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PINE POLLEN COLLECTION DATES - ANNUAL AND GEOGRAPHIC VARIATION[1/]

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Activity in pine breeding has increased throughout the temperate forest regions of the world since the Institute of Forest Genetics issued its first summary of pollen collection dates in 1947. Cooperation between pine breeders has increased at the same time. The information most essential for conducting cooperative breeding operations are the dates of pollen collection (which also approximate the dates at which the bagging of flower buds to control pollination should be done) for various species at various localities. This publication, adding four years' data to the note issued in 1947, covers a period of 14 years. In addition, some data are presented on the relation between temperature and development of catkins and on the effect of altitude on time of pollen collection. These new data, although still fragmentary, should assist workers elsewhere to generalize from the data collected at the Institute of Forest Genetics.

Some notes on the pollen collection techniques used at the Institute of Forest Genetics[2/] should help in the interpretation of the data which follow. Catkins, or twig-tips bearing catkins, are picked when the first catkins on a tree are starting to open. Thus a collection date usually corresponds rather closely to the date on which pollen shedding starts. The collection date also corresponds to a date five days to a week later than that on which bagging of conelet buds on the same tree would be advisable. Complete extraction of the pollen requires from one to five days or rarely longer. If the pollen has been extracted under conditions of low

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1/ A revision of Duffield, J. W. 1947. Dates and places of pollen collection by the Institute of Forest Genetics. Calif. Forest and Range Exp. Sta. Research Note No. 54. 5 p.

2/ Cumming, W. C., and F. I. Righter. 1948. Methods used to control pollination of pines in the Sierra Nevada of California. U. S. Dept. Agr. Cir. No. 792. 18 p.

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humidity (from 15 to 30 percent relative humidity) it should be a highly "fluid" dust. Otherwise it is advisable to reduce its moisture content by holding it in a desiccator over anhydrous calcium chloride for one to two days. If this is not done, the mold spores germinate (these spores cannot be eliminated from pollen samples by present methods). Then the pollen sample becomes felted into a lumpy mass by the growth of mold mycelia. Such pollen is of little or no value for controlled pollinations.

Combining the time required for extraction and desiccation, it is usually possible to ship pine pollen from one to seven days after it is collected. The extraction techniques used at the Institute of Forest Genetics[2] result in pollen samples of high purity (with the exception of mold spores) in spite of the fact that the pollen parents are almost invariably surrounded by many other pines of the same or different species, many of which are shedding pollen freely at the time when catkins are collected.

Pressure of work during the pollination season seldom permits tests of pollen germinability immediately following pollen extraction. Much reliance is placed on the physical properties of the pollen. If it is dry enough to act like a fluid, and no more than one year old, pollen is usually highly germinable. Most pine pollen shows high germinability for many months following extraction if: (1) extraction humidity has been low enough to prevent molding of the pollen; (2) pollen has been stored at 25 percent to 50 percent relative humidity at a temperature below 5°C (41°F).[3]

Table 1 has been compiled from the past 14 years' breeding records of the Institute of Forest Genetics. So far, systematic and comprehensive phenological records have not been kept. For this reason, data for many of the pines and other trees growing in the Eddy Arboretum[4] at Placerville are lacking.

The trees in the Eddy Arboretum are derived from trees growing in many parts of the Northern Hemisphere. When known with any degree of certainty, the original sites of trees from which pollen producers were derived are given in Table 1. Pollen of some species is collected from "wild" trees growing at the original site. Pollen of other species is collected from trees growing in the Eddy Arboretum near Placerville, at Berkeley, and at Fresh Pond, California.

3/ Duffield, J. W., and A. G. Snow, Jr. 1941. Pollen longevity of Pinus strobus and Pinus resinosa as controlled by humidity and temperature. Amer. Jour. Bot. 28: 175-177.

4/ Weidman, R. H. 1947. Trees in the Eddy Arboretum. Calif. Forest and Range Exp. Sta. Research Note No. 53. 8 p.

The table column showing the number of years in which pollen was collected is a rough index of reliability.

Figure 1 summarizes the dates of pollen collection for the fourteen pine species and hybrids from which pollen has been collected for five or more years in the Eddy Arboretum. The horizontal lines extend from the earliest to the latest collection date for each species, and the vertical bars near the center of each line indicate the mean collection dates. At the earliest and latest end of each line is indicated the year in which the record for earliness or lateness for the species was made. It will be noted that, generally, 1947 was a year of early pollen shedding, while 1948 was a year of late shedding. However, the data for P. radiata are exceptional; 1948, with high January and February temperatures but low temperatures from March through June, produced the earliest record for P. radiata pollen shedding.

