has been described as *T. surrigens* Dt. & Ohlsén (1935), but was later on recognized as *T. sinuatum* by Borgvall (1957). The two forms have achenes of different length. As Dahlstedt has given erroneous cone lengths for both (1925, 1935) I give new measurements (in mm):

Character	*sinuatum*	*surrigens*
Achene excl. cone	3.10–3.50	3.55–3.95
Cone	0.50–0.70	0.45–0.65

T. eudontum thus resembles the true *T. sinuatum*. It has pallid petioles, narrower and longer lobes, and a smaller terminal lobe abruptly

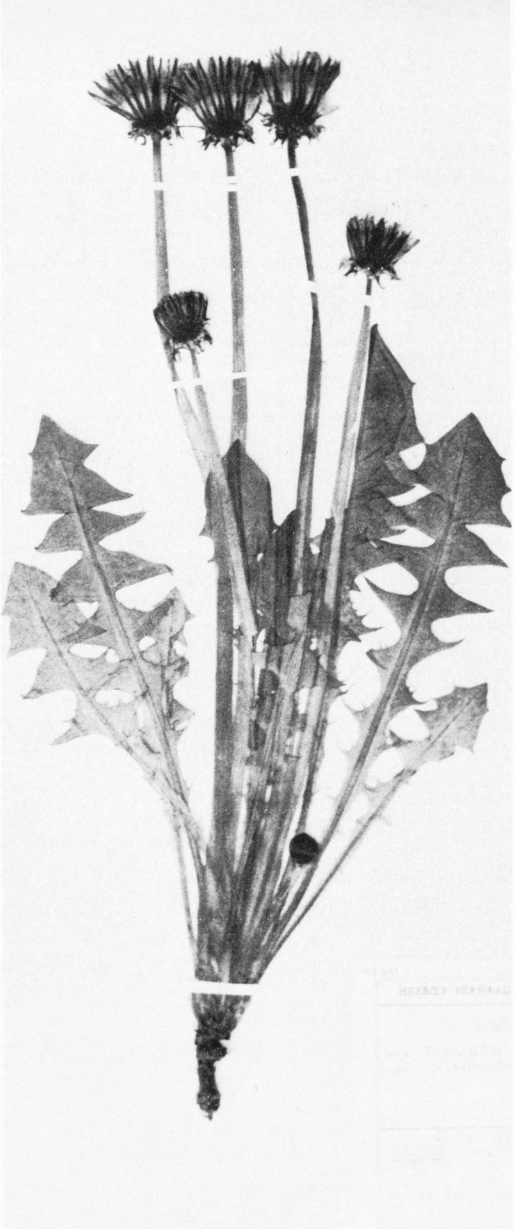

Fig. 3. *Taraxacum oinopopodum* Sahlin. Holotypus.

narrowed into a long and acute apex. Its achenes are a little shorter too. The small terminal lobe distinguishes *T. eudontum* from *T. undulatum* Lindb. fil. & Markl., *T. subaurosulum* M. P. Chr. and others.

T. eudontum is also related to a species group represented by *T. pannucium* Dt. and *T. macrolobum* Dt. It has earlier been identified with *T. lacerilobum* Dt. as there are some similarities to their leaves. But the latter differs considerably by having much narrower outer bracts, only 2 mm wide, and achenes 2.55 + 0.95 = 3.50 mm in length, according to my control of the type specimen in Oxford. The cone of *T. lacerilobum* is thus distinctly longer.

The Netherlands. Gelderland: Linge opposite Asperen, 7.V. 1960 v. S. et al.; 6.V. 1967 CIS, v. S. et al. – Buren, 7.V. 1960 v. S. et al. – Spijk, on Linge, 6.V. 1967 v. S. et al. – Stokkum, 3.V. 1953 v. S. – *Noord-Holland:* along the N. Holland Kanaal, 15.V. 1971 v. S. et al. – *Zuid-Holland:* Ablasserdam, humid pasture along Nieuwe boezen, and E Ameide along the river de Lek, 5.V. 1949 Haglund & v. S. (S). – Gouda, Scheepsvaart Kanaal and Waddriwver, both 12.V. 1958 v. S. – The Hague, Duin Tapijweg, 15.V. 1947 v. S. – Haastrech Stolwijk, 20.IV. 1957 Groot. – Leidschendam, Vliet, 4.V. 1941 v. S. – Poortugaal, on Oude Maas, 29.IV. 1967 v. S. & Zevenbergen; 29.IV. 1973 v. S. – Scheveningen, Pompstationsweg, 2.V. 1949 Haglund & v. S. (S). – Voorburg, the national motor road, 28.IV. 1949 v. S. – Brinkenhorstpolder, 25.IV. 1971 v. S. – Warmond, 6.V. 1953 v. S. – Woerden, at Valk Boumanlaan, 7.V. 1965 v. S. & v. d. Voo. – Zevenhuizen, 20.IV. 1948 v. S. – Zwammerdam, 7.V. 1965 Insje. – *Noord-Brabant:* Hoge en Lage Zwaluwe, lage Zwaluve and Jachthaven, 3.V. 1972 CIS & v. S.

Belgium. Luxemburg Belge: Marche-en-Famenne, 6.V. 1970 CIS.

Germany. Altenkirchen: 2 km W of Friesenhagen at the road to Bettorf, 11.V. 1972 CIS. – *Euskirchen:* Zülpich-Sinzenich and Blankenheim-Alendorf, 9.V. 1973 CIS.

France. Pas-de-Calais: Marquion 25 km ESE of Arras at Canal du Nord, 7.V. 1970 CIS.

T. oinopopodum Sahlin sp. nov. – Fig. 3

Holotypus: France, Essonne: the forest Verrières-le-Buisson between Verrères and Carrefour des Abbés, 12.V. 1973 de Retz (S).

Planta mediocris, 30 cm alta. *Folia* erecta, oblonga–spatulata, prasino-viridia, glabra, lobata. Lobi laterales sat approximati, oppositi vel non raro alternati, triangulares–subdeltoides, patentes, superiores integri et inferiores subulato-dentati, acuti. Lobus terminalus sat magnus, ovato-triangularis et hastatus, sat acutus, uno vel utrique latere profunde incisus vel uno–duobus dentibus praeditus. Anguli loborum obtusi. Petiolus sat angustus, aeque ac inferiore pars nervi mediani rubroviolaceis. *Scapi* foliis breviter superantes, glabri, virides. *Involucrum* sat parvum, 10–15 mm altum, olivaceo-viride, basi ovata. Squamae exteriores lineari-lanceolatae, 2–3 mm latae, c. 15 mm longae, recurvatae, supra griseo-virides, in apicem sensim attenuatae, inconspique marginatae. *Calathium* aureum. Ligulae marginales extus stria cano-violacea ornatae. Ligulae interiores apicibus purpurascentibus. Antherae polliniferae. Stigmata sicca obscura. *Achenium* stramineum, 3.1–3.4 mm longum (pyr. incl.), ad medium latissimum superne breve spinulosum ceterum usque ad medium tuberculatum inferne laeve, in pyramidem 0.4–0.6 mm longam subcylindricam sat abrupte abiens.

At a first glance *T. oinopopodum* seems to belong to the same group as *T. hamatum* Raunk. and its relatives. It has, however, rather characteristic leaves and outer involucral bracts. At the moment no close relatives are known and *T. oinopopodum* stands isolated in the section.

The type collection is rather comprehensive. The description is based on this material. The species is also found in Nordrhein-Westfalen. Its three localities indicate a centre of distribution in southwestern or central France.

Germany. Euskirchen: Zülpich, between Geich und Zülpich, 9.V. 1973 CIS. – *Grevenbroich:* Oekoven, Römerstrasse 5.V. 1975 CIS.

T. semicurvatum H. Öllgaard sp. nov. – Fig. 4

Holotypus: Denmark, Jutland, TBU-distr. 25: Skibet, roadside c. 200 m W of the church, 26.V. 1970 Öllgaard (C).

Planta mediocris. *Folia* crispula, obscure viridia, interlobiis piceo-coloratis, lobis interdum ± piceo-maculatis, petiolis alatis–alatissimis, leviter roseis, nervis medianis leviter sordide-roseis. Folia exteriora linguata, araneosa, obtusa–subobtusa, c. 3 binilobi; lobis 10–13 mm latis, hamatis, subobtusis, integris vel dentibus singulis brevibus instructis; interlobiis 0–8 mm longis, alatis, leviter piceatis; integris vel uno dente instructis; lobo terminalis mediocri, marginibus superioribus valde convexis, saepe uno dente lato et brevi instructis, marginibus inferioribus rectis–paulum concavis. Folia intermedia late lanceolata, manifesto araneosa, c. 5 binilobi; lobis 13–15 mm latis, quoque lobo aut hamato, ad apicem sensim angustato, margine superiore partis basalis saepe dente praeteriente instructo, aut patente, parte basali lata, integra vel parce subulata, parte exteriore ± late lineari, ± porrecta, marginibus inferioribus omnium loborum integris (vel interdum levissime subulatis); interlobiis alatis, 5–15 mm longis (inter lobum terminalem et summos lobos interdum 0), ± piceatis, irregulariter ± dentosis; lobo terminali mediocri, late cordato-ovato, obtuso–subobtuso, marginibus superioribus convexis, saepe irregulariter incisis, dentatis vel sine dentibus, apicibus sectionum basalium saepe rotundatis, marginibus inferioribus rectis vel paullo concavis. Folia interiora intermediorum simila; lobis terminalibus majoribus; lobis magis dentatis, magis piceato-maculatis. *Scapi* foliis aequantes vel superantes, ± cupreo-colorati, araneosi, maxime in superiore parte. *Involucrum* 13–15 mm longum, c. 9 mm latum, obscure viride, levissime pruinosum, squamis exterioribus 2.5–4 mm latis, ad 16 mm longis, ± retroversis, supra griseo-viridibus, subtus obscure viridibus, apicibus leviter corniculatis, rubescentibus, non marginatis vel interdum inconspicue marginatis. *Calathium* convexum, c. 50 mm diam., sat obscure luteum, ligulis marginalisbus subtus stria griseo fusca ornatis, apicibus florum interiorum ± rubris. Antherae polline carentes vel (raro) parce polliniferae. Stylus et stigmata virescentes. *Achenium* griseo-fuscum, 3.8–4.0 mm longum (pyr. incl.), superne crasse spinulosum, saepe squamuloso-spinulosum, ceterum dense ± manifesto verrucosum, pyramide subconica, c. 0.5 mm longa, sat abrupte abiente.

I am indebted to H. Öllgaard for this description and the following remarks: *T. semicurvatum* is a characteristic species, which is easy to recognize by its crispate, tar-coloured leaves with fairly round terminal lobes, the slightly irregular lobes and the faintly rose petioles. As a rule no pollen is formed. However, in one head of a cultivated plant pollen was formed. Since all of more than 50 spontaneous plants investigated lacked pollen, the presence of pollen seems to be an exception. At present *T. semicurvatum* is known only from Denmark and Nordrhein-Westfalen:

Germany. Lübecke: Blasheim 3 km W of Lübecke, 9.V. 1969 CIS.

In my opinion *T. semicurvatum* is close to *T. scotiniforme* Dt. It differs by lacking pollen and by having shorter and more obtuse terminal lobes and paler petioles.

T. virellum Haglund ex Sahlin sp. nov. – Fig. 5

T. virellum Haglund ex Hylander: Förteckn. skand. växter I, ed. 3, 1941 p. 136, nomen.

Holotypus: Västergötland, Sweden: Borås, Daltorpsskolan (map 7 C 0 f), 6.VI. 1946 Sandberg (S). Cotypus fructifer: Borås, Ekenberg (7 C 0 f), 6.VI. 1937 Sandberg (S).

Planta mediocris, 15–40 cm alta. *Folia* erecta, sat oblonga, sat obscura et prasino-viridia, canescentia, 2- ad 5-lobata, araneoso-pilosa et sat firmula. Lobi laterales sat breves et lati deltoides–triangulares, superioribus in dorso convexulo et integris, inferioribus aeque ac lobi foliorum interiorum in dorso subrecto et subulato-dentatis, in apicem patentem et acutum. Lobus terminalis nunc sat magnus nunc minor, triangularis et hastatus, in apicem acutum et saepe mucronatum, in foliis exterioribus saepius in uno vel in utroque latere profunde incisus et supra

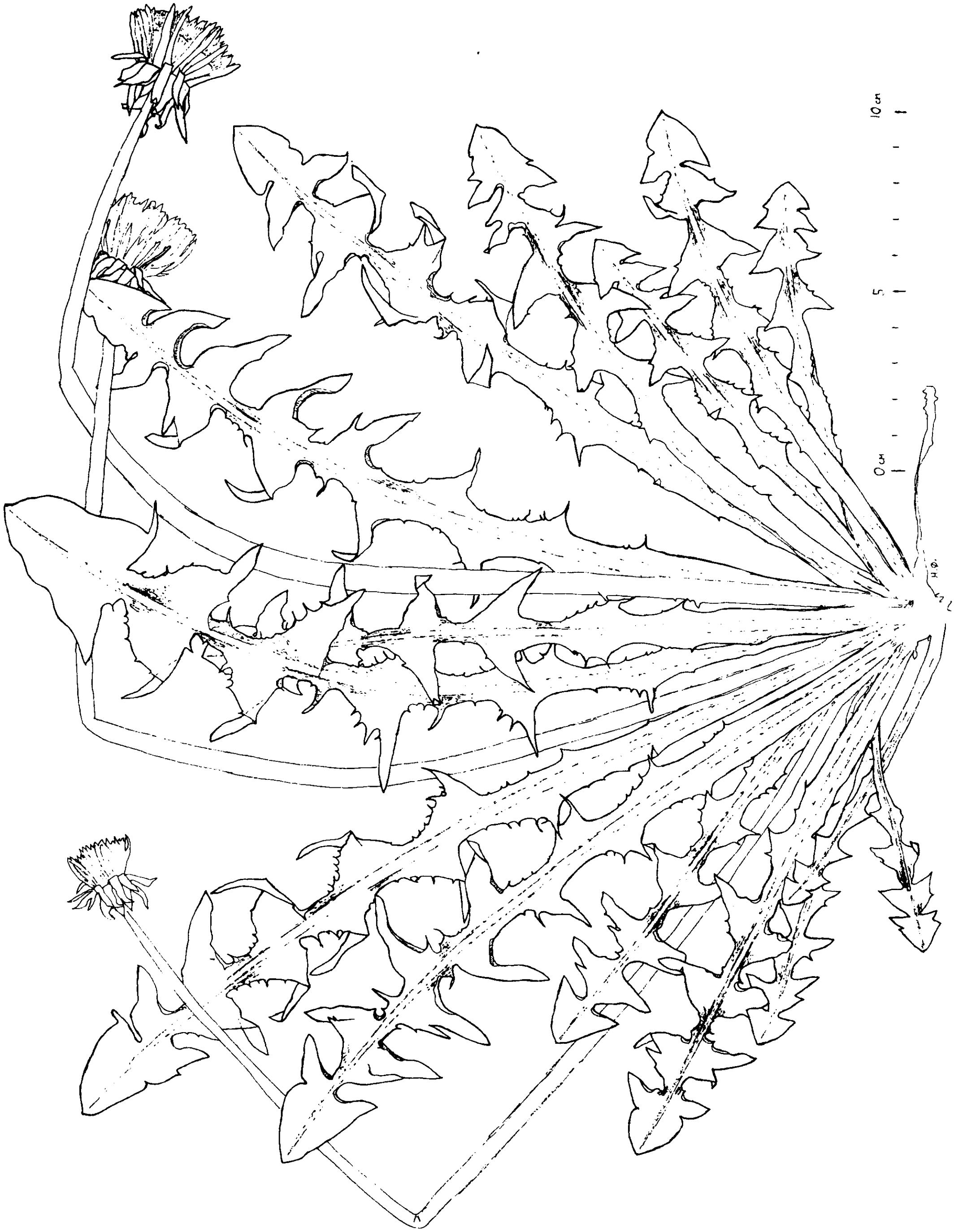

Fig. 4. *Taraxacum semicurvatum* Öllg. Holotypus. Öllgaard pinxit.

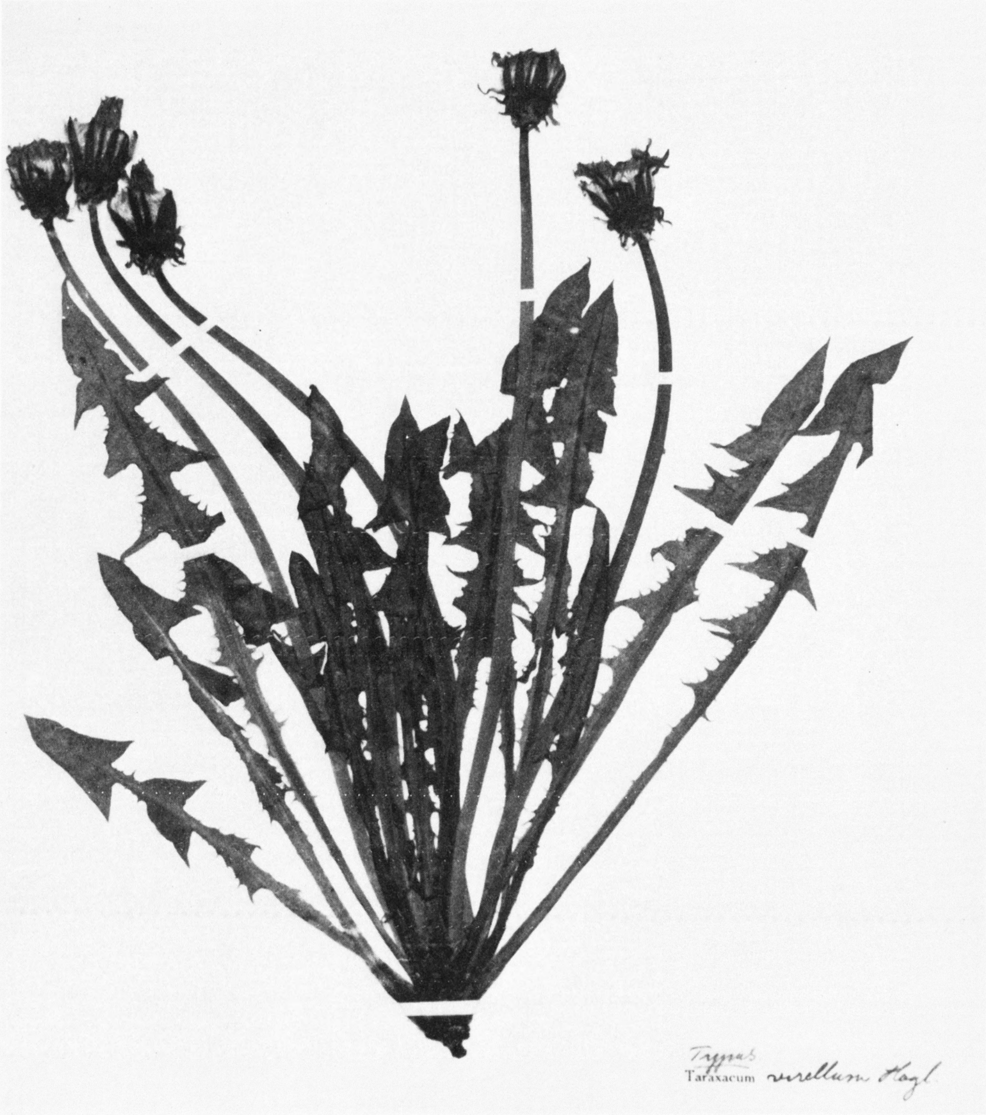

Fig. 5. *Taraxacum virellum* Haglund ex Sahlin. Holotypus.

incisuram margine rotundatus, in foliis interioribus supra lobulus basales semel et saepius profunde incisus. Interlobia in foliis interioribus sat angusta et subintegra vel dentibus singulis–pauci instructa, in foliis exterioribus nullis praedita. Petiolus subalatus, rubroviolaceus. *Scapi* foliis aequilongi vel ea breviter superantes, sub involucri ± araneosi, virides. *Involucrum* mediocre–sat parvum, ad 21 mm longum, olivaceo-viride, basi ovata. Squamae exteriores lineares, c. 2 mm latae et 14 mm longae, retroversae et apicibus saepe ± porrigentibus, supra laetiores, in apicem longum et sensim attenuatae, inconspique–haud marginatae. *Calathium* laete luteum ad suggilvum, sat plenum. Ligulae marginales extus stria fuscoviolacea ornatae, omnes dentibus croceis praediteae. Antherae polliniferae. Stigmata sicca sat obscura vel raro sublutea. *Achenium* hepaticum, 3.6–4.0 mm longum (pyr. incl.) et 0.8 mm latum, supra medium latissimum et sat breve et acute spinulosum, inferne ± laeve, in pyramidem anguste conicam 0.7–0.9 mm longam, sat abrupte abiens.

Fig. 6. *Taraxacum fridenii* Sahlin. Holotypus.

The leaves of *T. virellum* are very similar to those of *T. copidophyllum* Dt., but the involucres of the two taxa are quite different and they are not closely related. On the contrary, *T. virellum* seems to be related to *T. sterneri* Hagl., which grows in the same area on the European mainland. They differ *inter alia* by the hairiness of the leaves, the length of the outer bracts and the width of the petioles. *T. virellum* is also somewhat similar to, e.g., *T. fennorodiae* Hagl., but the latter and its relatives have shorter cusps on their achenes.

The localities of the two species *T. virellum* and *T. sterneri* are grouped in a zone around the Moselle. I have earlier described seven new species from this region (1975). My impression is that all have their centre of distribution in France and thus have entered Germany from SW. Representative specimens are:

Germany. Jülich, at the main road to Aachen, 6.V. 1970 CIS. – *Ingbert:* St. Ingbert-West, 10.V. 1970 CIS. – *Rhein-Hunsrück-Kreis:* Boppard on the Rhine, 3.V. 1971 CIS.

Sweden, Västergötland: Borås, Druvefors in a meadow on the river Viskan (7 C 0 f), 28.V. 1941, Hulta at the house of Good Templars (7 C 0 g), 6.VI. 1937, the fish ponds at Rya (7 C 1 f), 16.V. 1936, all Sandberg (S).

T. fridenii Sahlin sp. nov. – Fig. 6

Holotypus: Sweden, Västergötland: Trollhättan, a ravine 400 m N of Karlsberg (map 8 B 4 i), 27.V. 1960 Fridén (S).

Planta mediocris, c. 15–25 cm alta. *Folia* adscendentes, elliptica–ovalae, sat gramineo-viridia, canescentia, sat firmula. Folia extima et exteriora sat paucilobata, extima sat glabra ceteri araneosi; lobi laterales approximati, oppositi, triangulares, breves et basi sat lata, dorso recto et dentibus paucis praedito, in apicem brevem, patentem et subacutum; lobus terminalis mediocris, sat ovatus, hastatus, acutiusculus–subobtusus, supra lobulus basales interdum dentibus unis vel duobus et robustis praedito; anguli loborum plicati. Folia interiora integra et sinuoso-dentata vel paucilobata, araneosa; lobi laterales distantes, deltoides breves et basi sat lata, dorso raro dentatis interdum lobulato-inciso, in apicem patentem–recurvum; lobus terminalis saepe indistincte determinatus et grosse inciso, dentatus; interlobia et anguli loborum atrimarginata. Petiolus late alatus, pallidus. *Scapi* foliis breviter superantes, subaraneosi ad glabrescentes. *Involucrum* mediocre, c. 15 mm altum, olivaceo-viride. Squamae exteriores lineari-lanceolatae, 2.5 mm latae, c. 11 mm longae, patentes–recurvatae, superne laete griseo-virides et ± rubroviolaceae, subtus piceae, in apicem abrupte contractum et saepe ciliatum, anguste sed conspique marginatae. *Calathium* luteum–aureum, sat densum. Ligulae marginales sat breves, extus stria atroviolacea et marginibus rubro-purpureis–laete rubro-purpurea ornatae, omnes dentibus purpureis praeditae. Antherae polliniferae. Stigmata virescentia. *Achenium* fusco-olivaceum, 3.6–3.9 mm longum (pyr. incl.), supra medium latissimum, superne squamuloso-spinulosum, medio breve spinulosum et inferne ± valde tuberculatum, pyramis 0.65–0.85 mm longa, conico-cylindrica, interdum spinis binis et brevibus praedita, sat sensim abiens.

T. fridenii is characterized by its broad, pallid petioles, large, ovate or triangular terminal lobes and flowers with red stripes and red teeth. It is close to *T. insigne* Ekm., but the latter has a small terminal lobe of more triangular shape and its side lobes are often armed with a robust tooth. The flowers of *T. insigne* lack the red stripes and red teeth. The large terminal lobes and the broad petioles of *T. fridenii* are also reminiscent of *T. alatum* Lindb. fil. but *T. fridenii* differs markedly by its red-coloured flowers.

