Patterns of flowering periods in selected floras of the world.

By Yong No Lee

Abstract

The total sums and patterns of flowering periods in a number of local floras are compared. These variables are thought to characterize a given flora biologically as they circumscribe the periods of highest activity.

Introduction

Many viewpoints of flowering phenomena are very important in the study of floristics and human lives. Since ancient time the flowering periods have been used as a time indicator.

Recently many phenologists studied the flowering conditions in detail by comparing flowering periods in various countries (*Schnelle* 1955). They found that the major factors for flowering are temperature, day length, and light intensity. The geographical and topographical differences cause different flowering times even in the same species. Phenological studies also have practical aspects especially in horticulture and agriculture.

This study proposes to find the total sum and patterns of flowering periods in a number of floras of the world. The total sums distributed over the twelve months are summarized in Table 1 and 5 and in the diagrams, Figs 1 to 11 and 13, which may be referred to as patterns of flowering period. It is of particular interest to discuss the differences between such total sums of flowering periods, and the possible correlations to be found between the flowering periods, temperatures, day lengths, and precipitations.

This study has been done under the guidance of professor Tyge W. Böcher, Institute of Plant Anatomy and Cytology, Copenhagen University, Denmark, to whom the author is grateful for kind and valuable assistance. I would also like to thank Miss Yong Cha Oh,

graduate student, Department of Biology, Ewha Womans University, who has been of great help concerning the flowering periods of Korea. Thanks are extended to Mr. Knud E. Jensen, botanical librarian, Copenhagen University, who helped me find botanical literature, and to professor N. Kingo Jacobsen and Dr. Kr. M. Jensen, Geographical Institute, University of Copenhagen, who supported by investigations in various ways. Finally the author wishes to thank the Ministry of Foreign Affairs in Denmark who offered financial support for my study in Denmark.

Materials and methods

By the choice of floras to be used for calculating the data summarized in the flowering period diagrams the author attempted to to include floras from as widely different climates as possible. His choice, however, was also dependent upon the availability of floristic manuals and papers from the various regions containing sufficient information about flowering times. The bibliography below lists the principal sources used for the calculations.

Names of books and papers

Gelting, Paul: Studies on the Vascular Plants of East Greenland between Franz Joseph, F. Jord and Dove Bay (L. 73o15'-76°20'). 1934.
Sørensen, Thorvald: Temperature Relations and Phenology of the Northeast Greenland Flowering Plants. 1941.
Gröntved, Johs.: The Pteridophyta and Spermatophyta of Iceland. 1942.
Löve, Askell: Iceland Ferdaflora. 1970.
Rostrup og Jørgensen: Den Danske Flora. 1961.
Bing, August: Schul- und Exkursionflora der Schweiz. 1945.
Baroni, Eugenio: Guida Botanica DItalia. 1955.
Sampaio, Goncalo: Flora Portuguesa. 1947.
Paulsen, Ove: Træk af Vegetation i Transkaspiens Lavland. Thesis, Copenhagen 1911.
Levyns, M.R.: A Guide to the Flora of Cape Peninsula. 1966.
Kidd, Mary Maytham: Wild Flowers of the Cape Peninsula. 1950.
Brown, Clair A. et. al.: Wild Flora of the United States. 1967.
Backer, C.A.: Flora of Java. 1963.
Hyun Chung Tai: Illustrated Woody Plants of Korea. 1943.
Hyun, Chung Tai: Illustrated Korean Flora. 1955.

Flowering periods of the flora were calculated from January to December. The total of the flowering periods in a month is expressed in two ways, viz. absolute number of flowering entries, and number of species which are in flower in percent of the total number of species. If one species continues to bloom during the year from January to December, this is counted for each month in the year.