Figure 2 is an attempt to relate pollen shedding dates to temperature. Three years were selected for study: 1947, a year of early shedding; 1948, a year of late shedding, and 1949. Pollen collection dates were recorded for 5 representative species and hybrids for each of these 3 years. From thermograph records, corrected by semi-weekly thermometric readings, mean daily temperatures were computed. These are plotted for the period March 1 through June 21 for each of the 3 years. To establish a "normal" curve of mean daily temperatures, the following procedure was followed. Mean daily temperatures for the periods 1929-1937, inclusive[5/], and 1947-49, inclusive, were averaged for the period March 1 through June 21. These averages were then smoothed by means of computing 7-day moving averages. Finally, a free-hand curve was fitted to these averages. The resulting curve, of doubtful climatological value, has the advantage of furnishing a suggestive standard for comparing the course of temperatures in different years. This "normal" curve is plotted with the mean daily temperature for each of the 3 years. It is obvious that, for the period studied, 1948, the year of late pollen shedding, was abnormally cold, whereas 1947 was distinctly warmer. The spring of 1947 started cool and approached normal as the season progressed. Pollen shedding dates are quite consistent with these curves, with the exception of the early shedding of X P. attenuradiata pollen in 1948. This is no doubt a result of the relatively high January - February temperatures in 1948. The late shedding of pollen by this hybrid in 1949 appears to be the consequence of low temperatures in February.

One further generalization can be made from the data on hand. Pinus ponderosa, on the west slope of the Sierra Nevada, grows from 125 to 7,000 feet above sea level. Pollen collection dates for trees from 1,000 to 6,000 feet elevation have been recorded. From these data a mean interval of 8 days per 1,000 feet difference in elevation has been computed. This figure agrees moderately well with Hopkins'[6/] constant of 4 days for each 400 feet difference in elevation.

5/ Mirov, N. T. 1939. Climatological observations at the Institute of Forest Genetics, Placerville, California, from 1929 to 1937. Unpublished manuscript, Calif. Forest and Range Exp. Sta.

6/ Hopkins, A. D. 1918. The bioclimatic law. U. S. Dept. Agr. Weather Bureau; Monthly Weather Review - Supplement No. 9. pp. 1-42.

Table 1.--Dates of pine pollen collection by the Institute of Forest Genetics

O, indicates pollen-producing trees growing at original site;
E, at Eddy Arboretum, Placerville, California, Lat. 39°N, Long. 121°W, Alt. 2700 feet;
B, at Berkeley, California, Lat. 38°N, Long. 122°W, Alt. 200 feet; and
F, at Fresh Pond, California, Lat. 39°N, Long. 121°W, Alt. 3700 feet.

Species	Original site			Growing at	Pollen collection dates			No. of years
	Lat. (N)	Long.	Altitude (feet)		Earliest	Latest	Mean	
Pinus:								
albicaulis Engelm.	39	120W	8,900	O	-	-	July 23	1
apacheca (see P. latifolia)								
aristata Engelm.	37	117W	10,000	O	June 30	July 26	July 18	3
arizonica Engelm.	32	109W	-	E	Apr. 15	May 13	Apr. 29	5
do.	32	109W	-	O	-	-	May 22	1
Armandi Franch.	-	-	-	E	Apr. 25	May 25	May 11	8
attenuata Lemm.	39	121W	3,000	O	Mar. 20	Apr. 27	Apr. 10	4
do.	38	122W	2,000	O	-	-	Mar. 8	1
do.	39	121W	-	E	-	-	Apr. 19	1
do.	39	121W	-	F	-	-	Apr. 20	1
x attenuradiata Stockwell & Righter	-	-	-	E	Mar. 12	Apr. 15	Mar. 21	7
attenuata X attenuradiata	-	-	-	E	-	-	Apr. 21	1
ayachuite var. brachyptera Shaw	32	109W	-	O	-	-	May 22	1
do.	32	109W	-	E	May 25	June 1	-	2
Balfouriana Balf.	37	117W	10,000	O	July 12	July 27	July 20	3
Banksiana Lamb.	-	-	-	E	Mar. 20	Apr. 27	Apr. 14	10
do.	44	89W	-	O	-	-	May 24	1
Bungeana Zucc.	32	119E	-	E	Apr. 24	May 24	May 9	2
canariensis C. Smith	28	16W	-	E	-	-	May 3	1
do.	28	16W	-	B	Mar. 15	Apr. 10	Mar. 31	3
caribaea Morelet	-	-	-	E	-	-	Mar. 31	1
contorta	39	124W	-	O	-	-	June 9	1
do.	41	124W	-	E	-	-	May 11	1
contorta var. bolanderi Parl.	39	124W	-	O	-	-	June 9	1