The species is named after L. Fridén Rev., Trollhättan, authority on the flora of Västergötland. Representative specimens are only found at three localities in the northern part of Trollhättan, Sweden. But the town has close connexions with the Continent by the canal navigation to the industries around Vänern. Thus a Dutch-German origin of this species might be assumed. It has also been preliminarily identified both in the Netherlands and Nordrhein-Westfalen, but reconsiderations of the specimens calls the determinations into question. These are my reasons for including its description in this paper, hoping that it will be recognized in Nordrhein-Westfalen.

Sweden. Västergötland (all map 8 B 4 i): Trollhättan, the ravine 400 m N of Karlsberg 26.V. 1954, 2.VI. 1954, 4.VI. 1957, 17.V. 1960, 2.VI. 1960 and 14.VI. 1963 Fridén (S); 24.V. 1968 Lundevall, CIS, v. S. and Såltin (H, L). – Trollhättan, the ravine W of Nybergskulla 2.VI. 1962, 14.VI. 1963 Fridén (S). – Trollhättan, the ravine S of Hult 27.V. 1954 Fridén (S).

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Chromosome numbers and taxonomy in Cryptocoryne (Araceae)

Niels Jacobsen

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Chromosome numbers for 34 species of *Cryptocoryne* are reported. They represent a heteroploid series with the secondary basic numbers 11, 14, 15, 17, 18. Triploids have been found in several species, and they, as well as some of the tetraploids and hexaploids, have reduced pollen fertility but are able to reproduce vegetatively. It is possible to make a subdivision of the genus based on chromosome number, morphology and geography. The basic evolutionary event in the genus was the establishment in different areas of taxa with different chromosome numbers. Upon this basis, adaptive radiation between different river systems has given rise to a great number of species, many of which are narrow endemics. The spathes of most of the species discussed are illustrated in colour. One new combination, viz., *C. sarawacensis* (Rataj) Jacobsen stat. nov. is made.

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Cryptocoryne is a natural but polymorphic genus. It occurs in India, Sri Lanka, Bangladesh, the Indo-Chinese peninsula, Java, Sumatra, Borneo, New Guinea, and the Philippine Islands. The species are aquatic or amphibic.

More than 60 species are known, and most of them are endemics, a feature rare in water plants. Many more species are likely to be discovered in the future. Since Engler's monograph in 1920, three major papers have appeared on the taxonomy of *Cryptocoryne,* viz., Petch (1928), de Wit (1971) and Rataj (1975 a); recently the present author (N. Jacobsen 1976) has dealt with the species of Sri Lanka. Chromosome numbers have previously been reported for about 20 species (Tjio 1948, Pancho 1971, Marchant 1972, Legro 1967, Legro in de Wit 1971, and Sarkar et al. 1976).

The present paper is a link in a project dealing with taxonomy and evolutionary patterns in *Cryptocoryne*.

Material and methods

The material was cultivated in the hothouses of the Botanical Garden of the University of Copenhagen. Many of the plants were originally imported commercially by aquarium dealers, and for these plants the exact origin is not known. Singapore is one of the main export centres for aquatic plants which are brought in from all over South and South East Asia. This has led to confusion as to the origin and natural distribution of the species. Importers' information should be taken with some caution.

Cytological preparations were made from root tips according to the method described by P. Jacobsen (1957) with smaller modifications. Excised roots were pretreated in 0.1% colchicine for three hours in the dark at 20°C and then fixed in lactic acid/alcohol at 0°C. For species with high chromosome numbers a saturated solution of alphamonobromonaphthalene was used for pretreatment. The meristematic regions were squashed in cold 45% acetic acid, stained with pyronine for 20–30 minutes, and mounted in Canada balsam. Staining was improved if the fixations were stored for at least three days at − 15°C. Fixations have been kept at this temperature for up to 18 months without any deleterious effects.

To estimate the male fertility, pollen was stained with cotton blue, and the percentage of well-developed, stained, non-vacuolized grains was calculated. Two hundred grains were counted twice and the mean was calculated. Strid (1970) describes the sources of error and the reliability of the method.

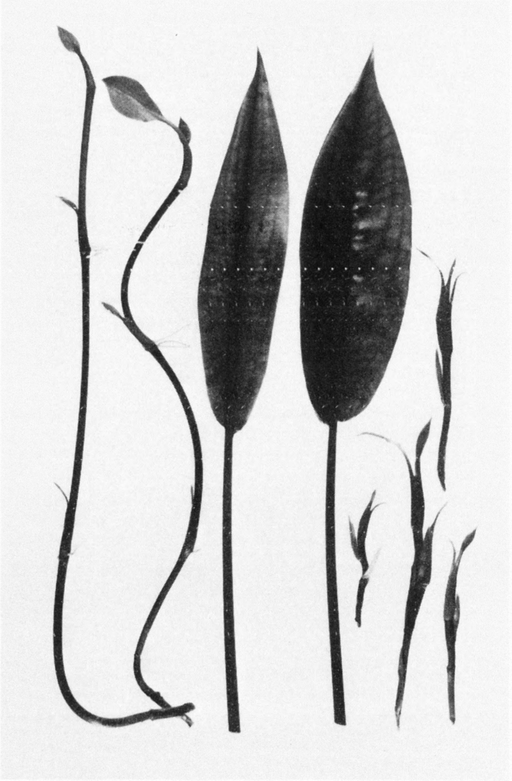

Fig. 1. *Cryptocoryne ciliata*. Leaves and runners of a plant with 2n = 22 (left) and 2n = 33 (right).

Voucher specimens are placed in the Botanical Museum, University of Copenhagen (C) under the number cited, and living plants are cultivated in the Botanical Garden.

Chromosome numbers previously reported

Comments on the counts are given under the species, but a general comment is given here.

Voucher specimens of Legro's (1967, 1971) counts do not exist, but I am inclined to regard most of them as correct. Two species, *C. grabowskii* Engler and *C. tortilis* De Wit, are reported to have 2n = 34 (Legro 1971). I have not had material of the two species.

Unfortunately, Marchant's (1972) voucher specimens are deposited very incompletely in the herbarium at Kew. It has only been possible to locate 7 herbarium specimens (of 14) which may originate from the plants studied by Marchant, but none of them is marked in any way. At Kew Gardens it has been possible to locate and obtain 3 living plants which may be identical with some of Marchant's material. "Kew Entry Numbers" (K.E.N.) do not always refer to single plants but are batch numbers that are applied to all plants received from the same source or shipment. After flowering and determination, the plants are given additional, unambiguous numbers (cf. Marchant 1972 p. 396 and 398, where several plants have the same number). Apparently only few of the *Cryptocoryne* at Kew Gardens had been verified when Marchant undertook his work. An attempt to match Marchant's plants with material from the herbarium and garden at Kew gave the following results: *C. affinis* K.E.N. 450(=430?)-63: One fertile herbarium specimen. – *C. affinis* K.E.N. 332-54: No material. – *C. beckettii* K.E.N. 518-49: Two fertile herbarium specimens, and one living plant. – *C. ciliata* K.E.N. 493-59: No material. – *C. ciliata* K.E.N. 460-67: One herbarium specimen. – *C. griffithii* K.E.N. 513-63: No material. – *C. longispatha* K.E.N. 723-68: One fertile herbarium specimen which has been determined by Rataj as *C. tonkinensis*. – *C. lutea* K.E.N. 358-57: No material. – *C. "nevillii"* K.E.N. 332-54: No material. – *C. purpurea* K.E.N. 86-68: Three sterile herbarium specimens with pickled spathes labelled: *affinis, cordata,* and *purpurea*. They belong to *C. affinis, C. griffithii,* and *C. purpurea,* respectively. – *C. thwaitesii* K.E.N. 102-67: The living plant at Kew Gardens has 2n = c. 102 and probably represents *C. blassii*. – *C.* cf. *wendtii* K.E.N. 309-67: One herbarium specimen which is *C. walkeri*. – *C. "willisii"* K.E.N. 533-48 and *C. "nevillii"* K.E.N. 533-48: Two living plants, *C. undulata* and *C. willisii* Reitz, respectively, were found at Kew Gardens. It could be that Marchant's count was made on the former. – *C.* sp. K.E.N. 203-53: No material. – *C.* sp. No. 2 K.E.N. 358-57: Two fertile herbarium specimens belonging to *C. beckettii* and one which was sterile.

Additional living plants at Kew Gardens: *C. bullosa* K.E.N. 450-63: It is a specimen of *C. wendtii* and cannot be Marchant's 530 (=550?)-63 *C. affinis*. – *C. undulata* K.E.N. 513-63: It cannot be Marchant's *C. griffithii* K.E.N. 513-63.

Rataj (1975 a) mentions several chromosome numbers but does not state the source of his information.

C. ciliata (Roxburgh) Schott – 2n = 22, 33

Material. 2n = 22: P 1958/1013 Bogor; NJ 2845 cult. – 2n = 33: 1671/6 cult.; NJ 2794 cult.; NJ 2895 cult.

Tjio (1948) reported 2n = 28 for this species. His work on tropical plants was done during a stay in Copenhagen. At that time a plant labelled *C. ciliata* was cultivated in the Botanical Garden. This plant flowered in 1956 and proved to be *C. beckettii,* and the count may refer to this species. It was not until 1958 that the Botanical Garden received true specimens of *C. ciliata*.

Legro (1971) reports 2n = 32, which could be a wrong count of 2n = 33. Marchant (1972) and Sarkar et al. (1976) reported 2n = 22.

The pollen of the plants with 2n = 33 is very defective (Table 1).

Rataj (1975 a) described two varieties of *C. ciliata,* viz., v. *ciliata* with 2n = 22 and v. *latifolia* Rataj with 2n = 32. My results fully agree with v. *ciliata* having 2n = 22 but indicate that v. *latifolia* has 2n = 33, and must be regarded as a triploid. The v. *ciliata* has rather narrow leaf-blades and long terranean, rooting stolons (up to 50 cm), which are quite firmly attached to the parent plant. The v. *latifolia* has short, erect, non-rooting stolons (up to 15 cm, branching at the internodes) which easily break off (Fig. 1). I can find no difference between the spathes of the two cytotypes.

Contrary to most of the other species *C. ciliata* has a very wide distribution. It is characterized by its terranean runners and by its habitat (close to the mouth of rivers). No doubt it has a greater colonizing ability than the other species, which are often more specialized ecologically. Nothing is known as to the distribution of the two cytotypes.

C. spiralis (Retzius) Fischer ex Wydler – 2n = 66, 88

Material. 2n = 66: Cook 327/73 Ernukalam, Kerala State; Cook 328/73 Ernukalam, Kerala State – 2n = 88: 1671/5 Calcutta; NJ 2970 cult.

Legro (1971) reported 2n = 42 (and 84), and Sarkar et al. (1976) reported 2n = 90.

The chromosome numbers indicate that the species may be tetra-, hexa-, and octoploid.

The numbers 2n = 66 and 88 indicate that *C. spiralis* may be placed together with *C. ciliata.* There are, however, differences in chromosome size and in the morphology of the plant (Fig. 2).

C. D. K. Cook, Zürich, made two collections of this species at Ernucalam, India. These plants are different from material in other parts of the range. Cook 327/73 has rather broad leaf blades with a rather long petiole, and the spathe has a very long and narrow limb. Cook 328/73 has almost linear leaves, reddish petioles, a dark green colour, and the spathe is short and compact. I can, however, find only quantitative differences between the forms, and de Wit (1971) and Rataj (1975 a) are probably right when they include *C. tortilis* and *C. huegelii,* respectively, in *C. spiralis.*

C. parva De Wit – 2n = 28

Material. 1671/16 Halloluwa; NJ 23-14 Halloluwa; NJ 22-4 Hiriwadunna.

Legro (1971) reported the same number.

C. willisii Reitz – 2n = 28

C. nevillii auct. non Trim. ex Hook. f.

Material. 1671/3 (= P 1914/114) cult.; P 1953/435 cult.; P 1966/353 cult.; NJ 2766 cult.; NJ 2897.

Legro (1971) reported the same number under *C. "nevillii".*

No material of the typical form with the yellow collar is known from nature. However, I collected some plants at Halloluwa with a dark purple collar, which no doubt belong to this taxon.

C. lucens De Wit – 2n = 28

Material. NJ 21-1 Peradeniya; NJ 21-2 Halloluwa; NJ 23-4 Halloluwa; NJ 24-3 Peradeniya; NJ 24-4 Peradeniya.

Legro (1971) reported the same number.

A specimen collected at Halloluwa, NJ 23-5, may belong to this species, but has a green limb with small purple warts and a purple collar. The leaves are larger than normally found in *C. lucens.* It is also possible that it is a hybrid.

C. beckettii Thwaites ex Trimen – 2n = 28

Material. 1671/4 cult.; NJ 2832 cult.; NJ 2902 cult.; Jayasuriya 2246 Rhuna National Park; NJ 22-2 Udamulle E of Kegalla; NJ 23-19 Halloluwa.

Legro (1971) and Marchant (1972) reported the same number. Tjio's (1948) report of 2n = 28 for *C. ciliata* no doubt refers to *C. beckettii.*

C. petchii Alston – 2n = 42

Material. 1671/12 cult.; P 1963/631 cult.; P 1965/336 cult.; P 1969/322 cult.; NJ 2769 cult.; NJ 2833 cult.; NJ 2847 cult.; NJ 2898 cult.

Legro (1971) reported the same number.

In my material there are several different variants, which can at times be hard to separate

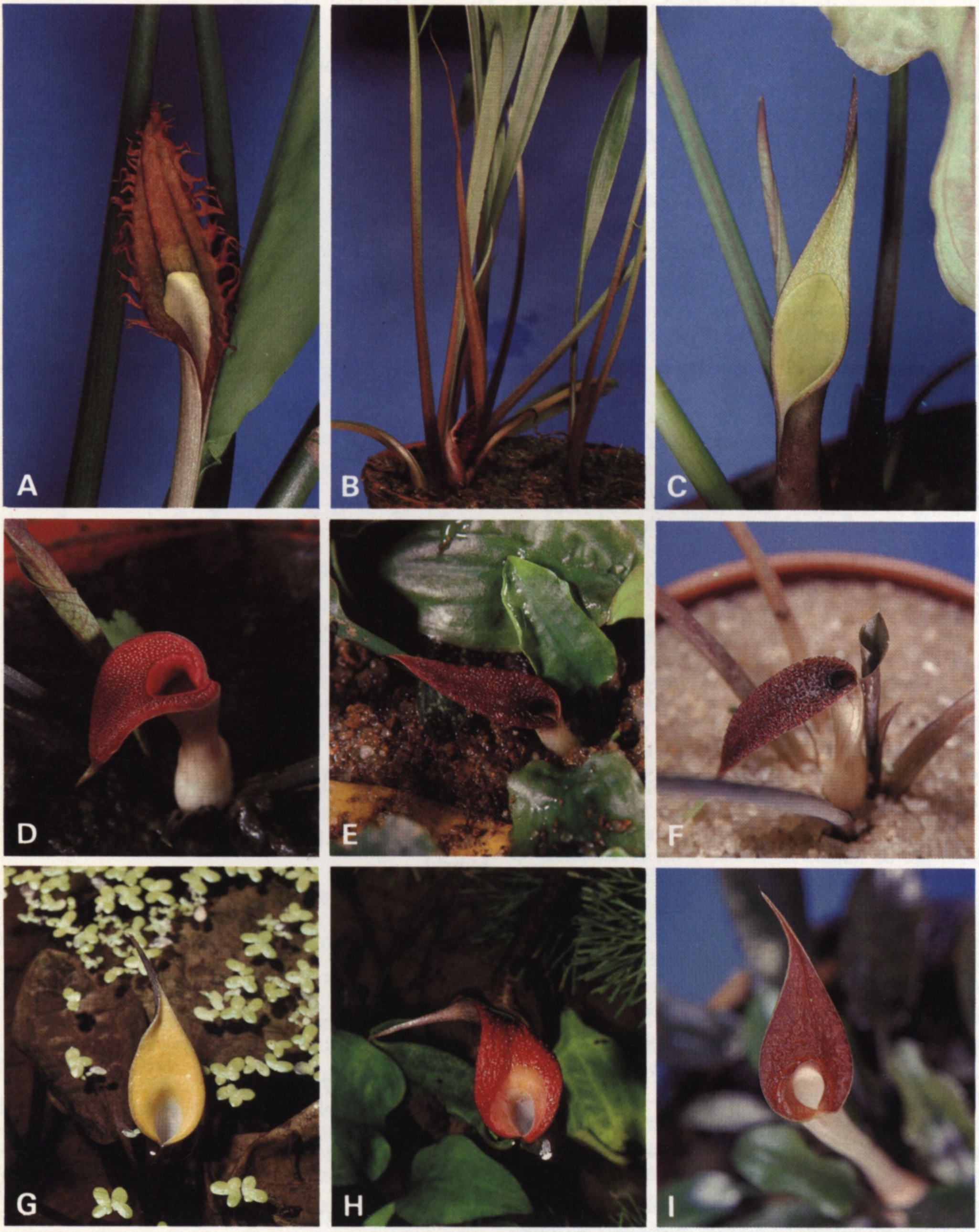

Fig. 2. A: *Cryptocoryne ciliata* (NJ 2845, 2n = 22). – B: *C. spiralis* (Cook 327/73, 2n = 66). – C: *C. pontederiifolia* (NJ 2963, 2n = 30). – D: *C. griffithii* (NJ 2805, 2n = 34). – E: *C. minima* (NJ 2990, 2n = 34). – F: *C. zewaldiae* (NJ 2912, 2n = 34). – G: *C. blassii* (1671/9, 2n = 102). – H: *C. purpurea* (P 1912/92, 2n = 34). – I: *C. jacobsenii* (NJ 2864, 2n = 34). – A, B × 0.5, I × 0.8, C–H × 1.0.

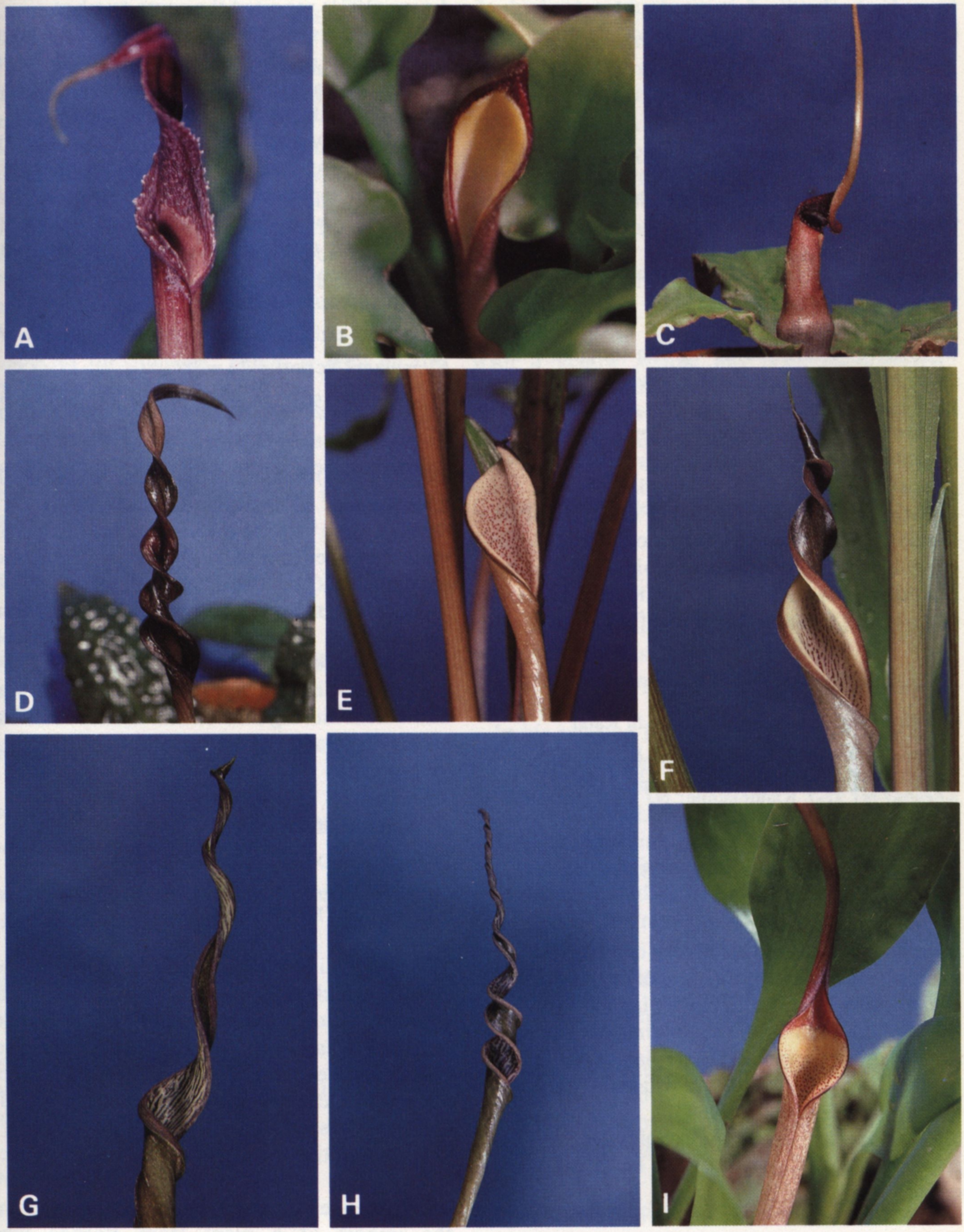

Fig. 3. A: *Cryptocoryne usteriana* (NJ 2875, 2n = 34). – B: *C. versteegii* (1671/8, 2n = 34). – C: *C. sarawacensis* (NJ 2954, 2n = 34). – D: *C. affinis* (1671/15, 2n = 34). – E: *C. costata* (NJ 2915, 2n = 36). – F: *C. albida* (1671/14, 2n = 36). – G: *C. balansae* (NJ 2893, 2n = 36). – H: *C. bertelihansenii* (Beusekom et al. 4486, 2n = 36). – I: *C. lingua* (NJ 2955, 2n = 36). – C–D × 0.8, E–I × 1.0, A–B × 1.6.

from *C. beckettii;* it is no doubt a triploid of *C. beckettii.* The pollen is highly defective.

C. wendtii De Wit – 2n = 28, 42

Material. 2n = 28: 1671/11 cult.; P 1961/342 cult.; P 1964/281 cult.; NJ 2474 cult.; NJ 2779 cult.; NJ 2867 cult.; NJ 2869 cult.; NJ 2924 cult.; NJ 2933 cult. – 2n = 42: 1671/11 a, Mi Oya; NJ 2781 cult.; NJ 2849 cult.; NJ 2855 cult.; NJ 2914 cult.

C. wendtii is one of the most polymorphic species in the genus. There are at least 8 different variants in cultivation in Copenhagen, with leaves classified as "green (normal), large red, small red, crisped red, brown, brown-green, long green, and small green."

Due to vegetative reproduction polymorphism is probably stable to some degree. The 2n = 42 plants have highly defective pollen.

Rataj (1975 a) established 5 varieties of this species. The species is polymorphic, but considering that it contains triploids, which only reproduce vegetatively, I find Rataj's basis for establishing these varieties insufficient.

C. undulata Wendt – 2n = 28, 42

C. willisii Engl. ex Baum; *C. axelrodii* Rataj

Material. 2n = 28: 1671/13 cult.; P 1961/338 cult.; NJ 2813 cult.; NJ 2825 cult.; NJ 22-1 Udamulle E of Kegalla; NJ 22-7 Kandekenne; NJ 23-2 Halloluwa – 2n = 42: NJ 3000 cult.

Legro (1971) reported 2n = 28 for *C. willisii* Engl. ex Baum.

One deviating specimen, NJ 3000, proved to have 2n = 42, and the discovery of a triploid form makes the situation quite parallel to that found in e.g. *C. wendtii.* The triploid plant differs from the diploid ones of *C. undulata,* by the much larger, silvery variegated, greyish green leaves, by the limb of the spathe which is brownish, and by the yellowish collar.

This species is in morphological respects rather close to *C. wendtii,* but lacks the purple collar.

C. lutea Alston – 2n = 28

Material. P 1963/629 cult.; P 1974/21 Halloluwa; NJ 2767 cult.; NJ 2817 cult.; NJ 2836 cult.; NJ 2853 cult.; NJ 23-1 Halloluwa; NJ 23-3 Halloluwa; NJ 23-6 Halloluwa; NJ 23-13 Halloluwa; NJ 23-20 Halloluwa.

Legro (1971) reported the same number.

C. lutea is rather polymorphic both in the leaves and in the colour and shape of the spathe; the latter can be pure yellow or densely sprinkled with purple on the outside.