The data of temperatures and precipitations were taken from the following records of weather stations:

Northeast Greenland (1922-32): Ella Ø, Scoresbysund, Mygg-bukta & Danmarks Havn.
Iceland (1873–1920): Reykjavik, Stykkisholmur, Mörduvellier, Grimsey Grimsladiv, Berufjordur, Fagurholsmyni, Veslaumaeyjard & Storinbur.
Denmark (1886-1925): Data for 8 larger parts viz.: Nordjylland, Østjylland, Vestjylland, Sønderjylland, Fyn, Sjælland, Lolland-Falster og Bornholm (cp. Statistisk Årbog p4.)
Korea (1931–1960): Haesanchin, Hamhung, Oju, Pyongyang, Owansan, Haeju, Seoul, Inchun, Kangnung, Chunchon, Taiku, Chonju, Chungju, Kongju, Kunsan, Kwangju, Busan, Mokpo, Cheju, Sokipo.
Switzerland (1864-1926): Basel, Geneva, Lucerne, Altodorf, Andermatt, St. Gotthard, Jungfraujoch, Sargans, Santis, Davis & Bevers.
Italy (1951-1960): Milano, Roma, Taranto, Trieste, Acona, Cagliari & Venezia.
Portugal (1941-1960): Lisboa & Sinta.
Transcaspian lowland (1897-1906): Tashkent, Askhabad & Petro Alexandrovsk.
Florida (1875–1923): Jupiter, Miami, Key West, Panpa, Apalachicala & Pensacola.
Java (1912-1918): Batavia, Buitenzorg, Pangerango, Bandung, Modjowarno, Pasuruan, Tosari, Sarokka, Christmas Insel, Keeling Insel & Mendo.

The monthly mean values for temperature and precipitation were calculated as averages of the values from a number of weather stations in each country.

The flowering periods for each flora was figured together with temperatures and precipitations in order to find correlations between the factors, and finally the flowering periods of eleven different floras were brought together in a diagram for the purpose of comparison.

The calculations as well as some of the climatological data are further transferred to a number of diagrams (Figs. 1-13), which may facilitate comparisons.

Discussion

Flowering plants exist in complex environments on the earth. Raunkiær analysed the position and protection of vegetative winter buds, and finally approached a conception that plant life forms are climatic indicators. On the basis of local floras Raunkiær calculated life form spectra giving the percentage distribution of his life forms in a flora, and he also compared life form spectra from different parts of the world.