Species	Original site			Growing at	Pollen collection dates			No of years
	Lat. (N)	Long.	Altitude (feet)		Earliest	Latest	Mean	
contorta var. latifolia Engelm.	39	120W	6,000	O	June 5	July 8	June 22	3
do.	39	120W	7,000	E	Apr. 19	May 11	May 1	4
do.	49	115W	-	E	Apr. 9	May 6		2
do.	51	119W	1,000	E	Apr. 14	May 7	Apr. 26	4
contorta var. latifolia x Banksiana	-	-	-	E	Apr. 11	May 7	Apr. 24	6
Coulteri D. Don	33	117W	-	E	Apr. 21	May 15	-	2
do.	34	116W	5,000	O	-	-	June 8	1
do.	37	121W	4,000	O	-	-	June 5	1
do.	38	122W	2,000	E	Apr. 25	May 26	May 15	5
echinata Mill.	33	93W	-	E	Apr. 3	Apr. 23	Apr. 11	3
do.	31	93W	-	E	-	-	May 9	1
echinata x caribaea	-	-	-	E	Apr. 14	Apr. 18		2
echinata x taeda	-	-	-	E	Mar. 31	May 5	Apr. 19	5
excelsa (see P. Griffithi)								
flexilis James	-	-	-	E	May 8	June 7	May 24	5
do.	37	118W	9,000	O	-	-	July 16	1
glabra Walt.	-	-	-	E	-	-	Apr. 15	1
Griffithi McClell.	27	81E	-	E	Apr. 24	June 3	May 17	8
halepensis Mill.	-	-	-	E	Apr. 15	Apr. 19	-	2
halepensis var. brutia Elw. & Henry	-	-	-	E	-	-	Apr. 21	1
Jeffreyi Grev. & Balf.	34	116W	5,000	O	-	-	June 8	1
do.	37	121W	4,000	O	May 21	June 5	-	2
do.	39	120W	5,000	O	-	-	June 21	1
do.	39	120W	6,000	O	June 12	June 26	June 18	5
do.	39	120W	7,000	O	June 22	July 1	June 25	3
do.	40	121W	5,000	O	-	-	June 11	1
Jeffreyi x Coulteri	34	116W	5,000	O	June 4	June 6	June 5	3
do.	37	121W	4,000	O	May 21	June 9		2
do.	33	117W	-	O	-	-	June 7	1
Jeffreyi x ponderosa	-	-	-	F	-	-	May 28	1
Lambertiana Dougl.	34	116W	5,000	O	-	-	June 8	1
do.	39	120W	5,000	O	-	-	July 8	1
do.	39	120W	6,000	O	July 1	July 9	July 6	4
do.	-	-	-	E	May 21	May 31	May 27	3