C. legroi which has 2n = 42 (Legro 1971) is probably best considered a triploid form of *C. lutea,* quite parallel to *C. beckettii–C. petchii,* and to *C. wendtii* coll. Another unidentified plant which resembles *C. lutea* (NJ 2809 cult., see N. Jacobsen 1976) also has 2n = 42 and highly defective pollen.

C. walkeri Schott – 2n = 28

Material. P 1965/337 cult.; NJ 2913 cult.; NJ 2931 cult.

Legro (1971) reported the same number. The specimen at K marked K.E.N. 309-67 *C.* cf. *wendtii,* may be from the same plant as Marchant counted under that name, however, it is in fact a specimen of *C. walkeri.*

A feature most useful in the determination of this species is the broad, conspicuous collar zone, which does not rise from the surface of the rest of the limb. The spathe changes in shape and colour during anthesis as it is first stiff and green(ish), and later becomes leathery and yellow(ish).

C. pontederiifolia Schott – 2n = 30

C. sulphurea De Wit

Material. Bogner 1093 cult. (type of *C. sulphurea*); NJ 2963 cult.; NJ 2999 cult.

The species is characterized by the rather short spathe, which is brownish on the outside, and greenish yellow on the inside. The limb is rugose and has a large collar. The leaves are green but sometimes have a shining reticulate appearance which can resemble *C. sarawacensis.* The leaf margin is entire.

Uncertainties about the identity of this species have come from the presumed absence of inflorescences on the type specimen, and from the import of a plant from Borneo which resembled *C. pontederiifolia* but had a purple, caudate spathe. The Borneo plant was illustrated by van der Vlugt (1969) and by de Wit (1971) who referred it to *C. pontederiifolia.* Rataj (1975 a) described it as *C. pontederiifolia* ssp.

sarawacensis, and in the present paper it is given rank of species.

V. Sadilek, Brno, (pers. comm.) is of the opinion that *C. sulphurea* is identical with *C. pontederiifolia*. A renewed study of the holotype of *C. pontederiifolia* has revealed one crimpled spathe between the cataphylls. Although this spathe is in a bad condition I find it identical with the newly imported plant with a yellow spathe and the large collar described as *C. sulphurea*, and can thus confirm Sadilek's assumption.

W. Meijer informed me that he has collected the species on Sumatra, where it grew in the lower parts of the rivers, in the fresh water tidal zone. Part of these collections were brought to Java for cultivation, and it is possible that it is descendants of these Sumatra plants that have recently been shipped to Europe as aquarium plants.

C. griffithii Schott – 2n = 34

Material. NJ 2805 cult.; NJ 2861 cult. (WAG).

Fruiting has been observed in NJ 2805.

C. minima Ridley – 2n = 34

Material. NJ 2816 cult.; NJ 2990 cult.

C. zewaldiae De Wit – 2n = 34

Material. NJ 2912 cult.

This species is closely related to *C. minima*, but has much larger leaves.

C. siamensis Gagnepain – 2n = 68

Material. NJ 2946 cult. (WAG, C).

This species is closely related to *C. blassii*. The plant counted is the one illustrated by van Bruggen (1975).

C. blassii De Wit – 2n = 102

C. evae Rataj

Material. 1671/9 cult.; NJ 2846 cult.; NJ 2873 cult.; NJ 2807 cult.

The specimens counted were somewhat different in appearance, both with respect to leaves and spathes. The pollen is highly defective.

Rataj (1975 a) lists *C. blassii* as a synonym of *C. siamensis* v. *kerrii* (Gagnep.) Rataj. I consider, however, *C. evae* as a synonym of *C. blassii*. The latter one was described from emersed plants, which are smaller than the submersed ones (described as *C. evae*). I find no characteristics in *C. evae* which are not to be found in *C. blassii*.

C. blassii may be considered as a sterile hexaploid due to the chromosome number ($2n = 6x = 102$) and the highly defective pollen. *C. siamensis* is probably the tetraploid ($2n = 4x = 68$), but as yet no fertile diploid ($2n = 34$) with a yellow spathe has been encountered. There are great taxonomic difficulties within the group of species: *C. blassii, C. siamensis, C. cordata, C. grandis, C. kerrii* etc.

C. purpurea Ridley – 2n = 34

C. hejnyi Rataj

Material. NJ 3004 cult.; P 1912/92 cult.

The pollen is highly defective, and a hybrid origin may be possible.

Legro (1972) and Marchant (1971) reported the same number.

In his revision Rataj (1975 a) lists *C. purpurea* as a synonym for *C. cordata* Griffith. Furthermore, he describes *C. hejnyi* as a new species, a taxon which is identical with Tab. 7719 in Botanical Magazine. Apparently he is not aware of the fact that it is in the type description of *C. purpurea* Ridley states that Tab. 7719 is *C. purpurea* and not *C. griffithii*.

C. jacobsenii De Wit – 2n = 34

Material. NJ 2864 cult. (holotype in WAG).

This species differs from *C. purpurea* and *C. griffithii* by narrow, obtuse leaves, by the red, rough limb, and by the indistinct collar which is sprinkled with red.

C. sarawacensis (Rataj) Jacobsen stat. nov. – 2n = 34

Basionym: C. pontederiifolia Schott ssp. *sarawacensis* Rataj, Revision of the genus Cryptocoryne Fischer, Studie ČSAV č. 3, p. 62 (1975). – Holotype: Cult. Sumperk, 18.9. 1974 Rataj (PR 335235).

Material. NJ 2954 cult.

This species is characterized by the short tube, the caudate, purple, rugose limb which has a prominent blackish purple collar. The leaves are irregularly dentate with a slightly undulate margin, and they have a characteristic glossy, green colour, with irregular purple stripes.

Mr Sadilek informs me that material which he received from van der Vlugt was passed on to Rataj and was subsequently used as type material. My material came from de Wit, and no doubt also stems from van der Vlugt.

C. usteriana Engler – 2n = 34

Material. 1671/17 cult.; NJ 2875 cult.

Pancho (1971) reported 2n = 28. It is unlikely that this species has both the numbers recorded. Pancho (1971) also reported 2n = 28 for *C. pygmaea* Merrill. These counts are rather puzzling, as 2n = 28 has only been found in plants from Sri Lanka; however it is by no means inconceivable.

C. usteriana is perhaps the largest species in the genus as the leaves can reach a length of more than 150 cm.

C. affinis N. E. Brown ex Hook. f. – 2n = 34

Material. 1671/15 cult.; NJ 2792 cult.

Legro (1971) and Marchant (1972) reported the same number.

C. versteegii Engler – 2n = 34

Material. 1671/8 New Guinea.

Legro (1967, 1971) reported the same number.

C. costata Gagnepain – 2n = 36

Material. NJ 2915 cult.

This species is closely related to *C. albida*. *C. costata* has brown variegated leaves, and a rather short limb with circular spots, whereas *C. albida* has green leaves, and a rather long limb which has long spots.

C. albida Parker – 2n = 36

C. hansenii Hu; *C. korthausae* Rataj; *C. retrospiralis* ssp. *albida* (Parker) Rataj.

Material. 1671/14 Ranawang (type of *C. hansenii*); NJ 2952 cult.

In transferring *C. albida* Parker to a subspecies of *C. retrospiralis*, Rataj does not cite the correct holotype which is Parker 2735 (K), but instead cites Parker 3089 (B) which is another specimen collected three years later. Furthermore, Rataj established *C. korthausae* Rataj which is quite identical with *C. albida* (conf. N. Jacobsen 1974, de Wit 1971, 1975).

C. balansae Gagnepain – 2n = 36

Material. NJ 2893 cult.

C. balansae is closely related to *C. crispatula*.

C. bertelihansenii Rataj – 2n = 36

Material. Beusekom et al. 4077 Chaiyaphum (isotype); Beusekom et al. 4486 Chaiyaphum (isosyntype).

The two collections are somewhat different in appearance. The holotype has narrow, almost smooth, and green leaves, while the syntype has broader, undulate leaves which are brown with darker brown lines. The vegetative characters are constant in cultivation. However, colour slides at L of Beusekom et al. 4077 together with Fig. 3 H indicate that these two specimens may be forms of *C. crispatula* incl. *balansae*.

C. cf. **tonkinensis** Gagnepain – 2n = 36

Material. P 1969/306 cult.

Marchant (1971) gives 2n = 36 for *C. longispatha*, a plant quite identical with mine.

Rataj (1975 a) gave an account of the uncertainty regarding Gagnepain's description of *C. tonkinensis*, and I am, at present, not sure that the above-mentioned material really is *C. tonkinensis*.

C. cf. **crispatula** Engler – 2n = 54

Material. NJ 2984 cult.

This plant has not flowered so far, but the denticulations on the very narrow leaves are very characteristic for *C. crispatula*.

It is probable that the present plant is a triploid.

C. retrospiralis (Roxburgh) Kunth – 2n = 72

Excl. *C. retrospiralis* ssp. *albida* (Parker) Rataj

Material. NJ 2971 cult.; NJ 2950 Hahabalishwar, Maharashtia, W India.

Legro (1971) reported 2n = 28 which is most puzzling.

There is some uncertainty as to the interpretation of the species, because it was believed to have been found on the Indo-Chinese peninsula. This is apparently not true, and the species occurring there (e.g. *balansae, albida, crispatula, tonkinensis*), among other things, have a different chromosome number. *C. retrospiralis* has cylindrical leaves in the winter-form, a feature not recorded elsewhere, and it also has a very strongly developed system of negatively geotropic roots.

C. bogneri Rataj – 2n = 36

Material. NJ 2917 cult.; NJ 2934 cult.

C. alba De Wit – 2n = 36

Material. Hermsen s.n. Dehiwala (from type collection).

This species is closely related to *C. thwaitesii,* and may prove to be a colour variant.

C. thwaitesii Schott – 2n = 36

Material. NJ 14-1 Kottawa.

Legro (1971) reported 2n = 56. Marchant (1972), however, reported 2n = 42. At Kew Gardens there exists living plants labelled K.E.N. 102-67 *C. "thwaitesii"*. This specimen has 2n = c. 102 and is probably *C. blassii,* although they have not flowered and therefore cannot be identified.

C. lingua Beccari ex Engler – 2n = 36

Material. NJ 2856 cult.; NJ 2928 cult.; NJ 2955 cult.

Legro (1967, 1971) reported 2n = 36. The chromosomes of this species are rather small.

Rataj (1975 a) suggested a close connection between *C. lingua* and *C. versteegii* on account of the thick, fleshy, green leaves, a feature which I would not regard as of great taxonomic importance, considering the differences in the spathe, in the distribution, and in chromosome number.

Fruiting specimens of *C. lingua* have been observed.

Male fertility

The values obtained are shown in Table 1. As expected, the pollen of the triploids is defective. *C. blassii* (hexaploid) also proved to have completely defective pollen. Several of the diploids have a somewhat reduced fertility, but it is very odd that e.g. *C. purpurea* has a fertility of 0% and *C. affinis* only has a fertility of 19%. A hybrid origin of *C. purpurea* is possible (*griffithii* × diploid *siamensis*-type?).

Hybrids

Several plants from e.g. Sri Lanka are deviating in appearance, and a hybrid origin is possible. The occurrence of triploids does complicate the situation, and allotriploids can be expected to have a deviating appearance.

Artificial hybrids have been reported by Legro (1963): *beckettii* × *lutea, beckettii* × *"nevillii"* (= *willisii*), and *wendtii* × *lutea,* but no further results have been published. Rataj (1975 a) reports artificial hybrids between, e.g., *beckettii* × *petchii* (3x), and *lutea* × *legroi* (3x), which does seem improbable.

Chromosome morphology

Although difficult to measure exactly, there is an obvious correlation between the different chromosome groups and the size of the chromosomes (Figs. 4–5). Unfortunately the same pretreatment could not be used for all the species, and in the illustrations given here, the chromosomes of *C. spiralis* and *C. retrospiralis* are not quite comparable with the others. Secondly, it was sometimes necessary to use late prophases in order to show the exact number. The different chromosome groups also proved to stain differently, especially *C. pontederiifolia,* and *C. bogneri* proved very difficult to handle, because of their diffuse heterochromatic ends.

The chromosomes of the genus are metacentric to submetacentric and the chromosomes showed heterochromatic ends, H-segments, most pronounced in the 22 and 28 groups.

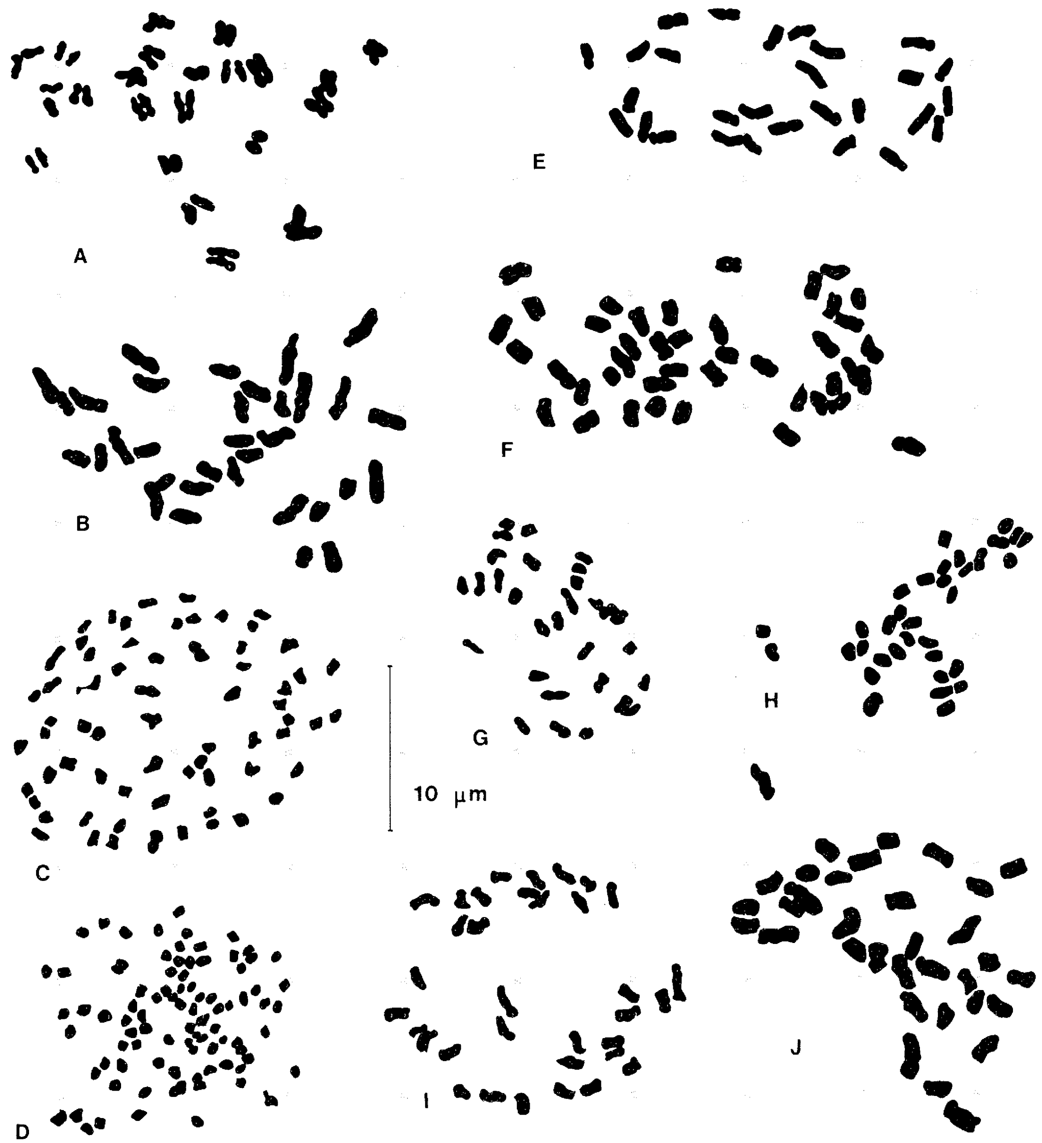

Fig. 4. Root tip mitoses. – A; *Cryptocoryne ciliata* 2n = 22 (P 1958/1013). – B: *C. ciliata* 2n = 33 (1671/6). – C: *C. spiralis* 2n = 66 (Cook 327/73). – D: *C. spiralis* 2n = 88 (1671/5). – E: *C. undulata* 2n = 28 (P 1961/542). – F: *C. wendtii* 2n = 42 (1671/11 a). – G: *C. pontederiifolia* 2n = 30 (NJ 2963). – H: *C. versteegii* 2n = 34 (1671/8). – I: *C. usteriana* 2n = 34 (1671/17). – J: *C. sarawacensis* 2n = 34 (NJ 2954).

In *C. spiralis* 3–4 small bodies occurred which may be satellites. However, sometimes they were not apparently associated with the other chromosomes (artifact?).

There are no karyological implications of the evolutionary direction of the aneuploid series.

Discussion

Subdivision of the genus Cryptocoryne

It is possible to make a subdivision of the genus *Cryptocoryne* on the basis of chromosome numbers, morphology and geography. The pres-

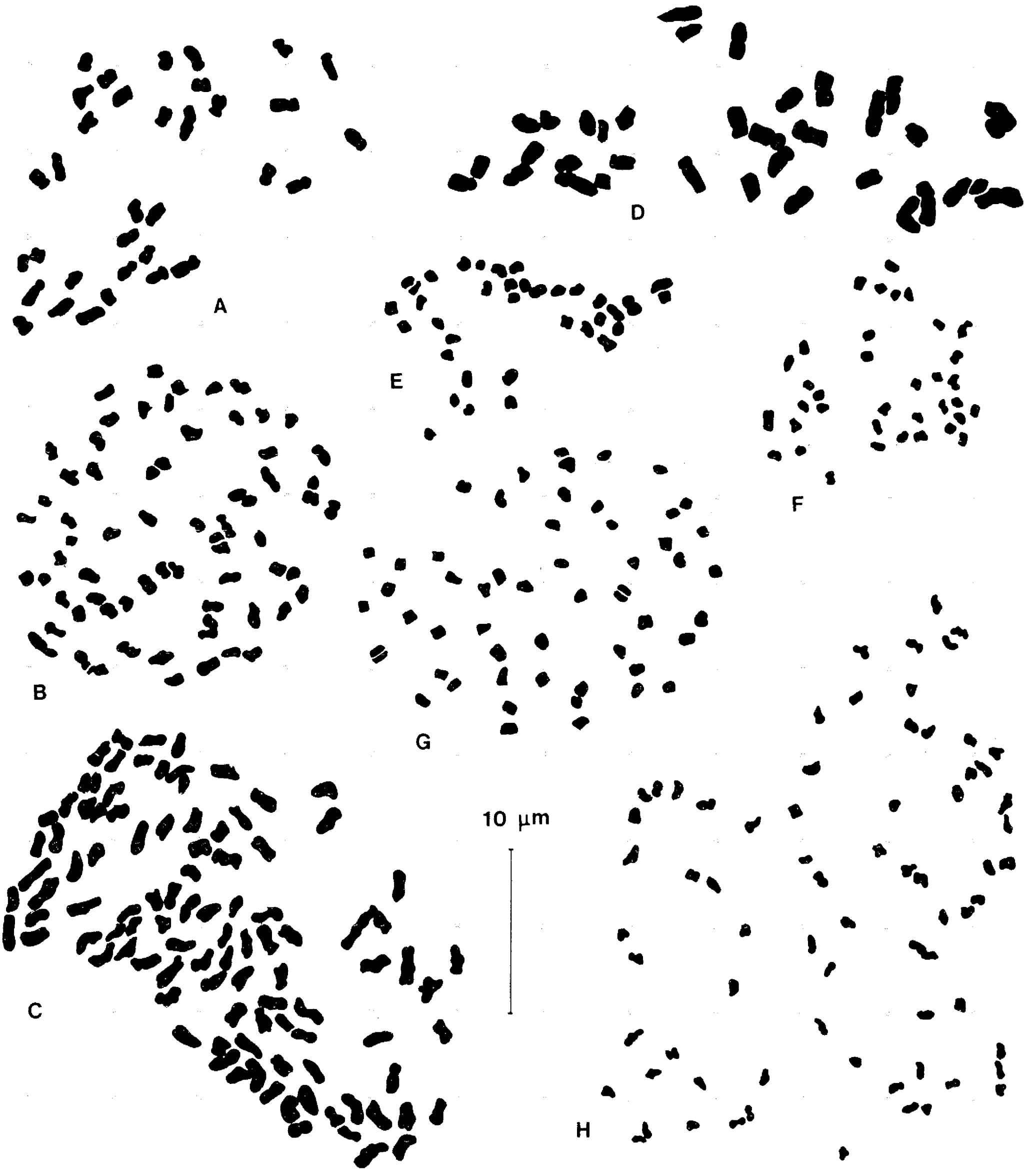

Fig. 5. Root tip mitoses. – A: *Cryptocoryne purpurea* 2n = 34 (P 1912/92). – B: *C. siamensis* 2n = 68 (NJ 2946). – C: *C. blassii* 2n = 102 (1671/9). – D: *C. thwaitesii* 2n = 36 (NJ 14-1). – E: *C. lingua* 2n = 36 (NJ 2856). – F: *C. albida* 2n = 36 (1671/14). – G: *C.* cf. *crispatula* 2n = 54 (NJ 2984). – H: *C. retrospiralis* 2n = 72 (NJ 2950).

ent material can be divided into eight groups, some of which have different basic numbers (Table 2). Generally there seems to be rather little morphological similarity between the different chromosome groups (Figs. 2–3) and they occupy different geographical areas (Fig. 6).

(1) *Cryptocoryne ciliata* – 2n = 22, 33. S Asia, widely distributed. The species is characterized by the large size, the thick green leaves and by the ciliate margin of the limb of the spathe (Fig. 2 A).

Table 1. Pollen stainability in different species of *Cryptocoryne*. Figures indicate number of specimens with the degree of ploidy given within parentheses.

Species	% stainable pollen										
	0	10	20	30	40	50	60	70	80	90	100
ciliata	1(3x)	1(3x)	1(3x)	.	.	.	.	1(2x)	.	1(2x)	
spiralis	.	.	.	.	.	.	.	.	2(8x)	2(6x)	
parva	.	.	.	.	.	.	.	.	.	1(2x)	
willisii	.	.	.	.	.	.	2(2x)	.	.	.	
lucens	.	.	.	1(2x)	.	.	1(2x)	.	.	.	
beckettii	.	.	.	.	.	1(2x)	.	2(2x)	1(2x)	1(2x)	
petchii	3(3x)	.	.	.	.	.	.	.	.	.	
wendtii	.	.	2(3x)	.	.	.	.	.	2(2x)	5(2x)	
undulata	2(3x)	.	.	.	.	.	2(2x)	.	.	.	
lutea	1(3x)	.	.	1(2x)	.	.	.	.	.	3(2x)	
walkeri	.	.	.	1(2x)	.	.	.	.	.	.	
pontederiifolia	.	.	.	.	.	.	.	.	.	1(2x)	
griffithii	.	.	.	.	.	.	.	.	.	1(2x)	
minima	.	.	.	.	.	.	.	.	1(2x)	.	
zewaldiae	.	.	.	.	.	.	.	.	.	1(2x)	
blassii	2(6x)	.	.	.	.	.	.	.	.	.	
purpurea	2(2x)	.	.	.	.	.	.	.	.	.	
sarawacensis	.	.	.	.	.	.	.	.	.	1(2x)	
usteriana	.	.	.	1(2x)	.	.	.	.	.	.	
affinis	.	1(2x)	.	.	.	.	.	.	.	.	
versteegii	.	.	.	.	.	.	.	.	1(2x)	.	
costata	.	.	.	.	.	.	.	.	.	1(2x)	
albida	.	.	.	.	.	.	.	.	1(2x)	.	
balansae	.	.	.	.	.	.	.	.	.	1(2x)	
bertelihansenii	.	.	.	.	.	.	1(2x)	.	.	.	
bogneri	.	.	.	.	.	.	.	.	.	1(2x)	
thwaitesii	.	.	.	.	.	.	1(2x)	.	.	.	
lingua	.	.	.	.	.	.	.	.	.	1(2x)	

(2) *Cryptocoryne spiralis* – 2n = 66, 88. India. The species is characterized by the narrow leaves, and the spathe which has a short tube and a long, twisted limb (Fig. 2 B).

(3) *Cryptocoryne beckettii* group – 2n = 28, 42. The species with 2n = 28 and 42 all come from Sri Lanka. They are morphologically uniform and clearly different from species coming from other parts of Asia. The leaves are lanceolate with a more or less rounded base. The spathe has a rather long tube and the shape of the limb is rather uniform in the different species. For the nomenclature and illustrations of the group, see N. Jacobsen (1976). The delimitation of the species is somewhat obscured by the different chromosome numbers within the same and closely related species. This group is more amphibious than most of the others, and is much better adapted to the terrestrial form of life.