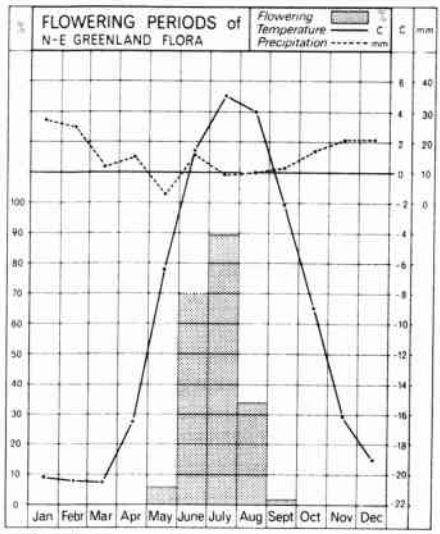


Fig. 1

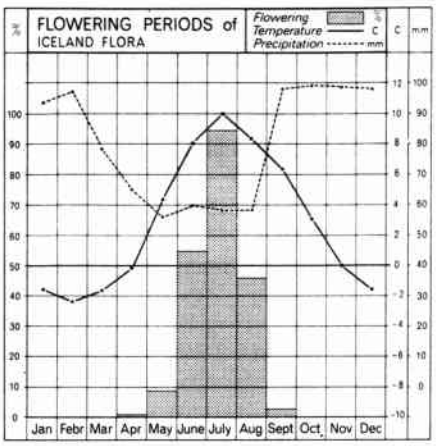


Fig. 2

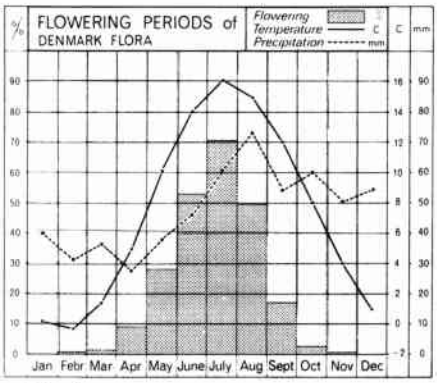


Fig. 3

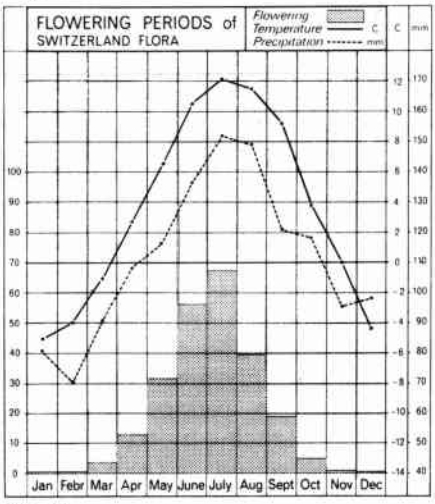
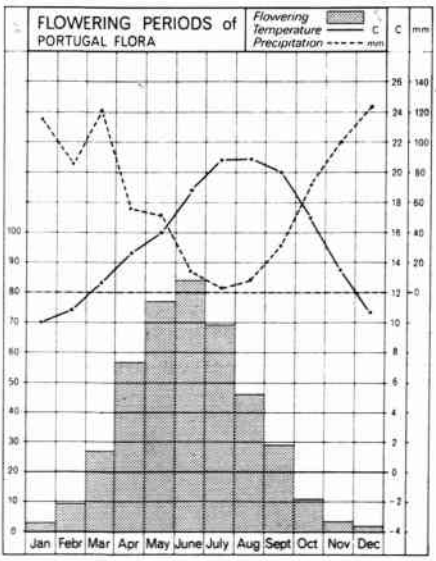


Fig. 4



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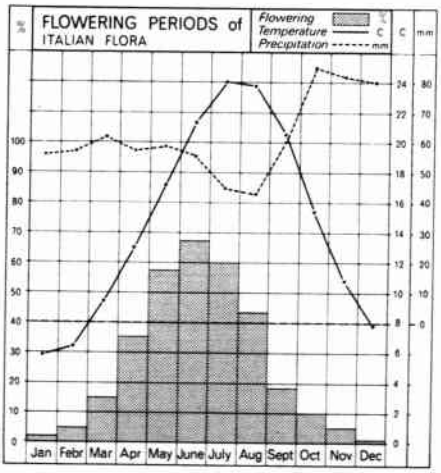

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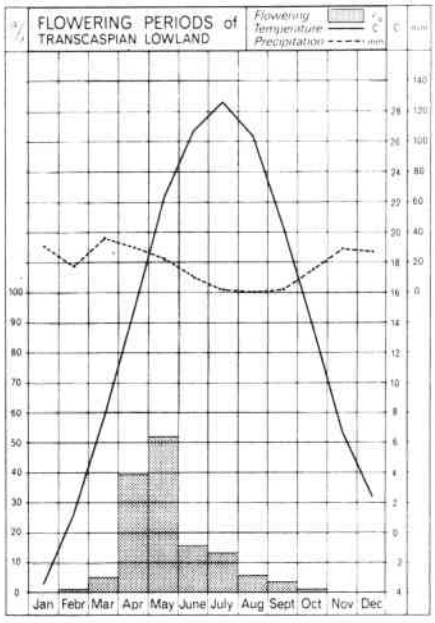

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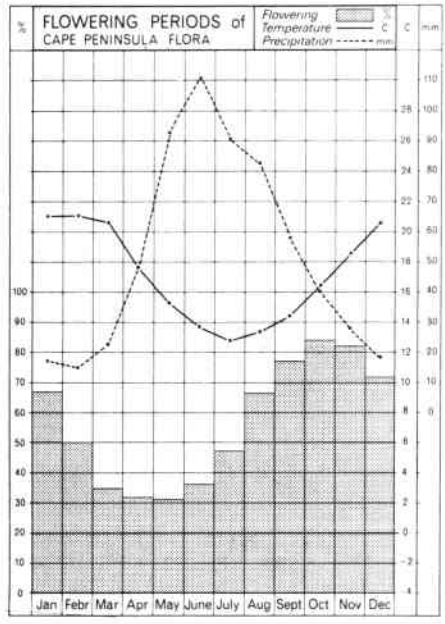

Fig. 9

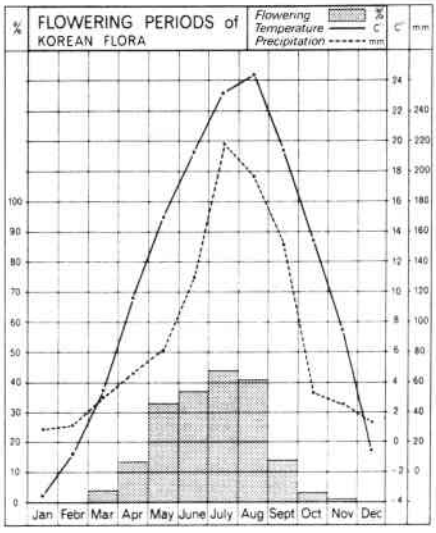

Fig. 8

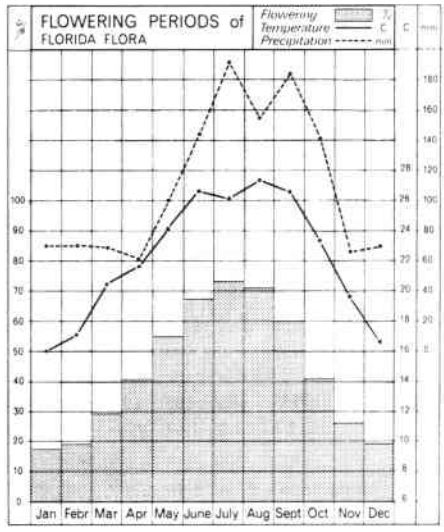

Fig. 10

Result of the Study

The data collected about the flowering periods, temperatures, and precipitations are summarized in Table 1, 2 & 3.

Table 1

Flowering entries and percentages

Locality	Taxa	Total	1	2	3	4	5	6	7	8	9	10	11	12	Month
Northeast	153	308	0	0	0	0	10	107	137	52	2	0	0	0	Entries
Greenland		201.1	0	0	0	0	6.5	69.9	89.5	33.9	1.3	0	0	0	Percentage
Iceland	363	751	0	0	0	1	33	200	343	166	8	0	0	0	Entries
		206.6	0	0	0	0.2	9.1	55.0	94.4	45.7	2.2	0	0	0	Percentage
Denmark	1341	3112	0	3	22	118	383	719	940	665	231	28	3	0	Entries
	231.9	0	0.2	1.6	8.8	28.6	53.6	70.0	49.6	17.2	2.1	0.2	0		Percentage
Korea	2856	5447	1	3	110	393	943	1064	1245	1175	405	86	21	1	Entries
		190.9	0.03	0.9	3.8	13.7	33.0	37.0	43.6	41.0	14.1	3.0	0.7	0.03	Percentage
Switzer-	2467	5813	3	12	87	312	789	1388	1657	971	469	111	12	2	Entries
land		235.4	0.1	0.4	3.4	12.6	31.9	56.2	67.1	39.7	19.0	4.5	0.4	0.1	Percentage
Italy	3084	9817	61	140	456	1082	1760	2057	1849	1336	573	309	156	38	Entries
		317.4	1.9	4.5	14.7	35.0	59.0	66.6	59.9	43.1	18.5	10.0	5.0	1.2	Percentage
Portugal	2275	9498	72	213	618	1311	1746	1916	1559	1046	641	251	78	47	Entries
		420.9	3.1	9.3	29.1	57.6	76.8	84.2	69.4	46.0	29.0	11.0	3.4	2.0	Percentage
Transcaspian	589	810													Entries
lowland		137		0.8	5.4	38.8	51.9	16.6	13.0	6.7	3.3	0.5			Percentage
Cape	1541	10552	1035	783	560	501	488	563	730	1031	1191	1298	1263	1109	Entries
Peninsula		678.8	67.1	50.8	36.3	32.5	31.6	30.5	47.3	66.9	77.2	84.8	81.9	71.9	Percentage
Florida	1027	5353	180	197	304	424	563	691	757	729	619	421	269	199	Entries
		525.5	17.5	19.1	29.6	46.2	54.8	67.2	73.7	70.9	60.2	40.9	26.1	19.3	Percentage
Java	4008	36351	2744	2809	2982	3095	3107	3198	3156	3144	3100	3069	3018	2929	Entries
		907.2	68.4	70.8	74.4	77.2	77.5	79.7	78.7	78.4	77.3	76.5	75.3	73.0	Percentage