(4) *Cryptocoryne pontederiifolia* – 2n = 30. Sumatra. The species is characterized by the short spathe with the long, yellow, rugose limb and the large collar (Fig. 2 C). On normally developed specimens there are numerous cataphylls.

(5) *Cryptocoryne griffithii* group and other species with an obscure relationship – 2n = 34, 68, 102. This group consists mainly of species with cordate leaves coming from the Indo-Chinese peninsula, Borneo and New Guinea. It is obviously heterogeneous, and a closer study may show that there are different karyotypes with the diploid number 2n = 34. On morphological grounds *C. minima*, *C. zewaldiae*, and *C. griffithii* are closely related (Fig. 2 E, F, D). This group of three species is probably related to *C. siamensis*, *C. blassii*, *C. jacobsenii*?, and *C. purpurea*? (Fig. 2 G, I, H), while *C. usteriana* (Fig. 3 A), *C. affinis* (Fig. 3 D), *C. sarawacensis* (Fig. 3 C), and *C. versteegii* (Fig. 3 B) stand rather isolated.

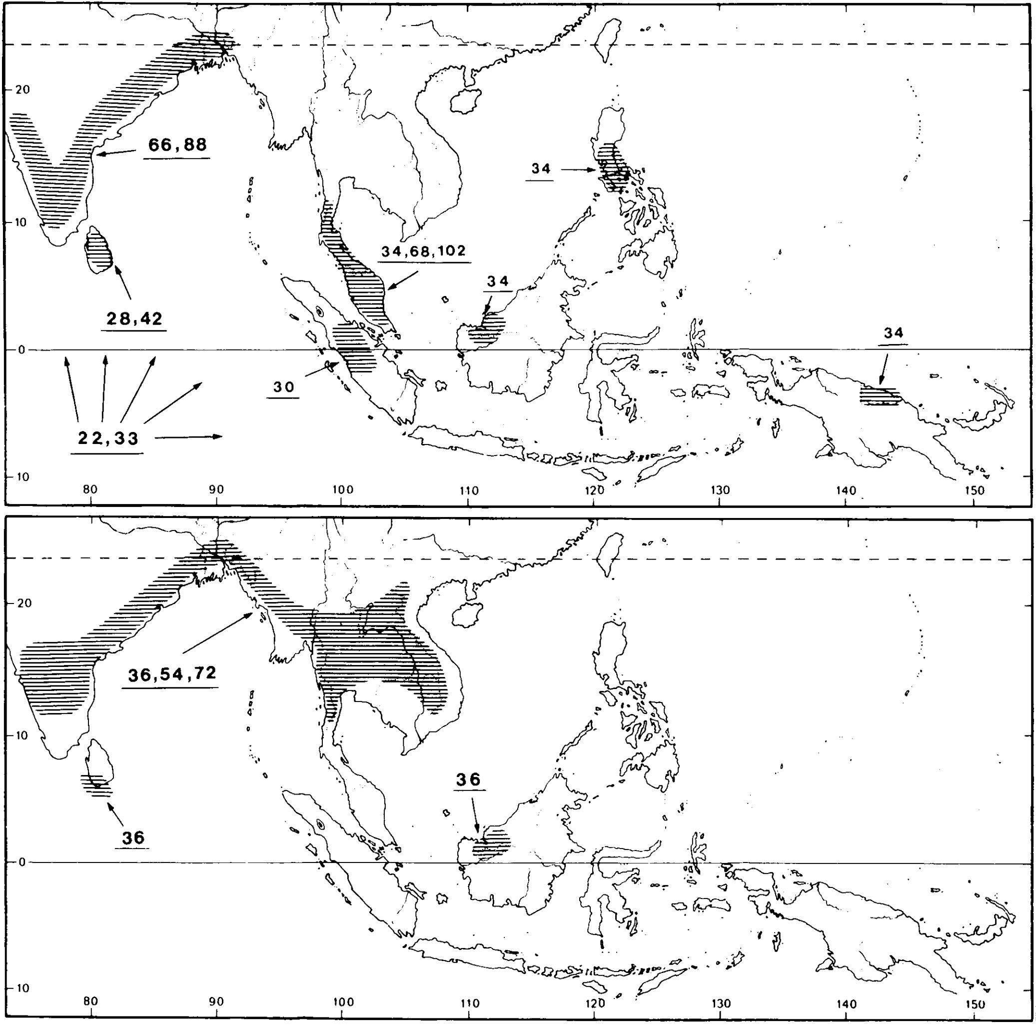

Fig. 6. The distribution of the different chromosome numbers.

(6) *Cryptocoryne albida* group – 2n = 36, 54, 72. Indo-Chinese peninsula to India. The group is characterized by the long, narrow leaves which are smooth, undulate or bullate. The limb of the spathe is more or less spirally twisted, and a collar is missing (Fig. 3 E–H). De Wit (1971) advocated a rather wide species concept, while Rataj (1975 a) was in favour of a narrow one. However, I believe that the species delimitation will prove to be different from both of the two interpretations.

(7) *Cryptocoryne thwaitesii* group – 2n = 36. Sri Lanka. Of these three broad-leaved species *C. alba* and *C. thwaitesii* are closely related, while *C. bogneri* is somewhat different with the short limb with the rough margin. The group is karyologically and morphologically very different from the *C. albida* group.

(8) *Cryptocoryne lingua* – 2n = 36. Borneo. The species is characterized by the spathulate, green leaves, and by the spathe with the caudate limb (Fig. 3 I). The rhizome is stout with numerous thick, white roots.

Table 2. The species of *Cryptocoryne* arranged according to their chromosome number, compared with the system proposed by Rataj (1975 a).

Species	Classification in Rataj 1975 a
2n = 22, 33	
ciliata	Subg. 2, sp. 5
2n = 66, 88	
spiralis	Subg. 1, sect. 1, sp. 1
2n = 28, 42	
parva	Subg. 4, sect. 9, spp. 25–27
willisii	
lucens	
beckettii	Subg. 4, sect. 10, spp. 28–31
petchii	
wendtii	
undulata	
lutea	
walkeri	
2n = 30	
pontederiifolia	Subg. 4, sect. 6, sp. 20 p.p.
2n = 34, 68, 102	
griffithii	Subg. 4, sect. 14, spp. 38–40
minima	
zewaldiae	
siamensis	Subg. 4, sect. 15, spp. 44–45
blassii	
purpurea	Subg. 4, sect. 16, sp. 50
jacobsenii	
sarawacensis	Subg. 4, sect. 6, sp. 20 p.p.
usteriana	Subg. 3, sect. 4, sp. 14
affinis	Subg. 4, sect. 12, sp. 36
versteegii	Subg. 4, sect. 7, sp. 22
2n = 36, 54, 72	
costata	Subg. 3, sect. 5, spp. 15–16 (+ 9 b)
albida	
balansae	Subg. 3, sect. 4, spp. 9 (– 9 b)–13
bertelihansenii	
cf. *tonkinensis*	
cf. *crispatula*	
retrospiralis	
2n = 36	
bogneri	Subg. 4, sect. 8, sp. c. 24 a
alba	
thwaitesii	Subg. 4, sect. 6, sp. 18
2n = 36	
lingua	Subg. 4, sect. 7, sp. 21

A criticism of Rataj's system

In his revision of the genus *Cryptocoryne*, Rataj (1975 a) proposed a division into 4 subgenera and 17 sections. Table 2 shows Rataj's system compared with the sequence indicated by the chromosome numbers. A linear sequence often exaggerates minor differences, but apart from this there are evident differences:

(1) Rataj states that "*C. spiralis* belongs evolutionally to the oldest species of the genus showing with the whole subgen. *Saturina*" (= subgen. *Cryptocoryne*) "to the relationship with the genus *Lagenandra*". The arguments "the absence of the tube and the shape of the limb" can be seen as a convergent adaptation to a mainly emerse habitat. The chromosome number of *Lagenandra* is 2n = 36. Without any other arguments I think it venturous to state that a hexaploid-octoploid (?) species with the highest primary base number belongs to the oldest ones of the genus. Rataj places *C. ciliata* and *C. spiralis* in different subgenera. However, I find no greater differences (or similarities) between these two species than between any of the other chromosome groups, e.g. between the *C. beckettii* group and the *C. thwaitesii* group. Legro (1971) counted 2n = 34 for *C. tortilis* De Wit. Rataj regards the two species *C. tortilis* De Wit and *C. fusca* De Wit as conspecific with *C. ferruginea* Engler. However, even if one leaves out the different opinions regarding the status of the above mentioned taxa, it is not likely that a species with 2n = 34 belongs to a group which as far as is known has the base number x = 11. I can find no basis for the "evolutionary lines" as proposed by Rataj on pp. 22–25.

(2) Rataj placed the Sri Lanka species of the *beckettii* group with 2n = 28 in the middle of subgenus *Submersina*, which contains other groups with the chromosome number 2n = 34 and 2n = 36. On account of the chromosome number and the morphology of the 2n = 28 group, I find no close relationship between them and the rest of subgenus *Submersina* Rataj.

The distinguishing between two sections in this 2n = 28 group, viz., sect. *Nevillae* and sect. *Walkeriae*, which have "evolved independently", is not supported by the chromosome numbers, nor do I find any basis for it in the morphology.

(3) Rataj places *C. pontederiifolia* ssp. *pontederiifolia* with 2n = 30 in the subgenus *Submersina,* and establishes *C. pontederiifolia* ssp. *sarawacensis* with 2n = 34.

(4) Rataj places *C. usteriana* with 2n = 34 in subgenus *Terrestrina,* section *Retrospiralae. C. usteriana* differs in many respects from the *albida* group. The bullate leaves have very prominent lateral nerves. The type collection has ovate as well as lanceolate leaves. The limb of the spathe has a collar and is not spirally twisted. The large cataphylls which are invariably present are very characteristic of the species.

(5) I do not agree with Rataj in placing *C. albida* (2n = 36) as a subspecies of *C. retrospiralis* (2n = 72). I believe that *C. albida* and *C. costata* are closely related. I find no reason to keep sect. *Retrospiralae* (excl. *C. usteriana*) and sect. *Costatae* apart. The backward twist of the limb of the spathe in *C. albida* and *C. costata* is just a matter of time after the opening. The general morphology of the young spathe is the same as in, e.g., *C. balansae.*

(6) *C. thwaitesii* and *C. bogneri* which both have 2n = 36 and come from Sri Lanka are placed in subgenus *Submersina* in section *Thwaitesiae* and section *Auriculatae,* respectively, and the two sections contain species from (1) Borneo, Malaya, and Sumatra and (2) Borneo and the Philippine Islands! Considering the strict endemism of most species and the chromosome numbers, which apparently have certain geographical correlations, I cannot find any support for placing them as Rataj does.

(7) *C. lingua* and *C. versteegii* have different chromosome numbers. Moreover, the embryo of *C. versteegii* is quite different as it has numerous plumulary processes, a feature only found in *C. ciliata.* I find no support for placing them in the same section.

The chromosome numbers

When interpreting chromosome numbers, primary base numbers are used. Thus it may be argued that x = 7 and x = 9 (or 6?) should be used instead of x = 14 and x = 18. However, this still leaves x = 15 and x = 17, and maybe even x = 11 to be explained. Supposing that aneuploidy occurs in addition to the primary basic numbers 7, 9, and 11, most combinations are possible, but I do not think that such arithmetics can be applied here. At present I find no morphological support for such a procedure.

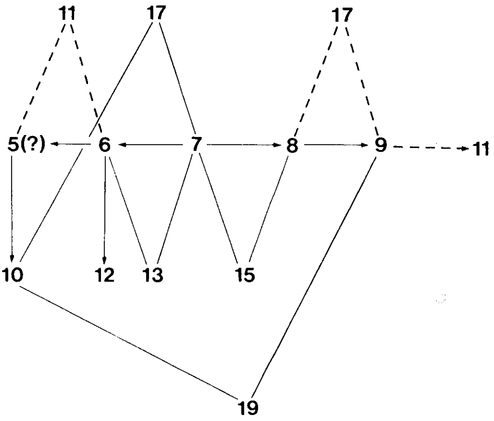

Fig. 7. Possible basic number relationships and direction of their evolution in the Araceae according to Marchant (1973).

The present chromosome counts in *Cryptocoryne* suggest that the chromosomal evolution has taken place at the secondary level, with large variation in chromosome number, in contrast to the closely related genus *Lagenandra* where only 2n = 36 has been found (*L. insignis, L. koenigii, L. lancifolia, L. meboldii, L. ovata, L. toxicaria,* and *L. thwaitesii,* Marchant 1972, N. Jacobsen unpubl.).

The formation and establishment of triploids, tetraploids, and hexaploids is very interesting. It is probable that the formation of triploid plants is an event which occurs with a higher frequency than is normally recognized (e.g. Alexander & Beckett 1973, Sandfaer 1970, Snogerup 1967).

Marchant (1973) pictures a possible chromosomal evolution within the Araceae (Fig. 7). It is striking that a scheme somewhat like it can be drawn for the genus *Cryptocoryne.* However, I do not consider the two situations quite comparable, as Marchant's table is based on a numerical interpretation of his results in the family as a whole.

Reproduction

The species of *Cryptocoryne* have to a great extent occupied niches in the rivers which are rarely inhabited by other plants. Part of their success is due to their rhizomes and subterranean runners which to some extent are protected under the soil, and at the same time are an excellent mode of reproduction. Examples of other phanerogams which have invaded the same habitat are species of *Crinum, Barclaya, Aponogeton* (van Bruggen 1968–73) and *Echinodorus* (Rataj 1975 b). The first three genera have bulbs or thickened rhizomes, whereas the latter often reproduces by means of plantlets formed in the inflorescence. The only other aquatic phanerogams which in radiation, speciation, and endemism resemble *Cryptocoryne* are the Podostemonaceae (Engler 1930, van Royen 1951–54, Willis 1926).

The ability for vegetative reproduction in *Cryptocoryne* opens possibilities for the establishment of more or less sterile populations, and it is obvious that many populations reproduce only vegetatively. Bothmer (1974) found a similar pattern in *Allium* from the Aegean Islands. Some species of the 2n = 28 group from Sri Lanka have developed numerous, short, bulb-like "runners" which are easily broken off.

Fruiting diploids have been observed several times in nature in the *C. beckettii* group, but only rarely in hothouses. Fruiting specimens of *C. griffithii, C. lingua,* and *C.* cf. *johorensis* have been observed in imported plants. Fruiting of triploid plants has not been observed.

Adaptive radiation

The evolution within the genus *Cryptocoryne* must be considered as an example of "island speciation", where the islands are the different river systems of South Asia.

The isolated rivers form the basis for the radiating evolution. The species occupy almost similar habitats throughout most of Asia. However, there is a diversification of the vegetative parts which undoubtedly must be adaptive. Also the differentiation of the inflorescence can in part be seen as an adaptation to the habitat of the plant, at least as to the character long tube versus short tube.

The occasional dispersal to new unoccupied river systems is of utmost importance in the evolution of the genus. Random factors, like genetic drift are likely to play a role. Long distance dispersal of rhizomes and runners must be taken into consideration, especially as the seeds have to germinate almost immediately.

An example which in several respects resembles the evolutionary pattern found in *Cryptocoryne,* is given by St. John (1966) for the genus *Cyrtandra* (Gesneriaceae) on the island of Oahu of Hawaiian Islands. *Cyrtandra* is found mostly in deep, wet ravines on the side of the volcano. These radiating river systems are separated from one another by relatively dry regions, so that geographically isolated, roughly similar habitats are found all around the island. In many cases, morphological characters that distinguish the species do not appear to have any selective value, which may be ascribed to geographic isolation in combination with the work of genetic drift.

Another interesting aspect is the influence of man, e.g. in Sri Lanka. 1000–2000 years ago large parts of the island were under cultivation (Mendis 1947), and it is very likely that the number of populations of *Cryptocoryne* diminished during that time. When the cultivated areas were abandoned, the remaining populations were able to reinvade formerly inhabited areas. This might have led to hybridisation and/or the establishment of new variants, which may partly explain why the taxonomy of the Sri Lanka species is so complicated.

The main evolutionary trend in the genus *Cryptocoryne* lies in the formation of the aneuploid series. When the plants proceed to a higher polyploid level their further evolution is probably often hindered by sterility.

Within *Cryptocoryne* there is a large diversification of the inflorescence, while the morphology and biology on the whole must be considered as rather uniform.

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Vascular plants from the Galápagos Islands: new records and taxonomic notes

Henk van der Werff

van der Werff, H. 1977 04 15: Vascular plants from the Galápagos Islands: new records and taxonomic notes. *Bot. Notiser 130:* 89–100. Stockholm. ISSN 0006-8195.

Thirty-five taxa are reported as being new for the Galápagos Islands, among them 8 species of *Thelypteris* (Polypodiaceae). Attention is drawn to a collection of *Thelypteris* that probably represents a new species. A key to the species of *Thelypteris* known from the archipelago is provided. Taxonomic and nomenclatural notes are made on taxa in the genera *Jaegeria* (Compositae), *Lippia* and *Verbena* (Verbenaceae), *Acalypha* (Euphorbiaceae), *Polygala* (Polygalaceae), *Hydrocotyle* (Umbelliferae) and *Tillandsia* (Bromeliaceae).

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From April 1974 to October 1975 the author conducted field work on the Galápagos Islands for a vegetation study of Santa Cruz and Volcán Alcedo, Isabela. Plants were collected on other islands as well. Thirty-five taxa are new for the archipelago. When determining the material, I found some changes in nomenclature to be necessary.

The first set of the collection is in U while a duplicate set will be deposited in CAS. A representative set will be deposited in an Ecuadorian Herbarium. The sequence of the taxa in the Flora of the Galápagos Islands (Wiggins & Porter 1971) is followed.

Hymenophyllaceae

Hymenophyllum plumieri Hook. & Grev.

Hook. & Grev., Icon. Fil. 2: pl. 123 (1829).

Collections: Isabela, the S slope of Cerro Azul, 750 m, van der Werff 2241 – San Cristóbal, summit area, 600 m, van der Werff 2190.

New for the Galápagos Islands. *H. plumieri* belongs to the section *Sphaerocionium,* which is characterized by the presence of hairs on veins and leaf margins and sometimes also on the leaf surface. *H. hirsutum,* reported by Morton (1947) from San Cristóbal, lacks hairs on the leaf surface, while such hairs are present in *H. plumieri.* The hairs are never numerous, but are always found on closer inspection. On the specimens from San Cristóbal they are quite sparse.

Both on San Cristóbal and Isabela this fern is terrestrial and found in wet areas, often on a slope with pendent leaves. The fronds are of a light colour and contrast rather sharply with the dark venation.

The Isabela specimens conform well with the Mille collection cited by Morton (1947). The specimens from San Cristóbal have fewer hairs, especially on the abaxial side, but otherwise conform.

H. plumieri is not common. On the mainland it is only reported from Ecuador, from where Morton (1947) cited 8 collections.

Polypodiaceae

Arachniodes denticulata (Swartz) Ching

Ching, Acta Bot. Sin. 10: 260 (1962).

Collection: San Cristóbal, on vertical walls of streambeds near the summit, 630 m, van der Werff 2188.

New for the Galápagos Islands. *A. denticulata* keys out in Wiggins & Porter (1971) to the group *Rumohra, Dryopteris* and *Polystichum*. It can be distinguished from the species of these genera by a combination of hairlike scales on the costae below, hairlike scales at the base of the stipe, laterally attached indusia and the semi-erect rhizome. *A. denticulata* is widespread on the American mainland.

Ctenitis pleiosorus (Hook. fil.) Morton

Morton, Leafl. West. Bot. 8: 190 (1957).

Collections: Isabela, a small crater on the S slope of Cerro Azul, 600 m, van der Werff 2244, 2256; same locality, but growing in a cave, van der Werff 2257 – Santa Cruz, Media Luna, 600 m, van der Werff 966.

C. pleiosorus is one of the few ferns endemic to the Galápagos Islands. It is fairly common but confined to the wetter zones.

Normally this species is not very tall and the description is based on medium-sized specimens. A few of the plants I collected were considerably larger (van der Werff 2256). The size of the pinnae, pinnulae and the branching of the veins in the pinnulae are quite different from that of medium-sized plants. Intermediates do exist and there are no differences in pubescence or scale characters. The measurements given below were obtained from the larger plants. Measurements from Wiggins & Porter (1971) are given in parentheses. Characteristics not mentioned do not differ from the description in the flora.

Fronds up to 25 dm tall (4–8 dm); stipe not measured separately but correspondingly larger, up to 7 mm thick (3–4 mm); length of the blades not measured separately; pinnae up to 30 cm long (8–12 cm); pinnulae up to 5 cm long (1.3 cm), 1.5 cm wide (0.4 cm), entire to incised 4/5 down to the costule; veins free, 1–4 times branched; sori up to 35 per pinnule (4–8), 2 mm in diameter (1 mm).

Dryopteris parallelogramma (Kunze) C. Alston

C. Alston, Amer. Fern J. 47: 92 (1957).

Collection: Isabela, in a small crater on the S slope of Cerro Azul, 600 m, van der Werff 2243.

New for the Galápagos Islands. *D. parallelogramma* will not key out to *Dryopteris* in Wiggins & Porter (1971) as it is very scaly but not very glandular. It differs from *D. patula,* the only other *Dryopteris* species known from the archipelago, by having bipinnate fronds, a densely scaly stipe and rhachis, and rufous brown rhizome scales. *D. patula* has bipinnate–pinnatifid to tripinnate fronds and few, light-coloured rhizome scales.

D. parallelogramma is rather widespread on the American mainland, ranging from Colombia to Argentina, mostly at higher altitudes (2500 m or more).

Dennstaedtia dissecta (Sw.) Moore

Moore, Ind. Fil. 305 (1861).

Collection: Isabela, from a small crater on the S slope of Cerro Azul, 600 m, van der Werff 2268.

New for the Galápagos Islands. Two other species of *Dennstaedtia* are known from the archipelago, *D. globulifera* and *D. cicutaria. D. dissecta* differs from *D. globulifera* by not having green alate axes of the pinnules, and from *D. cicutaria* by having larger sori (slightly over 1 mm in my specimens, 0.3–0.4 mm in *D. cicutaria*). *D. dissecta* occurs on the American mainland from Mexico to Bolivia.

Polypodium astrolepis Liebm.

Liebm., Vid. Selsk. Skr. B 1: 185 (1849).

Pleopeltis revoluta (Spr. ex Willd.) A. Reid Smith, Proc. Cal. Acad. Sci. ser. 4, 40: 230 (1975).

Collection: San Cristóbal, epiphyte on *Hippomane mancinella* near Tres Palos, 120 m, van der Werff 2174.

New for the Galápagos Islands. *Polypodium astrolepis* was recently transferred to *Pleopeltis.* As Wiggins & Porter only use the name *Polypodium,* I prefer not to introduce the name *Pleopeltis* here.

P. astrolepis has distinctly elongated sori up to 2 cm long. This characteristic distinguishes it from the rather similar *P. lanceolatum*. On San Cristóbal *P. astrolepis* is not uncommon as an epiphyte at middle elevations, mostly found on *Hippomane mancinella*. It occurs on the American mainland from S Mexico to Brazil.

Key to the species of Thelypteris known from the Galápagos Islands

1. Lamina bipinnate–bipinnatifid .... *T. torresiana*
– Lamina pinnate or pinnate–pinnatifid 2
2. Basal veins of adjacent segments united in the sinus between the segments or united in the leaf tissue below the sinus with an excurrent veinlet running to the sinus 3
– Basal veins of adjacent segments not united and reaching the leaf margin slightly above the sinus 9
3. Lamina with conform terminal pinna; some hairs on the lower side of the rhachis forked 2–4 times; basal veins united with excurrent veinlet 4
– Lamina with pinnatifid apex; rhachis hairs not repeatedly branched; basal veins united in leaf tissue or meeting in sinus 5
4. Lamina pinnate, the pinnae crenate; 5 or 6 pairs of uniting veins per segment; frond with 4 or 5 pairs of pinnae .... *T. poiteana*
– Lamina pinnate–pinnatifid, the pinnae lobed at least halfway down to the costa; only 1 or 2 pairs of veins united per segment. Frond with 7–9 pairs of pinnae .... *T. tetragona* ssp. *aberrans*
5. Pseudovein running from the costa to the sinus between the segments; lamina coriaceous and glabrous; veins conspicuous, white, sometimes forked .... *T. gardneriana*
– No pseudovein running from costa to sinus 6
6. Basal veins in adjacent segments united in leaf tissue and sending an excurrent veinlet to the sinus; rhizome erect or suberect .... *T. quadrangularis*
– Basal veins in adjacent segments not united in leaf tissue but connivent in the sinus 7
7. Costae with some ciliate, castaneous scales below; basal segments of the lower pinnae reduced in size; rhizome creeping .... *T. grandis*
– Costae without scales below 8
8. Rhizome erect; basal superior segments enlarged; veins on upper surface not hairy; lower pinnae not reduced in size .... *T. patens*
– Rhizome creeping; veins on upper surface hairy; lower pinnae reduced in size .... *T. conspersa*
9. Croziers covered with mucilage, aerophores present 10
– Croziers not covered with mucilage, aerophores present or absent 12
10. Rhachis with short, fasciculate hairs; aerophores at bases of pinnae 4 mm long; small aerophores present at bases of segments. Sori median .... *T. thomsonii*
– Rhachis without fasciculate hairs; aerophores small, not present at the bases of segments 11
11. Rhizome erect, fronds caespitose. Stipe shorter than lamina. Rhachis glandular, distance between pinnae about 2 cm .... *T. cheilanthoides*
– Rhizome creeping, fronds distant. Stipe as long as lamina. Rhachis not glandular. Distance between pinnae 0.6–0.8 cm .... *T.* sp. nov.?
12. Indusia absent 13
– Indusia present 14
13. Sori elongated along veins .... *T. linkiana*
– Sori round; rhachis densely and shortly hairy .... *T. oligocarpa*
14. Rhachis glabrous below; costa below with few stramineous, adpressed scales .... *T. pachirhachis*
– Rhachis pubescent below; no scales on costae below 15
15. Rhachis with stiff, short and non-septate hairs 16
– Rhachis with long (1.5– 2 mm), slender and multicellular hairs 17
16. Uncinate hairs present on lamina below .... *T. oligocarpa*
– Uncinate hairs absent .... *T. pilosula*
17. Well-developed pinnae up to 15 cm long, nearly always exceeding 10 cm. Segments with 12 or more pairs of veins; lamina with many sessile glands below .... *T. balbisii*
– Well-developed pinnae up to 7 cm long. Segments with about 8 pairs of veins. Lamina with few red glands below .... *T.* aff. *glandulosolanosa*

Thelypteris torresiana (Gaudich.) Alston

Alston, Lilloa 30: 11 (1960).