Table 2

TEMPERATURES

	Monthly mean	1	2	3	4	5	6	7	8	9	10	11	12
Northeast Greenland	-10	-20.3	-22.8	-20.3	-16.1	-6.07	1.6	5.1	4.1	-2.1	-9.5	-16.1	-18.8
Iceland	2.8	-1.8	-2.2	-1.9	0.9	4.4	8.1	9.7	8.6	6.4	3.1	0.05	-1.6
Denmark	7.4	0.1	-0.1	1.6	5.5	10.7	14.2	16.0	15.3	12.3	8.1	4.1	1.6
Korea	10.8	-3.6	-9.9	3.6	4.9	15.2	19.4	23.4	24.3	19.5	13.4	6.6	-0.5
Switzerland	3.5	-5	-3.8	-1.1	2.7	6.6	10.5	12.2	11.6	9.4	3.9	0	-4.4
Italy	14.6	5.9	6.6	9.5	13.0	17.3	21.5	24.0	23.7	20.5	15.5	10.9	7.9
Portugal	15.5	10.2	10.9	12.7	14.6	16.1	18.9	20.8	20.8	20.0	17.3	13.6	10.9
Transcaspian lowland	11.4	-2.6	1.3	6.8	14.6	22.2	26.8	28.5	26.5	20.5	13.4	6.7	2.5
Cape Peninsula	17.2	21.6	21.6	20.5	17.7	15.5	13.8	12.7	13.3	14.4	16.6	18.8	20.5
Florida	23.5	16.2	17.2	19.4	21.7	24.4	26.7	26.2	27.5	26.6	23.6	19.7	16.8
Java	23.2	23.0	23.0	23.2	23.5	23.5	23.1	22.9	22.9	23.3	23.5	23.4	23.1

Table 3

PRECIPITATIONS

	Total mm												
Northeast Greenland	181.4	27	24	12.3	15	4	12	9.8	10	12	13	21	21.3
Iceland	933.0	88	92	73	65	55	56.5	57.7	58	98	99	99	97
Denmark	579.5	41.7	32.3	38.1	28.1	38.5	42.8	60.3	74.2	55.1	61.8	51.7	54.9
Korea	1094.0	28.4	30.8	50.1	64.9	80.7	131.3	218.9	197.3	154.7	55.5	44.9	36.5
Switzerland	1345.7	81.2	71.1	91.4	109.2	116.8	137.1	152.4	149.8	121.9	119.3	96.5	99.0
Italy	748.6	56.4	57.9	62.1	57.4	59.4	56.9	45.7	43.2	60.7	84.9	83.3	80.9
Portugal	807.8	117.0	88.8	121.7	58.0	52.9	15.3	3.7	9.2	31.8	74.1	110.8	124.5
Transcaspian lowland	232.6	31.8	18.9	37.8	30.4	22.9	11.1	4.6	0.8	2.1	15.8	28.9	27.5
Cape Peninsula	630.3	17.7	15.2	22.7	48.2	93.9	111.1	91.4	83.8	58.5	40.6	27.9	19.3
Florida	1334	71	71	69	62	101	146	194	157	184	142	67	70
Java	2185	229	332	271	217	161	125	98	71	86	133	198	263

The day lengths given below were calculated on the basis of the data in Linke's Meteorologisches Taschenbuch (2) (1953).

Day length

Table 4

		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Northeast Greenland	75°		4.15	11.00	17.00	24.00	24.00	24.00	21.00	13.45	7.15		
Iceland	65°	5.04	8.32	11.43	15.18	19.08	21.56	20.12	16.36	13.04	9.40	6.09	3.40
Denmark	56°	7.36	9.38	11.49	14.15	16.22	17.35	17.01	15.05	12.45	10.26	8.13	6.59
Switzerland	46,5°	9.00	10.21	12.03	13.44	15.01	15.35	15.12	11.13	12.23	10.56	9.13	8.37
Italy	40°	9.40	10.43	11.56	13.18	14.25	15.01	14.40	13.44	12.14	11.08	9.54	9.21
Portugal	40°	9.40	10.43	11.56	13.18	14.25	15.01	14.40	13.44	12.14	11.08	9.54	9.21
Transcaspian Lowl.	40°	9.40	10.43	11.56	13.18	14.25	15.01	14.40	13.44	12.14	11.08	9.54	9.21
Korea	37.5°	9.52	10.50	11.56	13.18	15.21	14.46	14.27	13.36	12.21	11.09	10.08	8.37
Cape Peninsula	33°	15.01	14.40	13.44	12.14	11.08	9.54	9.21	9.40	10.43	11.56	13.18	14.25
Florida	27.5°	10.36	11.15	11.58	12.51	13.33	13.51	13.34	13.08	12.18	11.30	10.46	10.22
Java	5°	11.52	11.59	12.06	12.14	12.21	12.24	12.23	12.16	12.08	12.00	11.52	11.47

In the present study the author used flowering periods of all species in a flora and brought the data together in diagrams showing the monthly percentage of flowering species. The flowering is the most important period in the life of a plant species. Thus, such diagrams are believed to express something essential about a flora. In the early part of the twentieth century, flowerings were studied by many scholars using current methods, and they found many influential factors of flowering (Salisbury 1963). The main internal factor is florigen and the major external ones are temperature, light, and day length. Initiation of flowering is controlled by florigens. The florigens are principally affected by the temperature and photoperiodism. During the flowering period, the growth of vegetative organs is inhibited, while in a vegetative period flowering may be controlled. Florigen activations are key factors for flowering. Some florigens keep flowering constantly even in different environments, while some florigens do not. Many of the transplanted temperate plants are blooming the year round in

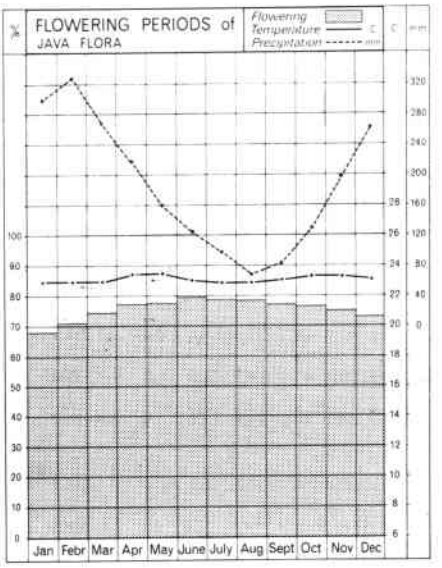

Fig. 11

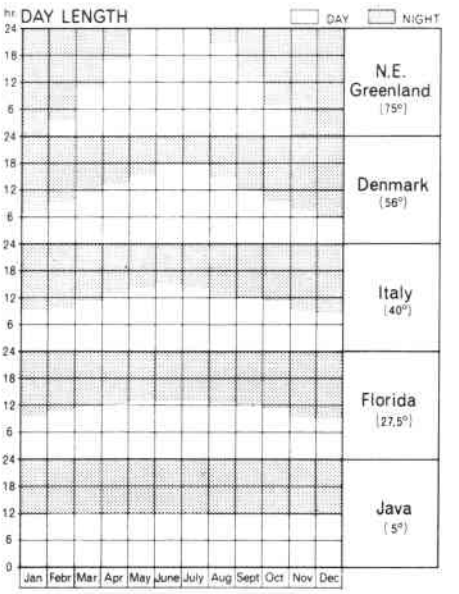

Fig. 12

tropical Java, but some of these plants are blooming only during a limited part of the year, and may have a genetically fixed flowering time. Many indigenous Java plants are flowering throughout the year, but some of them are not.

Flowering periods of the species in a flora are influenced by the environmental factors, climatic as well as topographic, and even geohistoric ones. The flowering periods of a total flora may be looked upon as a sum of responses of the flora to the environmental conditions during the year.

From arctic Greenland, Iceland, Denmark, Switzerland, Italy, Portugal, Cape Peninsula, and Florida to Java, the total sum of flowering periods of the floras and the number of species in each flora gradually increase. Between the flowering periods, temperatures, and day lengths correlations are found. In Greenland, Iceland, Denmark, Switzerland, Korea, and Florida the peaks of flowering periods and temperatures occur in the month of July where the temperature is most favourable. In Portugal, Italy and the Transcaspian lowland, however, the peaks of flowering periods occur in June or May. This displacement towards the early part of the summer presumably is caused by the very small precipitation rates during the middle of the summer which usually is the period of dominant blooming. The peak of flowering periods of Cape Peninsula occurs in October, but the peak of temperature in January. The peak of flowering periods of Cape Peninsula is shifted to October instead of January as a result of scanty precipitations

Table 5 Patterns of the flowering periods as compared with temperature and precipitation