Collection: Pinta, Cerro Colorado, 220 m, T. de Vries s.n. (U).

New for the Galápagos Islands. *T. torresiana* is the only species of *Thelypteris* known from the archipelago with bipinnate–bipinnatifid fronds (cf. the key). It originates from tropical Asia and has been introduced into the American tropics.

Thelypteris gardneriana (Baker) Reed

Reed, Phytologia 17: 278 (1968).

Collections: San Cristóbal, on vertical walls of deep streambeds near the top, 600 m, van der Werff 2189; Adsersen 720 (C).

New for the Galápagos Islands. *T. gardneriana* is the only member of the subgenus *Steiropteris* known from the Galápagos Islands. The presence of a pseudovein running from the costa to the sinus between the segments is characteristic for this subgenus. *T. gardneriana* has coriaceous and glabrous fronds with conspicuous veins, which are almost white on the dark leaf tissue. Most mainland collections are from Brazil but a few records are from Colombia and Ecuador.

Thelypteris conspersa (Schrad.) A. Reid Smith

A. Reid Smith, Univ. Cal. Publ. Bot. 59: 60 (1971).

Collections: Santa Cruz, Wiggins 18.617a (DS); van der Werff 1755 – Isabela, Cerro Azul, van der Werff 2265, 2266.

New for the Galápagos Islands. A specimen identified as *T. kunthii* (Desv.) Morton belongs to *T. conspersa* (Wiggins 18.617a, DS). *T. conspersa* differs from *T. kunthii* by having reduced lower pinnae. Most mainland collections of *T. conspersa* are from S Brazil, but it is also known from the Andean countries.

Thelypteris grandis A. Reid Smith var. **pallescens** (C. Chr.) A. Reid Smith

A. Reid Smith, Univ. Cal. Publ. Bot. 59: 99 (1971).

Collections: Santa Cruz, Howell 9274 (CAS), Bowman 93 (CAS), Dawson E-23 (DS) – Isabela, Alcedo, van der Werff 1201.

T. grandis var. *pallescens* was reported by Smith (1971) from the archipelago. It was not included in Wiggins & Porter (1971).

T. grandis is widespread in tropical America, ranging from the Antilles and Costa Rica south to Bolivia. Four varieties have been described from the mainland of which only var. *pallescens* has been found in the Galápagos Islands.

Thelypteris cheilanthoides (Kunze) Proctor

Proctor, Bull. Inst. Jamaica, Sci. Ser., 5: 58 (1953).

Collection: Isabela, in a small crater on the S slope of Cerro Azul, 600 m, van der Werff 2242.

New for the Galápagos Islands. In addition to the characteristics mentioned in the key, *T. cheilanthoides* has submarginal sori that are partly covered by the reflexed leaf margin. It is widespread in tropical America.

Thelypteris thomsonii (Jenm.) Proctor

Proctor, Bull. Inst. Jamaica, Sci. Ser., 5: 65 (1953).

Collection: Isabela, in a small crater on the S slope of Cerro Azul, 600 m, van der Werff 2258.

New for the Galápagos Islands. See key for characteristics. The species is known from Jamaica, Hispaniola and Colombia.

Thelypteris oligocarpa (Humb. & Bonpl. ex Willd.) Ching

Ching, Bull. Fan Mem. Inst. Biol., Bot. 10: 253 (1941).

Collections: Isabela, in a cave above Villamil, Stewart 905 (CAS); in a small crater on the S slope of Cerro Azul, 600 m, van der Werff 2260, 2262, 2263 – Fernandina, Adsersen 937 (C).

New for the Galápagos Islands. *T. oligocarpa* belongs together with *T. linkiana* to the section *Uncinella* A. Reid Smith, characterized by the presence of uncinate hairs. *T. oligocarpa* has round sori with small, setose indusia that are sometimes hard to find. It is widespread in the West Indies and tropical America.

Thelypteris pachirhachis (Kunze ex Mett.) Ching

Ching, Bull. Fan Mem. Inst. Biol., Bot. 10: 253 (1941).

Collection: Santiago, in a *Cyathea weatherbyana* brake near the top, 750 m, van der Werff 2349.

New for the Galápagos Islands. For characteristics see the key. Mainland collections are from Venezuela and Colombia.

Thelypteris aff. **glandulosolanosa** (C. Chr.) Tryon

Tryon, Rhodora 69: 6 (1967).

Collection: Isabela, in a streambed on the W slope of Volcán Alcedo, 790 m, van der Werff 1263.

New for the Galápagos Islands. *T. glandulosolanosa* belongs to a group that Smith (1974) places in the section *Adenophyllum* A. Reid Smith of the subgenus *Amauropelta* (Kunze) A. Reid Smith because of its suberect rhizomes, sessile red glands and stramineous stipe with a dark base. This group is in need of revision and consequently the identification is tentative. *T. glandulosolanosa* is known from Peru.

Thelypteris sp. nov.?

Collection: Isabela, from the SW slope of Cerro Azul, 750 m, van der Werff 2239.

This collection probably represents an undescribed species. It belongs to the subgenus *Amauropelta* (Kunze) A. Reid Smith. In some but not all of its characteristics it agrees with sect. *Blennocaulon* A. Reid Smith. It differs for instance by having a creeping rhizome with distant leaves. As the systematics of this group of ferns are rather confused I prefer to leave it unnamed until a revision of the genus has been made. It is included in the key as *Thelypteris* sp. nov.?

Description: Rhizome slender, creeping, up to 10 cm long and 0.4 cm thick. Tip of the rhizome and young leaves covered with some mucilage. Scales at rhizome very few, base of stipe almost glabrous. Stipe 10–25 cm, lamina 10–25 cm. Pinnae 20–25 pairs, up to 2.5 cm long and 0.5 cm wide. The lowermost pinnae (about 5 pairs) gradually reduced. The pinnae are pinnate or pinnatifid. Small aerophores present at the bases of the pinnae. Costae below with few dark scales and many stiff hairs, some of which are pluricellular. Veins dark, sunken in the leaf tissue, slightly widened towards the tip. Indusia absent, sporangia glabrous. Lamina coriaceous, a little shiny above.

I found this fern in only one locality on Cerro Azul, where fresh lava was overgrown by a thick layer of terrestrial mosses (*Thuidium delicatulum* (Hedw.) BSG and *Breutelia* sp. – Dr R. Gradstein and H. Sipman, pers. comm.). Apart from mosses and ferns few plants were present. The *Thelypteris* was creeping over the lava with only the laminae appearing above the moss layer, the stipes and rhizomes being completely hidden.

Thelypteris species excluded from the key

Thelypteris invisa (Sw.) Proctor var. *aequatorialis* (C. Chr.) Morton was reported from Santa Cruz. *T. invisa* is a hybrid between *T. grandis* and *T. serra* (Sw.) R. St. John (for an extensive discussion on the name *T. invisa,* see A. Reid Smith 1971) only known from Cuba, Haiti and Jamaica. All Galápagos material in DS and CAS identified as *T. invisa* turned out to belong to *T. grandis*.

T. kunthii (Desv.) Morton was reported from Santa Cruz. The specimens identified as *T. kunthii* in DS and CAS belong to *T. grandis* (Wiggins 18528) and *T. conspersa* (Wiggins 18.617a). *T. kunthii* is known from the West Indies and the Caribbean coast of Venezuela and Brazil. No collections are known from the W coast of S America and I do not think *T. kunthii* occurs on the Galápagos Islands.

Amaranthaceae

Achyranthes aspera L.

L., Sp. Pl. 204 (1753).

Collection: San Cristóbal, along a fresh water stream near Tres Palos, 150 m, van der Werff 2180.

New for the Galápagos Islands. *A. aspera* can be distinguished from the other Amaranthaceae known from the archipelago by its long (up to 20 cm or more) spikes with reflexed flowers and fruits. It is a common weed in tropical and subtropical regions.

Alternanthera sessilis (L.) R. Br.

R. Br., Prodr. 417 (1810).

Collection: San Cristóbal, common along the road near Tres Palos, 150 m, van der Werff 2179.

New for the Galápagos Islands. *A. sessilis* can be distinguished from other *Alternanthera* species in the archipelago by its creeping habit and large, obcordate utricles a little longer than the tepals. *A. sessilis* is a widespread weed in the tropics of the Old and New World.

Piperaceae

Peperomia tequendamana Trel.

Trel., Journ. Wash. Acad. Sci. 16: 207 (1926).

Collections: Isabela, SE rim of Alcedo, 1020 m, van der Werff 1970 – Santiago, epiphyte on *Zanthoxylum* near the summit, Adsersen 1070 (C) – Santa Cruz, in *Scalesia* forest near the two craters behind Santa Rosa, Adsersen 1311 (C).

New for the Galápagos Islands. *P. tequendamana* has opposite or alternate leaves like *P. petiolata*. However, *P. tequendamana* has densely rufous hirsute young shoots, petioles up to 2 cm long and the lower surface of the leaves are copiously black-dotted.

The Isabela collection is from the SE rim of the Volcán Alcedo where it grows as a creeping epiphyte on mossy branches of *Zanthoxylum fagara*. This habitat is much wetter than the preferred habitat of *P. petiolata* which is usually found in the lower *Scalesia* or Transition zones.

P. tequendamana is known from Colombia and Venezuela where it occurs at higher altitudes (2800–3700 m).

Compositae

Delilia biflora (L.) Kuntze

Kuntze, Rev. Gen. Pl. 333 (1891).

Collection: Isabela, near the tortoise nesting area in the NE part of the caldera of Alcedo, 740 m, van der Werff 1905.

New for the Galápagos Islands. *D. biflora* is an erect annual weed with leaves up to 6 cm. The two endemic *Delilia* species on the Galápagos Islands differ from *D. biflora* in several respects. *D. repens*, a fairly common plant in mesic forests, is a decumbent to trailing weed usually with small leaves (up to 3 cm). *D. inelegans*, collected only by Darwin, is erect and has larger leaves. It has three staminate and three pistillate flowers per head while *D. biflora* has only one staminate and one pistillate flower per head.

D. biflora is widespread in tropical America.

The name *Elvira* has often been used for this genus. The name *Delilia* is older and should therefore be used instead of *Elvira*.

Erechtites hieracifolia (L.) Raf. ex DC. var. **cacaloides** (Fisch. ex Spreng.) Griseb.

Griseb., Fl. Brit. W. Ind. 381 (1861).

Collection: Santa Cruz, from pasture land below Santa Rosa along the trail to El Chato, van der Werff 1372.

New for the Galápagos. For a discussion of the relationships between this species and *Senecio* and other genera, see Belcher (1956). *E. hieracifolia* var. *cacaloides* is a widespread weed in S America.

Galinsoga urticaefolia (H.B.K.) Benth. in Örsted

Benth. in Örsted, Vidensk. Meddel. Dansk Naturhist. Foren. København 1852: 102 (1852).

Collection: Santa Cruz, occasionally along the New Road, van der Werff 1284.

New for the Galápagos Islands. *G. urticaefolia* is a weedy species found in USA, C and S America and in Europe.

Jaegeria gracilis Hook. fil.

Hook. fil., Trans. Linn. Soc. Lond. 20: 213 (1847).
J. crassa Torres, Brittonia 20: 71 (1968).

Collections examined: Howell 9576, 9222, 9551a, 9006, 9204, Bowman s.n., Schimpf 91, Stewart 634, 637, Taylor G 34, Wiggins & Porter 633, 646, all in CAS – Colinvaux 347, 388, Wiggins 18.356, 18.774, 18.807, Itow 112, 30701-1, all in DS – van der Werff 957, 1175, 1154, 1353, 1401, 1509, 1528, 1678.

Cronquist recognised two species of *Jaegeria, J. gracilis* and *J. crassa,* in the Galápagos Islands. He uses the following differentiating characteristics:

J. gracilis: Involucral bracts thin and barely, if at all, wrapped around the edges of the subtended achene. Outer receptacular bracts slightly to strongly differentiated from the middle and inner ones, often somewhat clasping their achenes and occasionally approaching the structure and texture of those of *J. crassa*.

J. crassa: Involucral bracts thickened, wrapped around and fully enclosing the subtended achene, often some or even all of the bracts very like outer receptacular bracts; these are glabrous, strongly thickened, conspicuously grooved-striate, wrapped around and fully enclosing the achene. Larger, more robust and often less hairy than *J. gracilis*.

In addition to these differences I noticed that characteristic for *J. crassa* the number of flowers per head decreases to 15 (c. 50 in *J. gracilis*), that the achenes become fused with the receptacle and the head falls as a unit (achenes falling individually in *J. gracilis*), that the growth is erect (*J. gracilis* is trailing), and that it grows in forest (*J. gracilis* grows in wet, disturbed places).

Field observations and study of herbarium and my own collections have revealed that we are not dealing with two distinct *Jaegeria* populations, but rather with one variable population. A large number of collections are intermediate between the *gracilis* and *crassa* extremes. The plants are found in wet, disturbed sites (especially the *gracilis* type) but sometimes the more stable forest habitat is invaded. It is the collections from the forest that show the *crassa* characteristics: increased size (leaves up to 10 cm), strongly thickened involucral bracts, reduction in the number of flowers per head and fusion between the receptacle and the achenes.

Carlquist (1974) cites several examples from islands in the Pacific of evolutionary changes in originally weedy species upon their spread to more stable habitats. One of the changes is very often a reduction in dispersal ability. *Jaegeria* on the Galápagos Islands seems to be another example of this process. Eventually, the forest type will possibly separate from the weedy type and each of them will become a distinct taxon. Nowadays, however, the intermediates are so numerous that it does not seem possible to recognise the extremes taxonomically.

Tridax procumbens L.

L., Sp. Pl. 900 (1753).

Collection: Santa Cruz, on the open roadside along the new road just outside Puerto Ayora, van der Werff 2238.

New for the Galápagos Islands. *T. procumbens* is a decumbent, stiff-hairy weed with yellow-flowered heads on long, erect peduncles. It is a pantropical weed; I saw it in great numbers along roads in Guayaquil and it has doubtlessly been recently introduced into the Galápagos Islands.

Convolvulaceae

Merremia umbellata (L.) Hallier fil.

Hallier fil., Bot. Jahrb. 16: 552 (1893).

Collections: Santa Cruz, along the road near Bella Vista, van der Werff 1289, 2044.

New for the Galápagos Islands. *M. umbellata* is the only member of the Convolvulaceae in the archipelago with bright yellow flowers. It has been reported from both the New and Old World tropics.

Ipomoea pulchella Roth

Roth, Nov. Pl. Sp. 115 (1821); O'Donnell, Lilloa 29: 221 (1959).

Collection: San Cristóbal, along the road from Baquerizo Moreno to El Progreso, 180 m, van der Werff 2170.

New for the Galápagos Islands. *I. pulchella* is a slender plant that can easily be distinguished from all other Galápagos *Ipomoeas* by its long, filiform and coiled peduncles. The leaves are palmately pentafoliolate. *I. pulchella* is pantropical.

Ipomoea stolonifera (Cyrill.) Gmel.

Gmel., Syst. Nat. ed. 13, 2: 345 (1791).

Collection: Isabela, common on sand dunes behind Villamil, van der Werff 2317.

New for the Galápagos Islands. *I. stolonifera* grows on sandy sea shores. *I. pes-caprae* occupies the same habitat but is purple-flowered, while *I. stolonifera* has white flowers with a yellow throat. It is reported from both the Old and New World tropics.

Rubiaceae

Oldenlandia corymbosa L.

L., Sp. Pl. 119 (1753).

Collection: San Cristóbal, from the airport near Puerto Baquerizo Moreno, van der Werff 2201.

New for the Galápagos Islands. *O. corymbosa* is a low, branched annual that differs from the other indigenous, herbaceous Rubiaceae by having several seeds in each of the two cells of the fruit. It is widely distributed in the tropics of both hemispheres.

Solanaceae

Physalis peruviana L.

L., Sp. Pl. ed. 2: 1670 (1763).

Collection: Santa Cruz, along the road near Sta Rosa, 400 m, van der Werff 1830.

New for the Galápagos Islands. *P. peruviana* is a perennial, pilose species that is considerably larger than the other *Physalis* species reported from the archipelago. A good difference is the size of the anthers: 3 mm in *P. peruviana,* 1.5–2.4 mm in the other species. According to Macbride (1962) *P. peruviana* is frequently cultivated for its edible fruit.

Verbenaceae

Lippia rosmarinifolia Anderss. var. rosmarinifolia

Anderss., Kongl. Svenska Vet.-Akad. Handl. 1853: 198 (1855).

L. rosmarinifolia var. *stewartii* Moldenke, Phytologia 14: 217 (1967).

Collections: Isabela, Volcán Alcedo, van der Werff 1038, 2331, 2337.

L. rosmarinifolia var. *rosmarinifolia* is known from Isabela, Fernandina and Pinta.

Moldenke (in Wiggins & Porter 1971) gives as diagnostic characteristics for var. *rosmarinifolia:* leaves entire or obscurely toothed. Var. *stewartii* is described as having pinnately lobed leaves. Howell, on the label of his collection no. 9585 (CAS), states that the juvenile leaves are lobed. My own field observations confirm this: van der Werff 2337 is a juvenile, non-flowering plant from the coast below Volcán Alcedo, and has distinctly lobed leaves. All flowering *Lippia* plants in the area had entire leaves. Apparently *L. rosmarinifolia* keeps the lobed leaves longer on the top of the volcanoes than in the coastal areas, but such plants with juvenile, lobed leaves do not deserve taxonomic recognition.

L. rosmarinifolia var. *latifolia* Moldenke, described from Santiago, also has entire or obscurely toothed leaves when mature and lobed leaves when juvenile.

Verbena brasiliensis Vell.

Vell., Fl. Flum. 17 (1825); Icones 1: pl. 40 (1827).

Collection: San Cristóbal, along the road near Tres Palos, 150 m, van der Werff 2182.

New for the Galápagos Islands. *V. brasiliensis* has distant leaves and short, densely flowered spikes in fascicles. In *V. litoralis* the spikes soon become elongate. *V. brasiliensis* is a widespread weed on the American mainland.

Verbena townsendii Svens.

Svens., Amer. Journ. Bot. 22: 253 (1935).

V. galapagosensis Moldenke, Phytologia 2: 55 (1941).

V. glabrata var. *tenuispicata* Moldenke, Phytologia 14: 283 (1967).

V. stewartii Moldenke, Phytologia 2: 56 (1941).

Collections examined: Isabela, Stewart 3317, 3318, 3319, 3320, Howell 9007, all in CAS; van der Werff 2280, 2286, 1172, 1192, 1218, 1897, 2152; Vagvolgyi s.n. (C) – Fernandina, Lynn Hendrix s.n. (DS), Adsersen 486, 512, 543, 572, 913, 920, 944, 969 (C) – Pinta, Adsersen 1148, 1189 (C); van der Werff 2124.

V. townsendii in this wide sense is known from Santa Cruz, Isabela, Pinta and Fernandina.

V. townsendii, V. glabrata var. *tenuispicata, V. galapagosensis* and *V. stewartii* have been separated on leaf characteristics by Moldenke (in Wiggins & Porter 1971). In these four species the leaves range from linear to lanceolate or oblong and from entire to lobed or deeply trifid. Since there were only few collections of these species it appears that Moldenke came to accept them by correlating leaf characteristics with locations. From a study of the herbarium material available, my own collections and field observations I conclude that the taxa mentioned belong to one single, extremely variable species.

There are great differences in leaf shape within the population of Alcedo, Isabela (the type locality of *V. galapagosensis*) where I collected repeatedly. Juvenile plants have relatively wide leaves and would be referred to *V. glabrata* var. *tenuispicata*. Some older plants have linear, entire leaves and would be called *V. galapagosensis,* while others have lobed leaves and are closer to *V. townsendii* or *V. stewartii.* On Cerro Azul old plants have greatly reduced leaves or have leafless flowering branches, while the leaves at the base of the plants are large. Thus, by using material from the upper or lower part of the same plant one can easily arrive at different identifications.

In open, wind-exposed locations the plants are decumbent and the stems regularly carry young shoots with juvenile leaves. Old parts have much narrower leaves. Even the isotypes of *V. stewartii, V. galapagosensis* and *V. townsendii*

(CAS) do not show the characteristics ascribed to these species.

Consequently, the lax-flowered, narrow-leaved *Verbena* plants from the Galápagos Islands should not be separated into four species but should all be called *Verbena townsendii* Svens.

Euphorbiaceae

Chamaesyce lasiocarpa (Kl.) Arthur

Arthur, Torreya 11: 260 (1911).

Collection: San Cristóbal, along the road outside Puerto Baquerizo Moreno, 50 m, van der Werff 2171.

New for the Galápagos Islands. Diagnostic characteristics of *C. lasiocarpa* are pubescent capsules, cyathia arranged in leafy dichasia and erect habit. It is known from the Antilles, C America and the northern part of S America.

Acalypha parvula Hook. fil.

Hook. fil, Trans. Linn. Soc. Lond. 20: 185 (1847).

A. parvula var. *chathamensis* (Robins.) Webster, Madroño 20: 263 (1970).

A. parvula var. *reniformis* (Hook. fil.) Muell-Arg., Linnaea 34: 48 (1865).

A. parvula var. *strobilifera* (Hook. fil.) Muell.-Arg., Linnaea 34: 47 (1865).

Collections: van der Werff 1026, 1087, 1094, 1100, 1138, 1241, 1250, 1731, 1812, 1853, 1953, 1996, 2053, 2071, 2141, 2147, 2149, 2200, 2274, 2275, 2351 from Santa Cruz, San Cristóbal, Pinzón, Santiago, Santa Maria, Española and Rábida.

A. parvula is known from all the larger islands with the exception of the northern islands Pinta, Marchena, Genovesa, Wolf and Darwin.

There is a wide variation within *A. parvula*. Webster (in Wiggins & Porter 1971) recognises four varieties. However, nowadays when more collections are available, it is clear that the size, pubescence and leaf characteristics used in Webster's key do not separate four taxa. The four varieties are "simply arbitrary assemblages of plants selected from a mosaic of clinal and microgeographic variation" (Webster 1970).

Acalypha sericea Anderss. var. baurii (Robins. & Greenm.) Webster

Webster, Madroño 20: 261 (1970).

A. sericea var. *indefessus* Webster, Madroño 20: 261 (1970).

Collections: Santa Cruz, van der Werff 1278, 1297, 1391, 1667, 1736, 1746, 2617 – Isabela, Volcán Alcedo, van der Werff 1180, 1467, 1502, 1525, 1534, 1861, 1980.

A. sericea var. *baurii* in this sense is known from Isabela, Santa Cruz and San Cristóbal.

My collections clearly show that both *A. sericea* var. *baurii* and var. *indefessus* occur on Santa Cruz and Volcán Alcedo, Isabela. On both locations plants from dry areas show characteristics of var. *indefessus*, whereas plants from wetter areas correspond with var. *baurii*. A number of plants are intermediate. Consequently, the varieties *baurii* and *indefessus* do not deserve separate recognition and var. *indefessus* should be regarded as a synonym of *A. sericea* var. *baurii*.

A. sericea var. *sericea* and var. *baurii* can be distinguished by the following characteristics:

var. *baurii:* Staminate spike curved, often pendent; its peduncle very short in relation to the fertile part; terminal pistillate spike generally absent, present in specimens from southern Santa Cruz; leaves with 17 or more teeth on each side.

var. *sericea:* Staminate spike erect; its peduncle about as long as the fertile part; terminal pistillate spike present; leaves with 8–15 teeth on each side.

My collections of *A. sericea* var. *baurii* from Alcedo and western and northern Santa Cruz all lack a terminal spike. However, several collections from southern Santa Cruz do have a terminal pistillate spike. Near the Caseta at southern Santa Cruz I found a large heterogeneous population of *Acalypha* (van der Werff 1413, 1414, 1415, 1417, 1419). Some plants belonged to *A. parvula*, which often has well-developed terminal spikes. Others were typical *A. sericea* var. *baurii* lacking a terminal spike. A great number of intermediates were also collected. In this locality *A. sericea* var. *baurii* interbreeds with *A. parvula*. Plants with a terminal pistillate spike but in other respects similar to ordinary *A. sericea* var. *baurii* probably represent introgression from *A. parvula*.

Lythraceae

Cuphea racemosa (L. fil.) Spreng.

Spreng., Syst. 2: 455 (1825).

Collection: Santa Cruz, open terrain near Media Luna, 540 m, van der Werff 1692.

New for the Galápagos Islands. Only one other species of *Cuphea* is known from the archipelago, viz. *C. carthagenensis*. This species has axillary, purple flowers while *C. racemosa* has a terminal raceme with almost white flowers. *C. racemosa* is found in tropical S America, extending northwards to Mexico and Cuba.

Malvaceae

Sida glutinosa Commers. ex Cav.

Cav., Mon. Cl. Diss. Dec., t. 2 (8) (1785).

Collections: Isabela, E slope of Volcán Alcedo, 750 m, van der Werff 1135; 1020 m, van der Werff 1987 – Santa Cruz, near the Puntudo, Adsersen 173, 622 (C).

New for the Galápagos Islands. *S. glutinosa* is immediately distinguished from other species of *Sida* known from the archipelago by being glandular-pilose. The leaves are up to 4 cm long and 2 cm wide, serrate, cordate at base, acuminate at tip and have a stellate pubescence. The flowers are pale orange. *S. glutinosa* is reported from the West Indies and Mexico to S America.

Polygalaceae

Polygala L.

L., Sp. Pl. 701 (1753).

The genus *Polygala* in the Galápagos Islands was recently discussed by Howell & Porter (1968). They recognise five taxa, one of which, *P. anderssonii* Robins., is puberulent and the remaining four glabrous. Other characteristics said to separate *P. anderssonii* from the glabrous taxa show partially overlapping ranges. The difference in ratio of aril length to seed length is not as well-marked as indicated in the key.

Among my collections of *Polygala* are two from Rábida, one (no. 1092) from near the coast and one from the top (330 m, no. 2354). The coastal collection keys out to *P. sancti-georgii* Riley var. *oblanceolata* Howell while the specimens from the top only differ in being puberulent. I found a similar situation on Volcán Alcedo, Isabela: the coastal plants (no. 1000) were glabrous, belonging to *P. galapageia* Hook. fil. var. *galapageia*, while plants growing inside the caldera near the fumaroles at 840 m (no. 1928) were puberulent but otherwise similar to the coastal plants.

I expect that intense collecting along an altitudinal gradient on Rábida or Alcedo will show that taxa which are glabrous at sea level become puberulent at higher altitudes and that *P. anderssonii* should be reduced to synonymy under *P. galapageia*. At this moment not enough material is available to support this change.

Umbelliferae

Hydrocotyle umbellata L.

L., Sp. Pl. 234 (1753).

Collections: Santa Cruz, open terrain near Cerro Crocker, 600 m, van der Werff 1689 – San Cristóbal, near the summit, Adsersen 805 (C).

New for the Galápagos Islands. There is only one previous collection of *Hydrocotyle* from the Galápagos Islands. This collection was at first regarded as belonging to *H. umbellata* (Robinson & Greenman 1895) but was later on (Robinson 1902) described as an endemic species, *H. galapagensis* Robinson. This species is extremely similar to *H. umbellata*, the only difference being the leaf margin, which is shallowly crenate in *H. umbellata* but double dentate in *H. galapagensis*. It is quite possible that the type specimen of *H. galapagensis* (originating from San Cristóbal from where *H. umbellata* is reported here) is nothing but an aberrant individual of *H. umbellata*.

Bromeliaceae

Tillandsia insularis Mez in DC.

DC., Monogr. Phan. 9: 765 (1896).
T. insularis var. *latilamina* Gilmartin, Phytologia 16: 163 (1968).

Collections examined: Gilmartin 875, 876, 877, 879, 882, 883, 884, 885, 886, 906, 908, 917, all in CAS; van der Werff 2316.

T. insularis has been reported from San Cristóbal, Santa Maria, Santa Cruz, Santiago, Isabela and Pinzón.

Gilmartin (1968) recognises two varieties in this endemic species. The var. *latilamina* has floral bracts with lepidote outer surface, partly purple leaf sheaths, 4.3–7 cm wide leaves and ascending spikes. In contrast the var. *insularis* has glabrous outer floral bracts, not partly purple leaf sheaths, 2.4–4 cm wide leaves and spreading to recurved spikes.

These characteristics correlate with regard to size and vary between small and large specimens. Since large specimens are bulky and inconvenient to handle, quite a few older collections consist only of an inflorescence or part of an inflorescence, and a leaf rosette mounted on the same sheet. Usually the rosette comes from a small plant and the inflorescence from a larger one. This gives inaccurate information about the size of flowering plants. To illustrate this I will give the leaf widths of a number of flowering plants from two locations.

I measured 38 plants at Cerro Azul, Isabela. One had a leaf width of 4.0 cm, the others varied from 5.5 to 8.0 cm. At Pinzón I measured 20 plants: two were in the range ascribed to var. *insularis* (3.5 and 4.0 cm) and the remaining ranged from 4.3 to 8.0 cm. Only var. *insularis* had been reported from these localities. The data indicate that most flowering plants have a leaf width in the *latilamina* range but that a few small flowering plants are also found. Since large and small plants grow together extensively, there is no reason to keep them apart taxonomically.

Cyperaceae

Cyperus densicaespitosus Mattf. & Kuekenth.

Mattf. & Kuekenth., Pflanzenr. 4–20 (2): 597 (1936).

Collection: San Cristóbal, in mud along a fresh water stream near Fresh Water Bay, van der Werff 2175.

New for the Galápagos Islands. *C. densicaespitosus* is similar to *C. brevifolius* (Rottb.) Hassk. regarding inflorescence characteristics. However, it is a caespitose annual while *C. brevifolius* is a perennial with a slender, long-creeping rhizome. *C. densicaespitosus* is widespread in tropical America and Africa.

Cyperus odoratus L.

L., Sp. Pl. 46 (1753).

Collection: Santa Cruz, along the road near Santa Rosa, van der Werff 1829.

New for the Galápagos Islands. The rachilla in this species becomes corky after flowering and finally breaks into single-fruited segments. This characteristic is not found in any other species of *Cyperus* known from the archipelago. *C. odoratus* is a common pantropical species.

Gramineae

Axonopus compressus (Swartz) Beauv.

Beauv., Ess. Agrost. 12 (1812).

Collections: San Cristóbal, near El Junco lake, 660 m, van der Werff 2192 – Isabela, southern slope of Cerro Azul, 600 m, van der Werff 2289.

New for the Galápagos Islands. *Axonopus* resembles *Paspalum* in a number of characteristics but can easily be distinguished by its abaxial spikelets. Both areas where I collected *Axonopus* had large herds of free-roaming cattle. *A. compressus* is a widespread tropical grass.

Digitaria decumbens Stent

Stent, Bothalia 3: 150 (1930).

Collection: Santa Cruz, in pasture land near Santa Rosa, van der Werff 1838.

New for the Galápagos Islands. *D. decumbens* originates from South Africa and is widely introduced as a forage grass in the tropics. Unfortunately, in the Galápagos Islands this species easily escapes from cultivation and it threatens to overrun the native vegetation in the fern-sedge zone by means of vegetative reproduction. Locally, this grass is called "pangola grass".

Melinis minutiflora Beauv.

Beauv., Ess. Agrost. 54 (1812).

Collection: Santa Cruz, along the road near Santa Rosa, van der Werff 2087.

New for the Galápagos Islands. *M. minutiflora* is also an introduced forage grass. It does not spread as extensively as *Digitaria decumbens,* but is fairly well confined to the patches where it was planted.

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Resumen

Desde abril de 1974 hasta octubre de 1975 se realisaron trabajos de campo en las Islas Galápagos (Ecuador), para estudiar la vegetación de la Isla Santa Cruz y de la Isla Isabela, especialmente el volcán Alcedo. Durante dicho estudio además hubo oportunidad de coleccionar plantas en otras islas. Se encontraron 35 especies nuevas para el archipiélago y en unos casos hubo necesidad de cambios de nomenclatura. La presentación de los datos es según la secuencia en la "Flora of the Galapagos Islands" de Wiggins & Porter (1971).

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Masonhalea, a new lichen genus in the Parmeliaceae

Ingvar Kärnefelt

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The new genus *Masonhalea* is segregated from *Cetraria* s. lat. on the basis of anatomy, morphology, ecology and chemistry. Its only species, *M. richardsonii* (Hook. in Richardson) Kärnef. is described and illustrated and a distribution map is provided.

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In recent decades lichenology has seen enormous advances in all areas of the field. New criteria for the delimitation of lichen genera have been developed as the large, early described, heterogeneous genera are re-evaluated. There has been an increasing trend to recognize smaller groups of more closely related species at generic rank (e.g. Hale 1965, Culberson & Culberson 1968, Brodo & Hawksworth 1977).

During my work on the brown fruticose *Cetrariae,* e.g. *C. islandica* and allied species, which comprise a well-defined natural group, I realized that *C. richardsonii* (previously referred to this aggregate) was unrelated to other species within the complex. This plant has puzzled lichenologists for more than a century. Nylander (1857) transferred the species from *Cetraria* to *Evernia.* Three years later he suggested that this taxon would be better accommodated in *Parmelia* (Nylander 1860 a) and later in the same year he placed the species in *Platysma* (Nylander 1860 b). Trevisan (1861) transferred the species to *Cornicularia,* while Howe (1915) in his revision of North American *Cetraria* noted that his inclusion of this species was only "tentative" and that it would be better placed in *Everniopsis.*

I find the species is sufficiently isolated from *Cetraria* and other genera in Parmeliaceae and warrants recognition as a separate genus. The new genus is named in honour of Dr Mason E. Hale, Jr. Dr Hale has been a leader in shaping modern taxonomic thought in lichenology, and has encouraged and inspired numerous young lichenologists. When I first became aware of the unique characters of this lichen, Dr Hale immediately recognized their significance.

I have examined all collections and exsiccatae of *Masonhalea* in BM, CANL, COLO, FH, MICH, MIN, MSC, LD, O, US, WIS. I also studied the plant in the field on the Seward Peninsula, Alaska, in 1973.

For anatomical investigations thalli were soaked in water for a few hours, sectioned with a freezing microtome at 10–15 µm and mounted in cotton blue. One collection was examined using a scanning electron microscope following Hale (1973). The presence of alectoronic acid is easily determined using UV light. However, collections from several populations from the whole distributional range were also tested using the standardized procedure of C. Culberson (1972).

Masonhalea Kärnef. gen. nov.

Typus generis: *Masonhalea richardsonii.*

Thallus prostratus, cartilagineus, e paucibus ramibus principalibus irregulariter vel dichotome divisis formatus, in statu sicco saepe rotundatus. Superficies superior obscure brunnea ad pallide olivacea, superficies inferior in partibus corticatis concolor, in partibus decorticatis alba vel caerulescens. Cortex superior crassissimus, e hyphis gelatinosis et valde pachydermaticis constans, cortex inferior comparate tenuis, e hyphis gelatinosis, aliquantum pachydermaticis et valde pachydermaticis constans. Medulla

Table 1. Comparison of *Cetraria* and *Masonhalea*.

Character	Brown fruticose *Cetrariae*	Other *Cetrariae*	*Masonhalea*
Upper cortex	thin paraplectenchymatous	thin paraplectenchymatous	thick prosoplectenchymatous
Thallus and lobes	erect fruticose, tubular or channelled, corticate on both sides, dying off from the basal parts	subfruticose or foliose, tubular or channelled or plane, in some erect fruticose, corticate on both sides, dying off from the basal parts	cartilaginous, prostrate, in dry condition often somewhat rounded, slightly channelled, lower surface only partly corticate
Branching	dichotomous or irregular from the basal parts	dichotomous or irregular from the basal parts, broad foliose forms almost unbranched	dichotomous or irregular, radiating in several directions, in one plane
Ecology	terricolous or corticolous, tuft-forming or growing in small colonies	terricolous or corticolous, tuft-forming or growing in small colonies	rolling freely on the ground, single individuals aggregate into large clumps

crassa compacta, alba. Algae prope corticem superiorum glomeratae, ad Trebouxiam pertinentes. Apothecia laterali-marginalia, sporae non septatae, hyalinae, ellipsoideae vel subglobosae. Pycnidia marginalia, microconidia bacillaria.

Thallus prostrate, cartilaginous, formed of a few major branches dividing irregularly or dichotomously, in dry condition often with a somewhat rounded habit. Upper surface dark brown to pale olive brown, lower surface concolorous on corticate portions of the thallus, or whitish to bluish on decorticate portions. Upper cortex very thick, composed of gelatinized and very thick-walled hyphae, lower cortex relatively thin, composed of gelatinized moderately thick-walled and thick-walled hyphae. Medulla thick and dense, white. Algae clustered near the upper cortex, *Trebouxia* type. Apothecia lateral-marginal, spores non-septate, hyaline, ellipsoidal to subglobose. Pycnidia marginal, microconidia rod-shaped.

Delimitation of the genus

The new monotypic genus is segregated on a combination of characters (Table 1). The most important features are the structure of the upper cortex, the branching pattern, the partly decorticate lower surface and the ecology. Chemically *Masonhalea* does not show close affinity to *Cetraria*.

The thick upper cortex of *Masonhalea* is composed of thick-walled cells embedded in a dense matrix (Fig. 1 A, C). The cell walls are gelatinized and a homogeneous mass is formed where individual hyphae no longer are discernable. This kind of tissue is usually classified as being prosoplectenchymatous (Hale 1976, Jahns 1974) but sometimes as being scleroplectenchymatous (Degelius 1954). The upper cortex of *Cetraria* is relatively thin (15–40 μm) and formed of moderately thick-walled cells. Hale (1976) referred to this kind of cortical layer as being composed of pachydermatous (thick-walled) paraplectenchyma and it is characteristic of the Parmeliaceae. A similar cortical layer is also found in *Evernia, Everniopsis* and *Cornicularia* (e.g. *C. californica*). Other *Cornicularíae* have prosoplectenchymatous cortical layers (e.g. *C. normoerica*) or an unusual combination of both paraplectenchymatous and prosoplectenchymatous tissues (e.g. *C. aculeata*) (Hale 1976). *C. normoerica* has a thick upper cortex. However, this particular species differs markedly from other *Cornicularíae* (Henssen & Jahns 1973) and differs from *Masonhalea* morphologically, ecologically and chemically.

The thallus of *Masonhalea* is prostrate and its branching somewhat resembles that of an alga (*Chondrus*). The plant appears to initiate growth from one point and to divide horizontally in several directions, forming three or more major

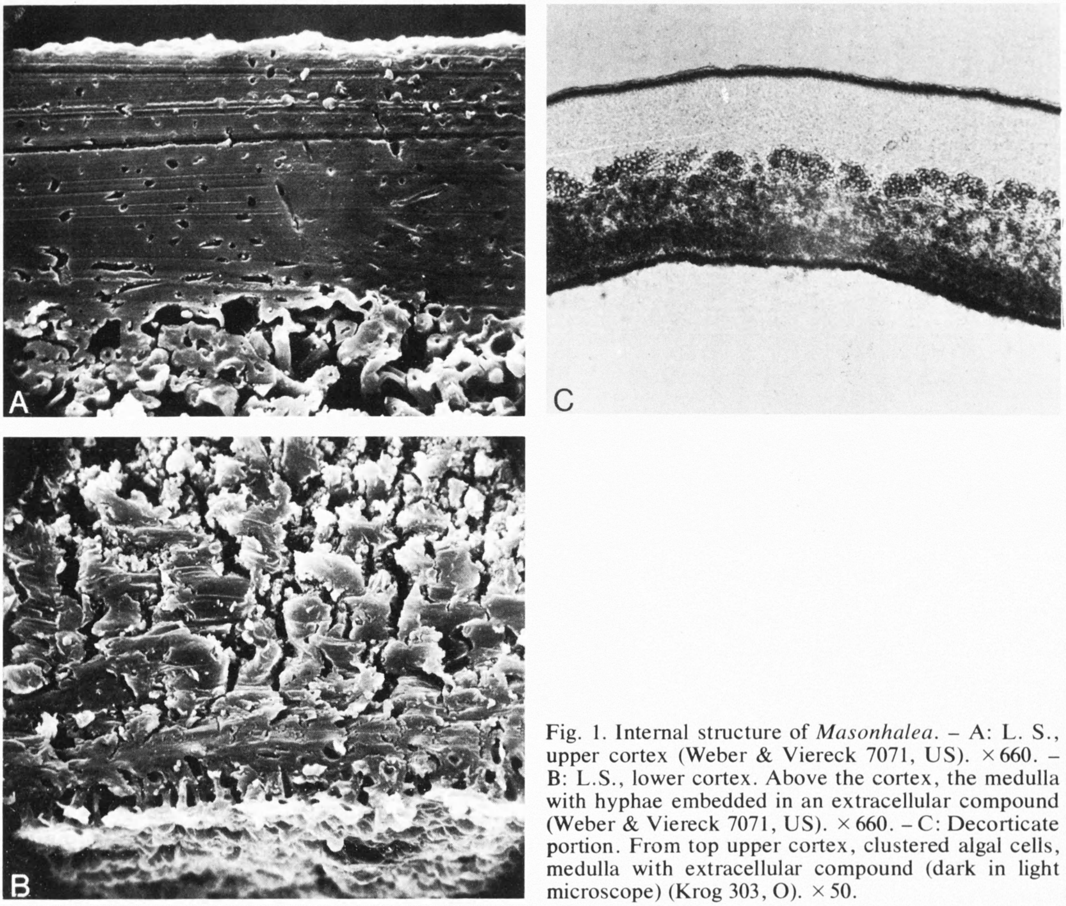

Fig. 1. Internal structure of *Masonhalea*. – A: L. S., upper cortex (Weber & Viereck 7071, US). ×660. – B: L.S., lower cortex. Above the cortex, the medulla with hyphae embedded in an extracellular compound (Weber & Viereck 7071, US). ×660. – C: Decorticate portion. From top upper cortex, clustered algal cells, medulla with extracellular compound (dark in light microscope) (Krog 303, O). ×50.

lobes which then divide dichotomously or irregularly (Fig. 2). The appearance is quite different from that of the erect, fruticose, dichotomously branched or foliose *Cetrariae*. The partly decorticate lower surface is another unique feature. These decorticate portions have sometimes erroneously been referred to as pseudocyphellae (Räsänen 1952). Pseudocyphellae, i.e. small cortical pores, are common in *Cetraria* and many other genera.

The ecological behaviour of the species is remarkable and differs from that of possibly related taxa. *Masonhalea* is usually not attached to the ground and actually rolls upon the other vegetation on the windy tundra. It is found as individual thalli or as fragments. Occasionally the individuals aggregate to form a large unorganized clump. Individual thalli or aggregates are sometimes also found in minor depressions on the tundra.

The orcinol depsidone alectoronic acid is the only secondary constituent found in *Masonhalea*. It is produced in large quantities and almost completely covers the medullary hyphae. The same substance is produced in a few *Cetraria* species (listed in C. Culberson 1969), e.g. *C. halei* and *C. pseudocomplicata,* but these species differ morphologically and have a thin paraplectenchymatous upper cortex. In addition *C. halei* contains atranorin and α-collatolic acid (Culberson & Culberson 1967).

Fruticose brown *Cetrariae* generally contain higher aliphatic acids, e.g. lichesterinic, protolichesterinic and rangiformic acids. These products are synthesized over the same acetate-polymalonate pathway as the aromatic com-

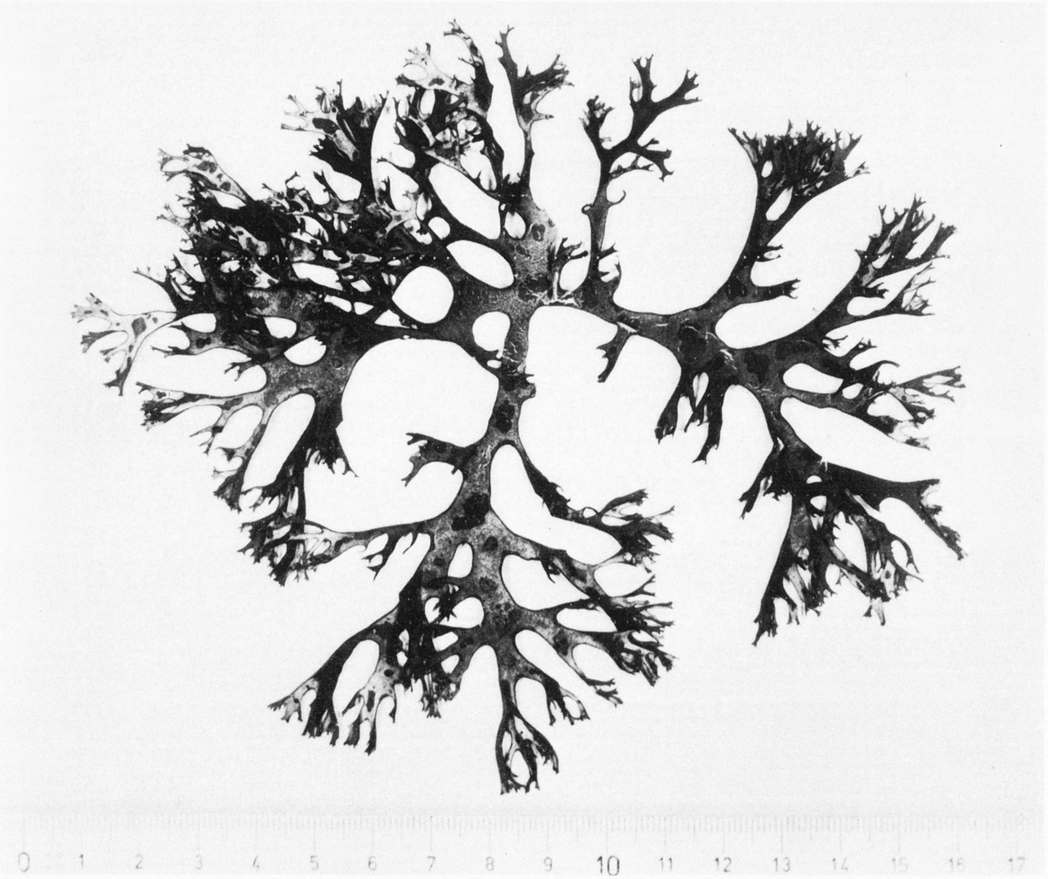

Fig. 2. ***Masonhalea***. Lower surface with decorticate portions (Scotter 18687, CANL). Scale in cm and mm.

pounds (C. Culberson 1969) but are structurally different.

Masonhalea richardsonii (Hook. in Richardson) Kärnef. comb. nov.

Basionym: *Cetraria richardsonii* Hook. in Richardson, Bot. App. Narrat. Jour. Polar Sea (1823) p. 761. Lectotype: Barren grounds from Point Lake to the Arctic Sea, l.c. Captain Franklin, N. American Land Expedition 1820 (preserved in BM but belonging to K). – *Evernia richardsonii* (Hook. in Richardson) Nyl. in Mém. Soc. Imp. Scienc. Natur. Cherbourg 5 (1857) p. 99. – *Platysma richardsonii* (Hook. in Richardson) Nyl. Synops. Lich. 1 (1860) p. 306. – *Cornicularia richardsonii* (Hook. in Richardson) Trev. in Flora 44 (1861) p. 51.