Countries	Latitude	Temp. mean	Yearly Prec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Sum
Northeast Greenland	75°	-10	181.4					6.5	69.9	*89.5*	33.9	1.3				201.1
Iceland	65°	2.8	933.0				0.2	9.1	55.0	*94.4*	45.7	2.2				206.6
Denmark	56°	7.4	579.5		0.2	1.6	8.8	28.6	53.6	*70.0*	49.6	17.2	2.1	0.2		231.9
Switzerland	46,5°	3.5	1345.7	0.1	0.4	3.4	12.6	31.9	56.2	*67.1*	39.7	19.0	4.5	0.4	0.1	235.4
Italy	40°	14.6	748.6	1.9	4.5	14.7	35.0	59.0	*66.6*	59.9	43.1	18.5	10.0	5.0	1.2	317.4
Portugal	40°	15.5	807.8	3.1	9.3	29.1	57.6	76.8	*84.2*	69.4	46.0	29.0	11.0	3.4	2.0	420.9
Transcaspian Lowl.	40°	11.4	232.6		0.8	5.4	38.8	*51.9*	16.6	13.0	6.7	3.3	0.5			232.6
Korea	37.5°	10.8	1094.0	0.03	0.9	3.8	13.7	33.0	37.0	*43.6*	41.0	14.1	3.0	0.7	0.03	190.9
Cape Peninsula	33°	17.2	630.3	67.1	50.8	36.3	32.5	31.6	30.5	47.3	66.9	72.2	*84.8*	81.9	71.9	678.8
Florida	27.5°	23.5	1334	17.5	19.1	29.6	46.2	54.8	67.2	*73.7*	70.9	60.2	40.9	26.1	19.3	525.5
Florida	23.5	16.2	17.2	19.4	21.7	24.4	26.7	26.2	27.5	26.6	23.6	19.7	16.8			
Java	5°	23.2	2185	68.4	70.8	74.4	77.2	77.5	*79.7*	78.7	78.4	77.3	76.5	75.3	73.0	907.2

Underlining indicates highest percentage of flowering period during the year.

during the month of high temperature. But in most floras flowering periods do not follow oscillations in the amount of precipitation.

The flowering periods and temperatures with day lengths of Java are almost parallel correlated to each other. During summer the flowering periods are slightly longer than in other seasons. Presumably this phenomenon is causes by species introduced from the temperate zones.

The diagrams of patterns of flowering period show flowering durations and monthly flowering percentages of a flora. They are calculated for tropic, temperate, arctic, mediterranean, and temperate – continental semidesert floras. In the tropics, flowering durations last the year round from January to December, while in temperate to arctic regions the durations become shorter. In summer the flowering percentages are comparatively very high, but the duration very short in the arctic area.

Between the sum of the flowering percentages and mean temperatures of the months, the above countries have shown almost