Thallus prostrate (1–)3–5(–8) cm, formed of a few major branches dividing dichotomously or irregularly, in dry condition with a somewhat rounded habit. *Lobes* cartilaginous (0.5–)2–5(–20) mm broad with the margins weakly recurved inwards. *Upper surface* dark brown, chestnut brown or olive brown, dull or glossy, smooth. *Lower surface* concolorous on corticate portions of the thallus, smooth or wrinkled. Decorticate portions whitish or bluish. *Soralia* rare. *Upper cortex* 110–130 μm thick, prosoplectenchymatous, matrix colourless except for external pigmentation, c. 10 μm thick. Medulla 110–200 μm, hyphae about 3.5 μm in diameter, superficially covered with extracellular deposits (Fig. 1 B). *Algae* often in clusters of about 20 μm, concentrated near the upper cortex, green, spherical, c. 6 μm in diameter (Fig. 1 C). *Lower cortex* 30–40 μm thick, a thin layer of moderately thick-walled, slightly anticlinal cells

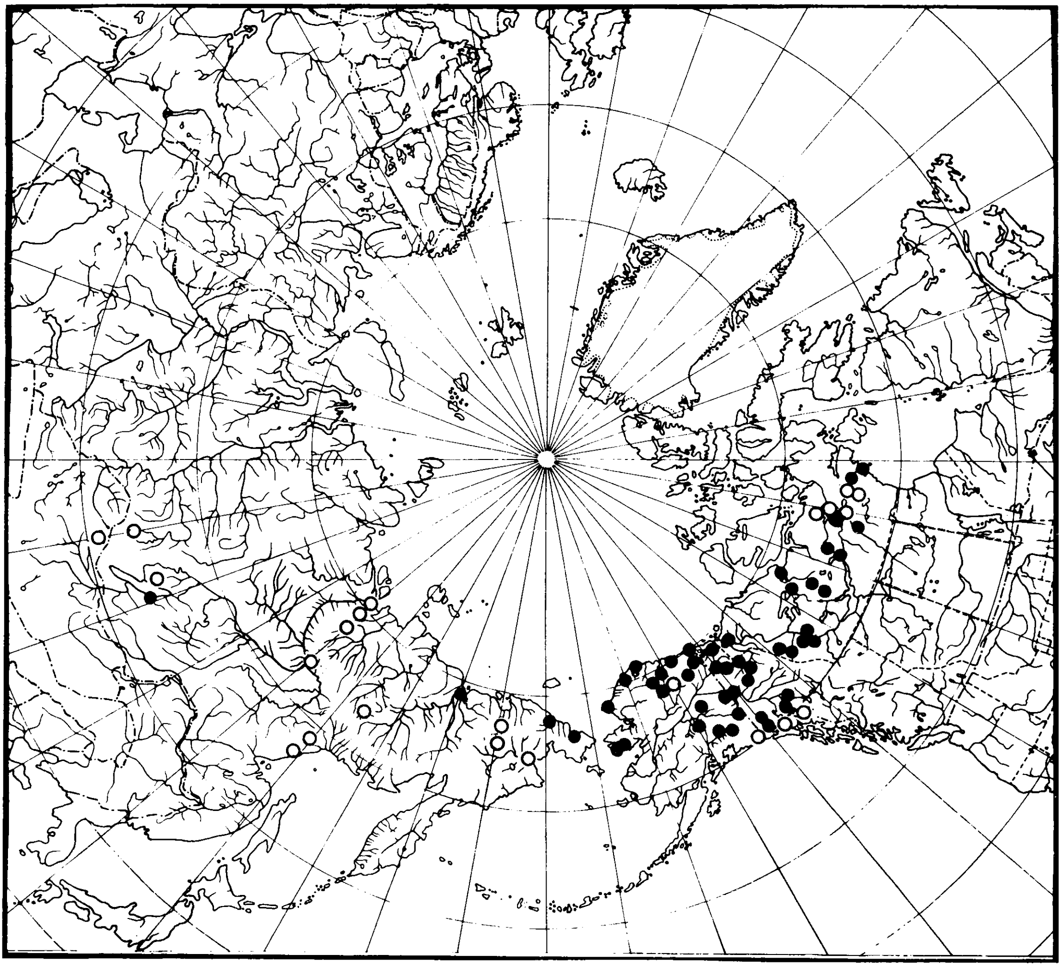

Fig. 3. Distribution of *Masonhalea*. Open circles in USSR from Rassadina (1950) and in North America from Thomson (1972).

covering a prosoplectenchymatous tissue, colourless except for a thin external pigmented portion, or lower cortex lacking, thickened medullary hyphae forming the lower surface. *Apothecia* rare, lateral, marginal; disc pale brown to brown, 0.5–3(–9) mm; hymenium 60–70 μm. *Asci* clavate to cylindrical, 10 × 40 μm. *Spores* 8 per ascus, non-septate, hyaline, ellipsoidal to subglobose, 6–6.5 × 3–6 μm. *Paraphyses* septate, c. 2 μm thick; hypothecium 30–40 μm, colourless. Pycnidia marginal, dark brown to black; microconidia rod-shaped, c. 0.75 × 5 μm. Medulla C –, K –, KC + pink, PD –, UV + bluish.

Nomenclature

Cetraria richardsonii was described in 1823 in a botanical appendix to Captain Franklin's *Narrative of a journey to the shores of the polar sea.* The appendix was written by John Richardson, surgeon and botanist on Franklin's first expedition, 1819–1822. We know from the preface to the appendix that William Jackson Hooker examined the lichens. Among the lichens *Dufourea arctica* was also described as new. Since both Hooker and Richardson were involved in the preparation of the lichen list, there is some question as to the authorship of the new taxa. Several new vascular plant species were described in the appendix and Richardson never wrote his name after a new epithet. In the same manner *D. arctica* has no author cited. On the other hand after *C. richardsonii* (Hooker, Ms) was cited. I therefore conclude that *D. arctica* should be attributed to Richardson as *Dactylina arctica* (Richardson) Nyl. and *C. richardsonii* to Hooker as *Masonhalea richardsonii* (Hook. in Richardson) Kärnef.

Richardson's collections are presently in BM. One collection clearly refers to the first expedition of Captain Franklin and I have therefore selected it as lectotype. The type locality was noted in the appendix as "Barren Grounds from Point Lake to the Arctic Sea". Isotypes: Fort Enterprise, Franklin's 1 journey, herb T. Taylor (FH: Sprague); Amer. Arctica, Fort Enterprise, Richardson det. Hooker (208) (FH: Tuck.); Arctic N. America, barren soil, Richardson det. Hooker (MICH: Fink 12093).

Variation

M. richardsonii has a normal variation amplitude in lobe form and colour and infraspecific taxa have never been described. The decorticate portions of the lower surface seem to expand with increased lobe width. A specimen from Alaska (Krog 539, O) with thallus parts up to 2 cm wide had an almost completely decorticate lower surface. A few specimens were found with soralia-like structures (1969 Krog, O; Scotter 19977, CANL; Bird & Benson 30543, CANL; 1947 Scholander, MIN; Thomson, Lich. Arct. 92).

Reproductive structures

The anatomical structure of apothecia and pycnidia is parmeliaceous. Apothecia are probably rare and only a few fertile specimens were observed (Kanewskij 1916, O; Krog 428, O; Johnson 17, CANL; Johnston 238, FH; 1970 Mitchell, CANL; 1971 Ironside, CANL; 1899 Williams, FH: Howe; Cantlon & Gillis 57-537, MSC; Thomson, Lich. Arct. 92; Bostock 40, CANL). Pycnidia are usually inconspicuous and do not occur in large numbers. Microconidia were only found in one specimen (H: Nyl. 36150). Reproduction by sexual means must be of minor importance.

Distribution

M. richardsonii is an arctic-alpine tundra species with a northern Beringian distribution (Krog 1968). It radiates from the northern part of Alaska and easternmost Siberia. Westwards it reaches the Lena River valley and Lake Bajkal and eastwards it extends towards Hudson Bay (Fig. 3). Its distribution in North America was mapped by Thomson (1972) and its range in the USSR was presented by Rassadina (1950) and Savicz (1923).

M. richardsonii seems to be a poor ecological competitor when compared with associated species. Fragmentation and wind dispersal has probably led to the local success and modern distribution of this fascinating plant.

Acknowledgements. I am deeply grateful to Dr Ove Almborn, Lund, Dr Irwin M. Brodo, Ottawa, Dr Peter A. Bowler, Irvine (Ottawa) and Mr Thomas Karlsson, Lund for discussion of this work. Peter Bowler in particular showed a great interest in my work and he also revised the English text. The Sweden-America Foundation made it possible for me to visit Ottawa during 1976.

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Botanical literature

Ainsworth, G. C., Sparrow, F. K. & Sussman, A. S. (eds.) 1973: *The Fungi, an advanced treatise. IV A. A taxonomic review with keys: Ascomycetes and Fungi Imperfecti.* X + 621 pp., 93 figs., 70 pls. *IV B. Basidiomycetes and lower Fungi.* XIII + 504 pp., 74 figs., 27 pls. incl. 1 coloured pl. Academic Press, New York, London. Price bound $ 29.– + 28.–.

The present work is undoubtedly the most ambitious mycological survey in modern time. It covers all important biological aspects, which is rarely the case in comparable textbooks. The volumes 1–3 deal with the fungal cell, the fungal organism, and the fungal population, whereas the last two-part volume is strictly morphological–taxonomic. A great many authors have contributed.

The system follows Ainsworth & Bisby's *Dictionary of the Fungi* (1971) and embraces the fungi in a conventional sense, but excludes the Hydromyxomycetes and Labyrinthulales. Both books begin with a key to the classes, and end with a cumulative index of Latin names and authors. Most papers follow a common pattern: at first a definition of the group, a morphological survey, keys to families and genera, description of the families, and finally selected references. Representative species are mentioned, sometimes even type species. Most articles are illustrated with drawings and/or photographs.

There has been an aspiration to include as many genera as possible within the restricted space. In the Saprolegniales (M. W. Dick) even all species are mentioned, and in orders as large as Mucorales, Pezizales, Agaricales, and Uredinales practically all known genera (c. 65, 93, 145, 110 resp.) are keyed out. Compared with corresponding figures in *Dictionary* the Pyrenomycetes are covered to c. 50%, the Discomycetes to c. 80%, and the Loculoascomycetes to almost 75%, which is impressive. In the Hyphomycetes and Mycelia Sterilia the key with 595 genera is completed with a list of 1541 generic names (incl. synonyms, references, and type species). *Dictionary* accepts 930 genera and 475 synonyms.

A doubling of several genera and a few families occurs, but this has been accepted by the editors in order not to conceal unsolved, taxonomic problems. Thus, for instance, *Ceratiomyxa, Acrospermum,* Thraustochytriales, and ten genera in "Perisporiaceae" (pp. 82, 90, 169, 170) turn up in two or three places in the system. With single exceptions the articles maintain a high standard – what else could be expected from outstanding experts? The existing differences are mainly due to the nature of the group treated, such as number of genera, taxonomic difficulties, and stage of present knowledge.

The number of illustrations varies from none (Agaricales) up to 66 plates with 559 genera in the Hyphomycetes (W. B. Kendrick & J. W. Carmichael), where the generic identification is founded on fine drawings following Saccardo's practical spore type system. The vouchers should have been mentioned, however. The authors' radical opinions of the nomenclature of these fungi have led them to accept S. J. Hughes's proposal of Persoon (1801) as a starting point, which has resulted in many illegitimate name changes. Knowledge of the conidial ontogeny is a must in modern Deuteromycete taxonomy, and both Kendrick & Carmichael and B. C. Sutton in his interesting treatise of the Coelomycetes report this as far as it is known. Since this development is still unknown in many type species, not few generic names are dubious and hence excluded (in the Hyphomycetes no less than 400; see Kendrick in *Taxon 23,* 1974). Other taxonomic problems refer to the kind of pycnidia or stromata. Thus, the Melanconiales seem to be more related to the Tuberculariales than to other Coelomycetes.

The treatment of well-known groups follows on the whole modern monographs and revisions, for example, as regards the Myxomycetes, Mucorales, Laboulbeniales, Pezizales, Ustilaginales, and Agaricales. But also the well-informed reader can find many items of interest here, such as a discussion of the still nebular origin of the slime moulds, the recent subclass division of the group (C. J. Alexopoulos), and two new families in Mucorales (by C. W. Hesseltine & J. J. Ellis). The Plasmodiophoromycetes have often been classified as parasitic slime moulds, but new cytological experiences seem to strengthen their affinity to higher zoosporic fungi (G. M. Waterhouse). The latter constellation forms here – like in many modern text-books – the Mastigomycotina. It is difficult to understand why this unnatural taxon has been created and accepted, when we finally have got rid of the "class" Phycomycetes. F. K. Sparrow gives a handy introduction to these fungi, based particularly on their zoospore morphology. Among the more interesting information is the suggestion that the absence of zoospore I in the Lagenidiales–Peronosporales could be primary, and that their zoospore II is thus not homologous to that of the Saprolegniales. The unexpressed consequence would be a splitting of the Oomycetes!

The Discomycetes (R. P. Korf) and Loculoascomycetes (E. S. Luttrell) have received admirable treatments with keys crammed with useful comments and references without being overloaded. The term 'interascicular' (p. 194), which is found in several publications of today, and probably originates from Luttrell, should be corrected to 'interascal'. There is no such basic word as 'asciculus'. From a taxonomic point of view one notices i.a. that the Patellariaceae are placed among the bitunicates, and the (plectomycetous?) Elaphomycetaceae among the truffles, which deviates from conventional systems. Plectomycetes has here received an unusually narrow circumscription by D. I. Fennel, who maintains one order only (Eurotiales s. lat.), and excludes i.a. all species with ostiolate perithecia or septate (!) spores.

Erysiphales is a well-defined group with a small number of clear-cut genera. In spite of this C. E. Yarwood treats the order very incompletely and mainly from his Californian horizon (8 genera out of some 20, and many omitted references), which is unsatisfactory in a book of this magnitude. Somewhat disappointing is also the chapter on the Pyrenomycetes by the eternal team E. Müller & J. A. von Arx. Even if their gigantic task is indeed impossible (a selection among some 800 genera), one could demand a more careful presentation of facts. Also the ordinal system is over-simplified, with Sphaeriales engulfing most of the other orders. A scrutiny of the treatment of the reviewer's own speciality, the Sordariaceae s. lat., has revealed many grave errors: Fig. 4 d is *Diplogelasinospora,* not *Apiosordaria;* the asci are said to lack an apical apparatus (p. 91), when most of the genera have such; *Ceriophora* (p. 110) should be *Cercophora* (*Ceriophora* is a different genus); *Hypocopra* in Xylariaceae (p. 123) is represented by the type of *Sordaria, S. fimicola,* an inexplicable lapsus! Many more examples could be given.

In the Basidiomycetes particularly the classification on the family level and higher is of interest. The traditional bipartition into Holo- and Phragmobasidiomycetes has been given a lower rank here, but the taxonomic importance of basidial septation is nevertheless stressed by a division of the jelly fungi (R. F. R. McNabb & P. H. B. Talbot), where those with one-celled basidia at last are transferred to the Holobasidiomycetes. Also in the Aphyllophorales recent ideas are confirmed: the pulverization of old genera as *Polyporus, Hydnum, Clavaria, Corticium* and their families, and the importance of anatomical characters. The authors have chosen a middle way with keys of cupuloid, thelephoroid, clavarioid, cantharelloid, hydnoid, and poroid groups. This means a certain overlapping of families and genera, but it is no disadvantage from a practical point of view. The reader will find much of interest here, such as R. H. Petersen's pruning of Corner's concept of the cantharelloid fungi, or Talbot's dissolution of the Thelephoraceae sensu Donk, or be surprised at D. N. Pegler's conventional circumscription of the Polyporaceae.

Overlapping problems are also demonstrated between agarics and Gasteromycetes. Many of the latter are found in the Agaricales as gasteroid elements, and no less than seven families contain such; other Gasteromycetes are of more problematic affinity. A. H. Smith's and D. M. Dring's chapters anticipate a forthcoming, unorthodox taxonomy of this border field.

Highly informative is G. F. Laundon's outline of the complex and ambiguous terminology of spores, spore stages, and life cycles in the rust fungi. The author prefers to base the spore stages on morphology and not cytology, but the uredinologists are not unanimous on this point. A perplexing error is how he can call plasmogamy ''diploidization'' (p. 248) or say that the aeciospores germinate to a diploid thallus, when it is a matter of a dicaryotic phase.

The Fungi offers stimulating reading, and on most pages there are problems and details to discuss or comment upon, of which only a fraction can find room within an ordinary review. Although this 1125 page opus has its shortcomings, the final judgement must be marked positive. There is an enormous amount of information within these four covers, and for some fungus groups modern surveys and keys are presented for the first time. These two books (and the other three volumes too) will no doubt become the mycologists' bible for a long period to come.

Nils Lundqvist

Ayensu, E. S. 1974: *Leaf anatomy and systematics of New World Velloziaceae.* 125 pp., frontispiece, 24 figs., 51 plates. Smithsonian Contributions to Botany 15. Washington. Price (paper) $ 2.20.

Velloziaceae is a very interesting family of ''woody'' monocotyledons that has many distinct morphological, ecological and phytogeographical features. The family has been thoroughly studied the last few years, especially by L. B. Smith and E. S. Ayensu. The latter has been primarily interested in comparative leaf anatomy, and he surveyed species of the Old World in 1969. Five years later the corresponding work for the New World species has appeared. In these papers Ayensu has collected a great amount of leaf anatomical data. Velloziaceae must at the moment be one of the best-mapped plant families in that respect. The author has also contributed with new valuable methods, making it possible to deduce many anatomical details from old herbarium specimens.

The work under consideration here gives leaf anatomical data for 106 species of the genera *Vellozia* and *Barbacenia.* According to the revision by Smith (1962) this represents about 65% of the species known from the area. The main emphasis has been put on patterns of sclerenchyma, but information on hairs, epidermis, stomata, mesophyll and vascular bundles is given. In addition to detailed descriptions considerable weight is given to figure documentation: drawings of leaf surfaces (28 species), detailed drawings of transverse sections (42 species), scanning electron micrographs of epidermal and hair structures (20 species) and of stomata (22 species) and photos of transverse sections of nearly all the species examined. The drawings are very clear and good which also applies to most of the photographic documentation.

Ayensu has shown that in most cases the two genera can be separated on leaf anatomical data, especially by the sclerenchyma patterns. He also claims that each species exhibits distinct mesophyll and epidermal features that permit their individual identification. The material presented does perhaps not appear quite convincing on that point. But if it really is possible to distinguish the species the author ought to have systematized the results in an anatomical key. My reason for questioning the statement on specific identification is that the author himself demonstrates intraspecific variation in some species, whereas for many other species he only investigates one specimen.

My main criticism of the work is the lack of discussion and systematizing of the data. The impressive collection of data has not been set into any sort of reference frame. Since the data are put to such limited use the reading is less interesting than it could have been. And even if the aim of the work was only to present a sort of anatomical atlas (the title of the book promises more than that), the results and documentation should still have been presented more systematically.

Apart from this the author is to be praised for his endurance in procuring information. The author's next work can be awaited with expectation and perhaps this will give some of the answers to the still many unsolved problems within the family: the delimitation of genera and the affinities between the taxa of the Old and the New World.

Inger Nordal

Correns, C. E. *Untersuchungen über die Vermehrung der Laubmoose durch Brutorgane und Stecklinge.* Jena 1899. Reprinted 1976 as Vol. 7 of Bryophytorum Bibliotheca. XXIV + 472 pp., illustrated. J. Cramer, Lehre. Price 120.-DM.

With this reprint an excellent, classical work has again become available. Carl Correns was the last pupil of Carl Nägeli, to whom also the book is dedicated. To most of us he is known as a famous geneticist and one of the rediscoverers of the Mendelian laws. But he was a clever and skilful morphologist too, and his early activity in the field of morphology of moss propagula, manifested in several papers, culminated in the present book. It treats the concept of propagula in its widest sense from fragile shoots and leaves to advanced gemmae-forming structures. Since the book certainly is new to younger bryologists, some notes about its content will be worthwhile.

The main content is divided into two parts. The first or special part (322 pp.) includes careful descriptions of propagula of a great number of genera and species ordered by families. A separate section here treats also those innovations from the stem which in the title of the book is called Stecklinge. The second part is a general one (166 pp.), and gives morphological and phylogenetical aspects of propagula from stem, leaves, protonema, sporophyte, etc. A second section here describes the development of propagula, how they get loose and are distributed. In two other sections germination, the conditions of germination, growth and development and the occurrence and conditions of formation are treated. The last section discusses the evaluation of propagula in taxonomic work and finishes with a survey of (key to) investigated species. There are 187 excellent figures, all drawings, in the text. A reference list and an index to taxa treated complete the volume.

The reproduction of text and illustrations in the reprint edition is clear and distinct. The format is almost the same as that of the original and fits the other volumes in the series (with the exception of the first one).

Olle Mårtensson

Iwatzuki, Z., Vitt, D. H. & Gradstein, S. R. 1976: *Bryological herbaria. A guide to the bryological herbaria of the world.* Bryophytorum Bibliotheca Vol. 8. 144 pp. J. Cramer, Lehre. Price 25.-DM.

The present book is, in addition to its general usefulness, also an excellent indication of how far the international cooperation between bryologists has advanced during the last decades. The demand for a special index of bryological herbaria was raised at the Colorado meeting of the International Association of Bryologists in 1973 by one of the authors (Dr Iwatzuki). According to the resolution, the material was collected by distribution of a questionnaire to the 735 herbaria listed in Index Muscorum but also to all members of I. A. B. In May 1975 when the main part of the questionnaires had been returned, the compilation work could start.

The index which can be considered as a continuation or supplement of Index Herbariorum embraces 292 herbaria with material of bryophytes available. Of these 44 refer to private (personal) collections. The herbaria are arranged alphabetically by city and their abbreviations are also those of I. H., and can be decoded by a separate index. For practical reasons the persons with private herbaria which lack herbarium abbreviations have been listed separately with reference to relevant city (and country) under which one has to look. The final list gives the cities with herbaria ordered alphabetically by countries.

Print and covers are those earlier adopted to the series. This guide to bryological herbaria is obviously as complete as one can expect and will be an indispensable and convenient tool in the taxonomic work on bryophytes.

Olle Mårtensson

Whittier, H. O. 1976: *Mosses of the Society Islands*. 410 pp., 101 figs. The University Press of Florida, Gainesville. Price (bound) $ 17.50.

The scientific – and romantic – interest in exotic islands does not seem to cease. Many of them are scientifically explored to an extent which leave many continents far behind. Most of these islands are created by fairly recent volcanic activity and are of great biohistorical and biogeographical interest. As far as bryophytes are concerned, two island groups of the southern Pacific have recently had their moss floras monographed: the Samoa Islands (Schultze-Motel 1974) and, now, the Society Islands by Dr Whittier. This last work is based on a dissertation from 1969.

The Society Islands form a central group in the southern Pacific. Tahiti is by far the largest and highest of the islands and the best explored from many points of view. The group embraces 13 other islands, but only 4 have been bryologically investigated: Moorea, the double islands Raiatea and Tahaa, and Bora Bora. The author gives an excellent view of the natural history and history of exploration of the islands.

It is not just the larger size of Tahiti which makes it predominate the present work. Its height (2237 m) is impressive for an island of its size (1036 km^2). Almost perpendicular walls up to 1000 m surround several of its valleys. The precipitation is extremely high, particularly on the windward (NE) side. In some elevated places in the central part of the island it is estimated to 2500 *cm*. Obviously this island should be a lovely place for bryologists.

The author applies the zonation introduced by Pappy (1948–58). The main vegetation belts are the maritime, mesotropical and hygrotropical zones, of which the first and third include several sub-zones. They are well defined by characteristic moss species. Drawings illustrate representative transects.

The systematic arrangement follows Brotherus' treatment in the second edition of *Die natürlichen Pflanzenfamilien*. There are keys to families, genera and species. For all taxa descriptions are given. More than a hundred species are illustrated by drawings from authentic specimens and references to other authentic illustrations are given. Synonyms, heterotypic as well as homotypic – and they are often many – are included and show together with the taxonomic discussions that the revision in many cases has been a difficult task, particularly so since the material is spread over herbaria in many countries. The author's own collections include more than 1700 numbers. The occurrence and ecology within the Society Islands, and the general distribution is reported for all species. There are only seven new descriptions (including four *Fissidens* species earlier described by the author and H. A. Miller jointly).

Before the revision about 400 species (the author here uses the word taxa in an unclear sense) have been reported from the islands. Now this number has been reduced to about 175. The author estimates the real number to about 200. Of the accepted species, less than 20 per cent are considered as endemic. Many elements indicate a relationship with other Polynesian islands, such as Hawaii, Marquesas Islands and New Zealand.

Of course, the composition of the moss flora is quite another than what we are familiar with in the northern temperate zone. For instance, Bryaceae is represented just by *Brachymenium indicum* and four *Bryum* species (of which *B. argenteum* is one), Mniaceae only by the cosmopolitan *Mnium (Rhizomnium) rostratum*, Grimmiaceae only by the endemic *Racomitrium papeetense* and Polytrichaceae by two species of *Pogonatum*. No *Andreaea* or *Sphagnum* species is reported. Instead we find species from many more or less exotic families, such as Calymperaceae, Hookeriaceae, Leucobryaceae, Meteoriaceae and Sematophyllaceae. Orthotrichaceae is not represented by its type genus but by two widespread *Zygodon* species and by eight *Macromitrium* species of which no less than six are endemic. Some of these tropical species are cosmopolitan in this belt, such as *Octoblepharum albidum* and *Rhizogonium spiniforme*. The world cosmopolite *Ceratodon purpureus* is not reported and in all probability is absent from the islands.

The bibliography (ten pages) has been worked out with care and seems to be very complete. The following glossary of terms could perhaps have been left out since one has to expect the users of this flora to know the terminology. In the index, keys as well as specific epithets are listed under the generic names.

The editor has made an attractive volume bound in green cloth with the signatures intact and with broad margins. The printed text and the reproduction of illustrations are good, and the typography greatly facilitates the use of the book. Perhaps the generic names could have been in boldface or have been moved to the centre of the page. Serious misprints and inadvertences have not been met with hitherto. The price must be considered as low.

Mosses of the Society Islands is an excellent work which will be indispensable for the continued study of the mosses of the southern Pacific as a whole.

Olle Mårtensson

Fægri, K. & Iversen, J. 1975: *Textbook of pollen analysis*. 3rd revised edition. Munksgaard, Copenhagen. Price DKr 100.–.

For more than 25 years the "Fægri–Iversen book" has been the main textbook for pollen analysts dealing with Quaternary biostratigraphy. The first edition was published 1950, the second slightly revised edition 1964 and the third thoroughly revised edition in 1975. Due to Johannes Iversen's death in 1971, Knut Fægri alone had to prepare the final revision. He has consequently added important new knowledge to the text chapters. However, Iversen's excellent main contribution, the identification key of NW European pollen types, was completely revised already in 1964, and this key still stands out as the most important part of the book for pollen analysts in the daily microscope work.

The textbook covers the methods in the field, laboratory and at the microscope important for pollen analysts working with mainly bog and lake deposits of Late Quaternary age. The identification key is restricted mainly to pollen grains of spermatophytes growing in NW Europe. The authors do not regard the book as a textbook of pollen morphology. However, in the last edition the very comprehensive chapter on "The pollen grain, its form and function" is the very best introduction to pollen morphology, useful for pollen analysts as well as taxonomists.

The following comments are concentrated on the new information in the last edition.

The expanded chapter on pollen morphology seems to cover references to the most recent literature on the morphology, stratigraphy and chemistry of pollen grains. The terminology is distinct and carefully explained in text and figures. This is the basis for the identification key. Different terminological "schools" exist in pollen morphology, but the Fægri–Iversen terminology seems to be the most simple and logical, which is a prerequisite for a reliable pollen key. This chapter could possibly have been illustrated by more stereoscanning pictures.

The chapter on production and dispersal of pollen grains has also been expanded due to the growing amount of literature and knowledge within this field. Experimental studies on present-day pollen dispersal during the last few years have given pollen analysts an instrument for a more thorough interpretation of pollen diagrams. This knowledge has given the pollen analytical biostratigraphy a paleoecological approach. It should have been possible to add still more information to this chapter, and also some illustrations.

The three chapters on peat, sediment and field technique are in all editions of the textbook much too abbreviated. However, the reader obtains an introduction with the most important references. The field technique is fundamental for a good result of a pollen-analytical study, and this chapter should have been expanded and better illustrated.

In the chapter on pollen diagrams a pollen analyst is looking for advice in arranging the pollen types into ecological groups. I am convinced that the experienced authors do have important contributions in this respect.

New results from studies on pollen production, absolute pollen frequency diagrams and forest soil profiles are added to the chapter on interpretation of pollen diagrams. It makes this chapter extremely valuable.

The chapter on error has also been expanded, and it is better illustrated than before. In the chapter on statistical errors three pages have been added on numerical treatment. However, also in this respect the pollen-analytical method has been treated more in detail. The literature dealing with multivariate analysis of pollen data is growing enormously, and young pollen analysts, as well as older ones who are not trained in mathematics, need much more advice than can be found in this textbook. However, within the near future we will get a textbook dealing exclusively with numerical methods in pollen analysis.

I would also like to say that the chapter on pollen-analytical zones is old-fashioned. The modern terminology for stratigraphy, used in Pre-Quaternary geology for decades, has been introduced into Scandinavian biostratigraphy. One would expect to be given advice, with illustrated examples, on the usage of this important tool for subdividing pollen diagrams. In this textbook it is only briefly mentioned and discussed.

The last part of the book comprises the identification key. Though other, more complete keys are prepared and will be printed in the future, this Iversen key will remain indispensable for decades. It is based on an enormous experience in pollen-analytical research on NW European vegetational history combined with pollen morphological studies. The restricted selection of taxa is based on this experience. The terminology is simple and logic. However, the pollen analysts miss the pteridophyte spores in the key, since these are normally included in the analyses.

The textbook contains a valuable reference list. However, the literature is enormous within this wide field of science. The authors have made a good selection, but some important references are missing.

The conclusion is that this partly new book on pollen analysis stands out as an indispensable textbook for pollen analysts dealing with geological and paleoecological problems, as well as for taxonomists dealing with pollen-morphological problems.

Björn E. Berglund

Ferguson, I. K. & Muller, J. (eds.) 1976: *The evolutionary significance of the exine.* Linnean Society Symposium Series 1. VII + 591 pp. Academic Press Inc. Ltd., London, New York. ISBN 012 253650 9. Price £ 28.–.

The present volume is based on some twenty papers presented at an international symposium on the evolutionary significance of the exine held in London and Kew in 1974 under the auspices of the Linnean Society and the International Commission for Palynology. Studies on pollen and spore morphology, exine ultrastructure, formation and function of exine, pollen dimorphism etc. are included.

Sporopollenin, usually confined to pollen and spore exines, is known to occur in fossil cysts already in the Devonian or even earlier. A morphological feature like the proximal triradiate suture functioning as the germination site has persisted for a long time and through many types of spores and pollen. The exine evidently has a long fossil history.

The exine formation of species of *Pinus, Cosmos* and *Lilium* is strikingly similar while the ontogeny of Hepaticae spore walls differs both from pteridophytes and angiosperms.

The pollen wall shows a certain plasticity during the pollen development and carries physiologically active materials both from the sporophytic parent (exine domaine) and the gametophyte (intine domaine). These materials (enzymes) play a part in compatibility control. The ontogeny of the pollen grain wall of various genera in the Liliaceae, Juncaceae and Cyperaceae suggest phylogenetic relationships which are not obvious in mature pollen grains.

Studies on the arrangement of pollen grains during meiosis (successive and simultaneous types) are relatively few although they are essential in order to understand polarity, symmetry and aperture position. A close correlation between the simultaneous-type meiosis and the acquisition of radially symmetrical grains is suggested.

The major part of the book is devoted to the morphology of spore and pollen walls in taxa of the Hepaticae, Musci, Pteridophyta and Angiospermae. The ultrastructure of the walls as revealed by electron microscopy brings new information which aids in interpreting the taxonomy and phylogeny of several taxa.

The mature spore walls of Hepaticae consist of intine and lamellated exine which is reminiscent of the endexine in certain pollen walls. The spore walls of the Musci, generally consist of intine (endospore), exine (exospore) and perine (perispore). The perine appears to be absent in the Hepaticae spores which, however, have a more prominent and variable wall ornamentation than the Musci spores. The fine structure of the spore walls (exospore) of

Pteridophytes varies from group to group with reference to, e.g., relative position of the lamellated and non-structured exospore parts.

Taxa from nearly 50 angiosperm families were pollen-morphologically investigated. Morphological trends have been particularly emphasized. Within angiosperm taxa pollen apertural configurations are referable to two main models, "successiformy" and "breviaxy". Successiformy (tricolpate–pericolpate–periporate) is found in, e.g., the Centrospermae, Rosidae and Asteridae (sensu Takhtajan). Periporate conditions are also present in the Malvales, but the geometrical principle is different. The end result is due to disappearance of ectoapertures and spiralization of apertures.

In a survey of families of the Ranalean complex it was concluded that ancestral angiosperm pollen grains are large, boat-shaped, psilate, atectate, monosulcate and probably without endexine. Two clear-cut pollen types are reported in the Annonaceae. Outside the Ranalean complex the following families were treated: Anacardiaceae, Dichapetalaceae, Labiatae, Onagraceae, Sapindaceae, Saxifragaceae, Umbelliferae, and Xanthorrhoeaceae. Pollen dimorphism was reported in the Sterculiaceae and Commelinaceae.

In the Labiatae the ultrastructure of the opercula are of special interest as they may explain a possible passage from an operculum to a normal mesocolpium, i.e. passage from tricolpate to hexacolpate conditions. Based on the ectexine fine structure a number of patterns are recognized in the Onagraceae. The typical viscin threads are morphologically variable. In the Sapindaceae morphological trends of vegetative parts, flowers, and pollen grains are compared. As a result a new classification of the Sapindaceae is proposed. The concept "stereostructure" is further defined and illustrated in the Saxifragaceae. Numerical analysis of palynological characters supports the observations based on stereostructural study of only the exine and endoapertures. In the five pollen types in the Umbelliferae the exine changes from type to type, i.e., ectexine evolves with the change of pollen type. A number of pollen groups are recognized in the Xanthorrhoeaceae, the monosulcate pollen grains being derived from the liliaceous stock and the spiraperturate ones pointing towards the Eriocaulaceae.

The volume is a masterpiece from an editorial point of view. The grouping and sequence of papers and illustrations are logical and exemplary, and the printing is of excellent quality. The editors' hope that the symposium would function as a guide directing future studies in palynology is entirely fulfilled. *The evolutionary significance of the exine* is an indispensable book for institutes, libraries and scientists engaged in palynology.

Siwert Nilsson

Frey-Wyssling, A. 1976: *The plant cell wall.* Allgemeiner Teil, Band III (Cytologie), Teil 4 des Handbuches der Pflanzenanatomie (2. A.) von K. Linsbauer, fortgeführt von G. Tischler u. A. Pascher. Dritte, völlig neubearbeitete Auflage. XI + 294 Seiten mit 193 Abbildungen und 28 Tabellen im Text sowie auf 20 Bildtafeln. Verlag Gebrüder Borntraeger, Berlin–Stuttgart. ISBN 3-443-14009-2. Preis (Leinenband) DM 176.–.

In der von K. Linsbauer gegründeten Serie *Handbuch der Pflanzenanatomie* ist nun die Monographie *Die Pflanzenzellwand* in dritter, völlig neubearbeiteter Auflage erschienen. Der Autor, Prof. Frey-Wyssling, ist als Fachmann und Fachautor zahlreicher Lehrbücher internationell so wohlbekannt, dass er keiner Introduktion bedarf und dass man automatisch eine klar konzipierte moderne Monographie der kompletten Zellwand erwartet.

Das Buch ist in drei Abschnitte gegliedert und zwar in die Ultrastruktur und Biogenese der Zellwand, in die Biochemie der Zellwand und schliesslich in die Biophysik der Zellwand.

Die Entwicklungsgeschichte (Entstehung, Ultrastruktur und Wachstum) der einzelnen Zellwandschichten (M, P, S und T) und ihre Veränderungen im dritten Entwicklungsschritt (Inkrustation) werden im ersten Abschnitt ausführlich besprochen, gleich wie die Entwicklung lokaler Wandveränderungen (Differenzierungen). Der Abschnitt ist mit vielen instruktiven Abbildungen und elektronenmikroskopischen Aufnahmen versehen. Auffallend ist vielleicht das Fehlen rasterelektronenmikroskopischer Aufnahmen, die durch ihren dreidimensionalen Bildcharakter dort, wo es nicht gilt Mikrofibrillen abzubilden, instruktives Bildmaterial liefern.

Der Abschnitt Biochemie der Zellwand gliedert sich in die Besprechung der Zellwände der niederen (Thallophyten) und höheren (Kormophyten) Pflanzen. Der Autor weist im Vorwort darauf hin, dass die biochemische Forschung in letzter Zeit den Wissensumfang so erweitert hat, dass im Rahmen dieser Monographie nur eine stark kondensierte Darstellung möglich ist. Dennoch erscheinen Fragen nach der Kettenlänge der Nativcellulose, deren Polydispersität und intermolekulare Wasserstoffbrückenbindung etwas zu stiefmütterlich behandelt zu sein. Jeder Autor einer solchen Monographie steht vor besonderen Schwierigkeiten, wenn es gilt das gegenwärtige Wissen über die Konstitution des Lignins und insbesondere der Hemicellulosen auf wenige Buchseiten zusammenzufassen. Vielleicht wären hier besondere Hinweise auf ausführlichere zusammenfassende Darstellungen am Platze gewesen.

Der Abschnitt Biophysik der Zellwand umfasst teils die optischen Methoden (Röntgenanalyse, Lichtbrechung und -Doppelbrechung, Lichtabsorption, Dichroismus usw.) und wichtigen Ergebnisse in der Erforschung von Zellwandstrukturen, teils die physikalisch-chemischen Eigenschaften der Zellwandsubstanzen wie auch der Zellen bezw. Zellgewebe. Die stärkere Betonung der Eigenschaften des Holzes (spez. Gewicht, Wasseraufnahme, Schrumpfung, Festigkeitseigenschaften usw.) machen diesen Abschnitt besonders interessant für den Holzforscher.

Die wichtige Literatur ist bis 1974/75 grossteils berücksichtigt, was dem Buch besondere Aktualität verschafft.

300 Jahre Zellwandforschung haben eine solche Fülle von Erkenntnissen gebracht, dass man dankbar sein muss, wenn ein so berufener Fachmann die wichtigen Ergebnisse in einer leicht lesbaren, weniger als 300 Seiten umfassenden Monographie zu einem geschlossenen Überblick über den gegenwärtigen Stand der Zellwandforschung zusammenfassen konnte.

Das Buch kann nicht nur warm allen Botanikern sondern auch den Holzforschern sowie Agrar- und Forstwissenschaftlern empfohlen werden.

Erich Treiber

Harling, G. & Sparre, B. (eds.) 1973–1976: *Flora of Ecuador 1–5*. Swedish Natural Science Research Council, Editorial Service, Stockholm. Price SKr 35 + 25 + 35 + 50 (paperback). – Address for subscription: Swedish Natural Science Research Council, Editorial Service, P.O. Box 23136, S-104 35 Stockholm 23, Sweden.

In 1973 the first instalment of Flora of Ecuador appeared containing 47 pages about the family Cyclanthaceae by G. Harling. Since then the following families have been dealt with: Tropaeolaceae (31 pages) by B. Sparre 1973, Onagraceae (46 pages) by Ph. A. Munz 1974, Columelliaceae (5 pages) by K. Fagerström 1975, Lentibulariaceae (15 pages) by P. Taylor 1975, Plantaginaceae (16 pages) by K. Rahn 1975, and Umbelliferae (71 pages) by E. Mathias and L. Constance 1976.

The work is sponsored by the Swedish Natural Science Research Council and the Chief Editors are G. Harling and B. Sparre and the Assistant Editor is Uno Eliasson. The flora is issued at irregular intervals. The families are numbered and the circumscription follows Ed. 12 of Engler's *Syllabus der Pflanzenfamilien*. Each family of a reasonable size is allotted its own fascicle. Very small families are treated together with larger ones, e.g. 182 Columelliaceae and 183 Lentibulariaceae.

The treatment follows traditional lines. New taxa are described in the flora. There are not many references under the families and genera, but as far as can be judged full synonymy is given. The descriptions are elaborate but by no means too long. All specimens are cited for every species. This is a policy which might prove rather troublesome in 10 years' time with the numerous expeditions being carried out in Ecuador at the moment. In any case it will make the flora increasingly expensive both to print and to buy. Today most floras have abstained from this procedure because printing costs are rising every year. Plantaginaceae are dealt with on 14 pages; one third of these are locality lists. Some species which have not yet been found in Ecuador, but are known from neighbouring countries, have been included. *Centella asiatica* is an example: in this case the 21 synonyms might have been printed continuously in order to save paper. Illustrations are few and of varying technique; the most elegant ones are those illustrating the Umbelliferae. Some families are not illustrated at all. Let us hope that in the future it will be possible to find funds to finance more line drawings.

The above should not be interpreted as a serious criticism. All in all this is a very promising beginning for a flora which will be of enormous dimensions as the area to be treated harbours a unique richness in plant species. It is difficult to give an exact number since each new expedition brings back numerous undescribed species, at a rough guess based on a moderate species concept it could amount to about 18,000 species. Let us hope that the Editors will not accept splitters among their men.

Kai Larsen

Miège, J. & Stork, A. L. (eds.) 1975: *Origines des flores africaines et malgaches. Progrès–conservation–écologie.* Comptes rendus de la VIIIe réunion de l'AETFAT, Vol. 2. Boissiera 24 b, pp. 423–692. Genève.

The eighth meeting of the "Association pour l'Etude Taxonomique de la Flore d'Afrique Tropicale" (AETFAT) was held in Geneva in September 1974. The first volume of the congress report consists of 47 papers concerning mainly the topic of this meeting: "The origin of the flora of Africa and Madagascar and the nature of speciation" (review in Bot. Notiser 1975 p. 371). Volume II, which is considered here, contains 64 papers grouped under four more general themes: "Nature conservation; Ecology–Mapping, their problems in the African flora; Progress made in the study of the African flora and vegetation; Progress made in the mapping of the African flora and vegetation". Unfortunately these headings are not given in the text.

In the first paper on Nature conservation the urgency for the governments in Africa to get important vegetation types protected is underlined. Out of 43 countries consulted only 23 gave more or less extensive reports. Only 13 countries are making improvements in nature protection. The conclusion is not new but important: in most of the countries the lack of financial resources limits the progress in conservation of nature. The intentions of the Threatened Plant Committee (TPC) were presented in the second paper. Specialists are invited to collaborate and an international (African) Tropical Garden is suggested to function as a refuge for species on the verge of extinction.

Under the Ecology–Mapping heading some disparate papers are collected: Phytogeography of Basse-Casamance; Phytogeographic importance of the Loma Mountains; The origin of the termitophile flora of Haut-Shaba; Fibre plants in Ghana. Two papers treat exhaustively the vegetation and the rôle of the epiphytic vegetation in Uluguru Mountains. A multicoloured large map (1:50,000) with 30 vegetation units is interfoliated inside the cover. In the text five more vegetation units are described and mapped, as well as important environmental factors for the vegetation.

Of interest for a broad public is the announcement of four new flora projects: Flora Macaronesica, Flora of Cape Coast, Ghana, Flore général de la Côte-d'Ivoire and Flore du Rwanda. These floras are planned to be published in many volumes and in the last two about 80% of the species will be illustrated. The area covered by these new floras has already partly been treated in larger flora projects: Flora Europaea (the Azores), Flora of West Tropical Africa and Flore d'Afrique Central. Despite this it is justified to start new local floras which can give a more precise and current picture of taxonomy and phytogeography for their respective areas.

The last 150 pages of this volume are occupied by detailed progress reports of plant-collecting, flora-writing and vegetation-mapping for various regions of Africa. Some diverse papers can be mentioned: Ecologic studies in pasture land at IEMVT (Institut d'Elevage et de Médecine Vétérinaire des Pays Tropicaux); A list of orchids in Côte-d'Ivoire; The history of the botanical exploration in Gabon. In this part of the volume the principle to start all articles on right-hand pages has become too space-consuming. In a volume of totally 270 pages it is too much with 40 blank pages. The 29 less-than-one-page articles could have been set in continuation under a Short Reports-heading.

The last paper in Volume II is worth noticing for all botanists working at herbaria and with determination of African or Madagascan plants. It is a catalogue of "Which families are treated where" for the main floras of tropical Africa, Das Pflanzenreich IV and Die Natürlichen Pflanzenfamilien ed. 2. In this long table of the families it is also indicated which families are absent in the area covered by each flora. This last article is a good example of the practically useful knowledge often presented in the AETFAT-reports.

The articles of the second volume deal with a variety of subjects out of which only a few have been mentioned here. To sum up, the eighth Comptes rendus is a good continuation of the tradition of AETFAT to survey the progress made in botanical taxonomy and ecology in Africa.

Mattias Iwarsson

Moore, D. M. 1976: *Outline studies in biology. Plant cytogenetics.* 64 pp. Chapman and Hall, London. ISBN 0 412 13440 3. Price £ 1.30.

This slim volume gives a readable, up-to-date account of classical plant cytogenetics, i.e. the study of chromosomes at the light microscopic level. Far from being exhausted this branch of study is alive and kicking – a fair percentage of the references are from 1970 and later.

The book is one in a series of texts called *Outline studies in biology* intended – according to the editor's foreword – as guidebooks, not textbooks, presenting the conceptual framework within which biological research is progressing. The author is an experienced cytotaxonomist who himself has made important contributions in the field. The emphasis is on the mechanics of chromosome behavior and to some extent on evolutionary aspects. There is virtually nothing on cytological techniques – here the reader is referred to standard texts like Darlington and La Cour: *The handling of chromosomes.*

Cytogenetics dates its origin as an independent although composite branch of science to the early years of this century when the chromosomal theory of inheritance was proven by the Morgan school. It is still possible to present some of the current work at the frontiers of the discipline without loosing sight of the founding fathers. Prof. Moore has achieved this goal remarkably well. The senior undergraduate who wishes to gain an insight into this important field could hardly be given a better introduction.

Arne Strid

Smith, P. 1976: *The chemotaxonomy of plants.* In E. J. W. Barrington & A. J. Willis (eds.), Contemporary biology series. 313 pp., 63 figs., 26 tables. Edward Arnold Ltd., London. Price £ 13.– (board), £ 6.50 (paper).

This is virtually the first student text about the use of chemical data in botanical taxonomy. P. M. Smith of Department of Botany, University of Edinburgh has written a book which is quite readable for botanists as well as for chemists, although for different reasons, as will be discussed below.

The text is divided into 3 parts the first of which deals with the inherent possibilities of chemistry as a tool in systematic botany. Chemical reactions are the basis for development of the whole phenotype of any plant and the information used for this is buried in the chemical composition of the DNA of the cells. The use of chemical information from plants is placed in perspective with other taxonomic activities of the botanist, and this part of the book appears to be valuable reading for the phytochemist starting on taxonomic work. The author recommends teamwork involving both chemists and biologists, and chemists producing results on their own "should suggest what changes (in classification) are to be made, in as strident a fashion as possible".

The second part comprises 9 chapters of which the first 6 deal with micromolecular compounds, i.e., amino acids, phenolics, carbohydrates etc. Each chemical group is described and accounts are given about their variation among plants, about their function and taxonomic value. Important groups of compounds such as quinones, polyacetylenes and glucosinolates are not mentioned at all which seems strange as a chapter has been devoted to the taxonomically unimportant fatty acids. Two chapters treat proteins and nucleic acids while one is devoted to the technique and use of serological methods.

Examples of applications of chemotaxonomic methods form the third part of the book. One chapter deals with "The Case of the Bacteria" where the morphological characters are not sufficient for classification and where chemical methods have been used for a long time. Another chapter contains examples of the use of chemotaxonomy at different levels, among these also the betalain story. Finally phylogeny and the use of protein sequences for construction of phylogenetic trees are discussed.

The author is apparently not a chemist. We have noticed many errors both in the formulas (in 7 of the 24 formulas on pp. 92–93) and in the text. In the section about anthocyanidins some of the information is erroneous and the term anthocyanin is not even used, which is strange as these are the natural flower pigments. Several minor misunderstandings and/or mistakes can be found in the chapters dealing with chemistry.

Trivial errors like the above-mentioned are not really serious. It is more important that the author seems uninterested in biosynthesis as shown in the quotation (p. 7): "Unlike biochemists, taxonomists and evolutionists are only incidentally interested in molecules from the standpoint of how they may be synthesized or what their function may be". To a certain degree this principle is followed through the book. Biosynthetic evidence is only used in the negative sense as the reader is often warned that a compound may be biosynthesized through different pathways in unrelated plants (which is appropriate). Unfortunately, the positive evidence which can be deduced from biosynthetic sequences has been almost completely ignored. An example is the large, homogeneous group of indole alkaloids biosynthetically derived from the iridoids, which are monoterpenes. The two groups are naturally connected and this should to some degree be correlated with their distribution. Such connections can only be discovered by the use of biosynthetic evidence or by deduction using biosynthetic principles. Full use of the available information will perhaps demand the teamwork advocated by the author – also when writing a book on chemotaxonomy.

Despite these mainly critical remarks we can recommend the book as an introduction to the subject for botanists and chemists planning to start chemotaxonomic research. The references provide an entry to the recent phytochemical literature. Teachers will welcome it for their students as a textbook on a subject that has been missing so far.

The majority of professional taxonomists who have apparently been conservative in their view upon chemical characters will find many examples of successful applications here, especially at family and lower level.

Bent Juhl Nielsen
Søren Rosendal Jensen