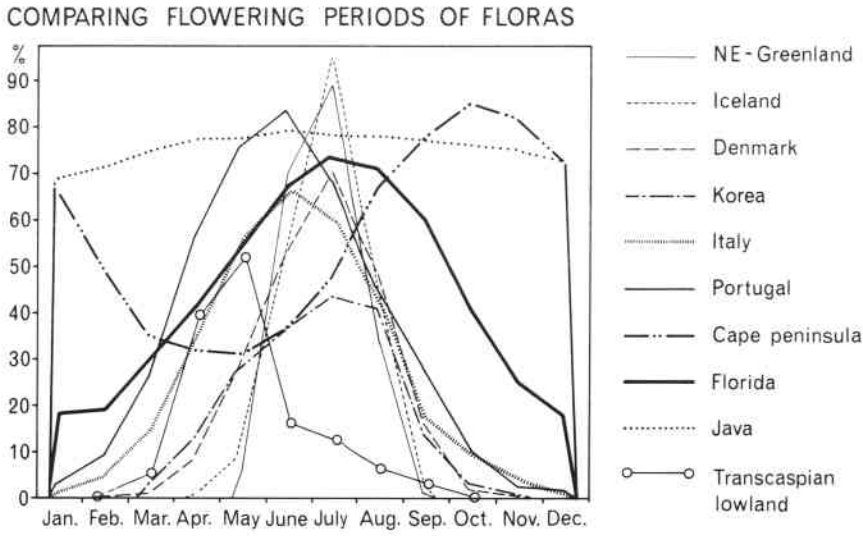

Fig. 13

parallel correlations, with the exceptions of Florida, Korea and Switzerland. In Florida there is a significant difference between summer and winther, while in Java the temperatures are almost 23°C. the year round. These differences between the temperatures of the countries are considered to have influence on two types of flowering periods in the flora (Figs. 9, 10, 11). Portugal, Italy, and Transcaspian lowland are located at the same latitude in the northern hemisphere. The patterns of flowering period resemble each other, but the total sum of flowering is gradually reduced from Portugal to Transcaspian lowland (Table 1 and 5 Fig. 7 and 13). This phenomenon is probably caused by a decrease in temperatures and precipitations from the western to the eastern countries. The total sums of flowering periods for the Transcaspian lowland amount to less than one third of that found in other countries. Its pattern of flowering period corresponds with that of a continental semidesert climate.

From the present study it also became evident that certain groups of plants were blooming during a limited part of the season only, whereas some other plant groups bloomed at any time or round the year.

In Korea the only plant families blooming in spring (March – May) are: Ginkgoaceae, Taxaceae, Salicaceae Ulmaceae, Buxaceae, and Adoxaceae, while the only plant families blooming in summer (June-August) are: Typhaceae, Sparganiaceae Lemnaceae, Pontederiaceae, Piperaceae, Chloranceae, Ceratophyllaceae, Menispermaceae, Droceraceae, Geraniaceae, Linaceae, Zygophyllaceae, Sapindaceae, Sabiaceae, Alangiaceae, Haloragaceae, Diapensiaceae, Myrsinaceae, Polemonbiaceae, and Pedaliaceae. Many of the plant

families bloom from spring to summer or spring to autumn (September-November). Families doing so are as follows: Pinaceae, Potamogetonaceae, Graminaceae, Cyperaceae, Juncaceae, Liliaceae, Dioscoreaceae, Iridaceae, Orchidaceae, Betulaceae, Moraceae, Loranthaceae, Aristolochiaceae, Polygonaceae, Caryophyllaceae, Ranunculaceae, Papaveraceae, Saxifragaceae, Rosaceae, Leguminosae. In Gramineae, flower blooming takes place from April to November. During these months the following number of plants bloom: 3,32, 67, 68, 63, 41, 5, and 1 (entry). The peak of blooming (67–68) occurs in June-July.

This study is not a complete work about flowering periods, and many unsolved problems remain. A flowering period diagram of a total flora, however, will also cover several similar flowering period diagrams for local floras within the country in question. Such local variations in the composition of a flora may be due to climatic differences or other mainly historical conditions e.g. easy immigration or local survival. We do not always have a relevant floristic manual and neither do we from all countries have enough weather data which are sufficiently established.

However, the flowering periods in a flora presumably constitute a good biological indicator, as it summarizes the most active periods for plant life in that flora.

Resume

Formålet med nærværende undersøgelse er at sammenligne blomstringsperiodernes totalsummer og mønstre inden for en række områder og at undersøge korrelationerne mellem blomstringsperioder, middeltemperaturer og daglængder. Følgende 11 lande, der spænder fra arktiske til tropiske regioner, er udvalgt: Grønland, Island, Danmark, Schweiz, Korea, Italien, Portugal, Det transkaspiske Lavland, Cape Peninsula, Florida og Java.

Blomstringsperiodernes totalsummer og antallet af arter vokser gradvis fra det arktiske Grønland til Troperne samtidig med gradvise ændringer i de månedlige middeltemperaturer og i dagens længde. I Grønland, Island, Danmark, Schweiz, Korea og Florida kulminerer blomstringen i juli, i Italien og Portugal skifter det til juni, medens maj er den rigeste blomstringsmåned i Det transkaspiske Lavland. Disse forskelle skyldes antagelig den ringe nedbørsmængde i juli i de sidstnævnte områder. I Troperne finder blomstringen sted hele året rundt, i tempererede til arktiske områder bliver perioden kortere. Parallelle korrelationer kan påvises mellem blomstringsperioden og den månedlige middeltemperatur sammen med daglængden. Visse plantegrupper har en begrænset blomstringssæson, andre er ikke bundet til et bestemt tidspunkt eller blomstrer hele året.

Blomstringsperiodernes fordeling antages at karakterisere et lands flora, da de repræsenterer planternes biologisk set mest aktive perioder.

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