Species	Original site: Lat. (N)	Long.	Altitude (feet)	Growing at	Pollen collection dates: Earliest	Latest	Mean	No. of years
latifolia Sarg.	32	109W	-	0	-	-	May 24	1
do.	32	110W	-	E	Apr. 25	June 1	May 16	6
leiophylla Schl. & Cham.	-	-	-	E	-	-	May 20	1
longifolia (see P. roxburghii								
massoniana Lamb.	-	-	-	E	-	-	Apr. 19	1
monophylla Torr.	37	118W	-	E	-	-	June 2	1
Montezumae Lamb.	-	-	-	E	Apr. 21	May 5	Apr. 26	4
monticola Dougl.	39	120W	7,000	0	June 8	Aug. 5	July 11	7
do.	48	114W	-	E	May 8	June 2	-	2
do.	47	116W	3,000	0	-	-	July 2	1
do.	46	121W	-	E	-	-	May 29	1
muricata D. Don	34	120W	-	E	Apr. 7	Apr. 20	-	2
muricata var. borealis D [illegible]								
Duffield	39	124W	-	0	-	-	Apr. 19	1
nigra var. austriaca								
Asch. & Graeb.	-	-	-	E	Apr. 29	May 10	Apr. 30	3
nigra var. calabrica Schneid.	-	-	-	E	May 5	May 12	May 9	3
nigra var. cebennensis Rehder	44	4E	-	E	-	-	May 14	1
patula Schl. & Cham.	-	-	-	E	Mar. 20	Apr. 25	Apr. 11	3
pinaster Ait.	-	-	-	E	Apr. 1	Apr. 25	Apr. 14	5
pinea L.	-	-	-	E	Apr. 30	May 20	-	2
ponderosa Laws.	35	112W	-	E	-	-	May 27	1
do.	37	122W	0	0	-	-	May 8	1
do.	37	122W	0	E	-	-	May 6	1
do.	39	123W	2,000	E	-	-	May 16	1
do.	39	121W	1,000	0	-	-	May 2	1
do.	39	121W	2,000	0	Apr. 21	May 14	May 4	4
do.	39	121W	3,000	0	Apr. 15	May 28	May 11	7
do.	39	121W	4,000	0	Apr. 25	May 30	May 21	2
do.	39	120W	5,000	0	June 3	June 11	June 6	2
do.	39	120W	6,000	0	June 14	June 27	June 20	2
do.	42	121W	-	E	-	-	May 26	1
do.	42	123W	-	E	-	-	May 27	1
do.	42	124W	-	E	-	-	May 5	1
do.	43	122W	-	E	-	-	May 2	1
do.	46	114W	4,000	E	-	-	May 3	1
do.	47	121W	2,000	E	-	-	May 4	1
do.	48	113W	-	E	-	-	May 5	1

Species	Original site: Lat. (N)	Long.	Altitude (feet)	Growing at	Pollen collection dates: Earliest	Latest	Mean	No. of years
ponderosa var. scopulorum Engelm.	37	113W	-	E	-	-	Apr. 18	1
do.	40	105W	-	O	-	-	May 25	1
do.	40	107W	-	O	-	-	May 24	1
do.	42	107W	-	E	Apr. 16	Apr. 28	-	2
do.	43	99W	-	E	Apr. 16	May 14	Apr. 29	5
pungens Lamb.	40	78W	-	E	Mar. 25	Apr. 25	Apr. 12	4
quadrifolia Sudw.	33	117W	-	E	-	-	June 9	1
radiata D. Don	34	122W	0	E	Jan. 28	Apr. 12	Mar. 13	7
do.	34	122W	0	F	Apr. 19	Apr. 24	-	2
resinosa Ait.	-	-	-	E	Apr. 17	May 10	Apr. 26	6
rigida Mill.	-	-	-	E	Apr. 8	Apr. 29	Apr. 17	4
rigida x taeda	-	-	-	E	Mar. 26	Apr. 17	Apr. 8	3
Roxburghii Sarg.	-	-	-	E	Mar. 6	Mar. 30		2
Sabiniana Dougl.	39	121W	3,000	O	Mar. 24	Apr. 28	Apr. 18	4
do.	39	121W	3,000	F	-	-	Apr. 20	1
Sinensis Lamb.	-	-	-	E	-	-	Apr. 28	1
Sinensis var. yunnanensis Franch.	-	-	-	E	-	-	Apr. 24	1
x Sondereggeri H. H. Chapman	-	-	-	E	Mar. 22	Apr. 5	Mar. 29	2
strobus L.	44	72W	-	E	May 2	June 8	May 20	5
sylvestris L.	-	-	-	E	Apr. 18	May 23	May 1	5
tabulaeformis Carr.	-	-	-	E	-	-	Apr. 14	1
taeda L.	-	-	-	E	Mar. 23	May 10	Apr. 12	9
taeda x caribaea	-	-	-	E	-	-	Apr. 3	1
taiwanensis Hayata	-	-	-	E	-	-	Apr. 25	1
Thunbergii Parl.	-	-	-	E	Apr. 8	May 4	Apr. 20	3
Torreyana Parry	33	117W	0	E	Feb. 25	Apr. 5	Mar. 20	4
do.	33	117W	0	B	Feb. 20	Mar. 30	Mar. 5	3
virginiana Mill.	-	-	-	F	-	-	May 8	1
do.	-	-	-	E	Apr. 11	Apr. 23	Apr. 19	3
washoensis Mason & Stockwell	39	120W	8,000	O	June 13	July 12	July 2	4

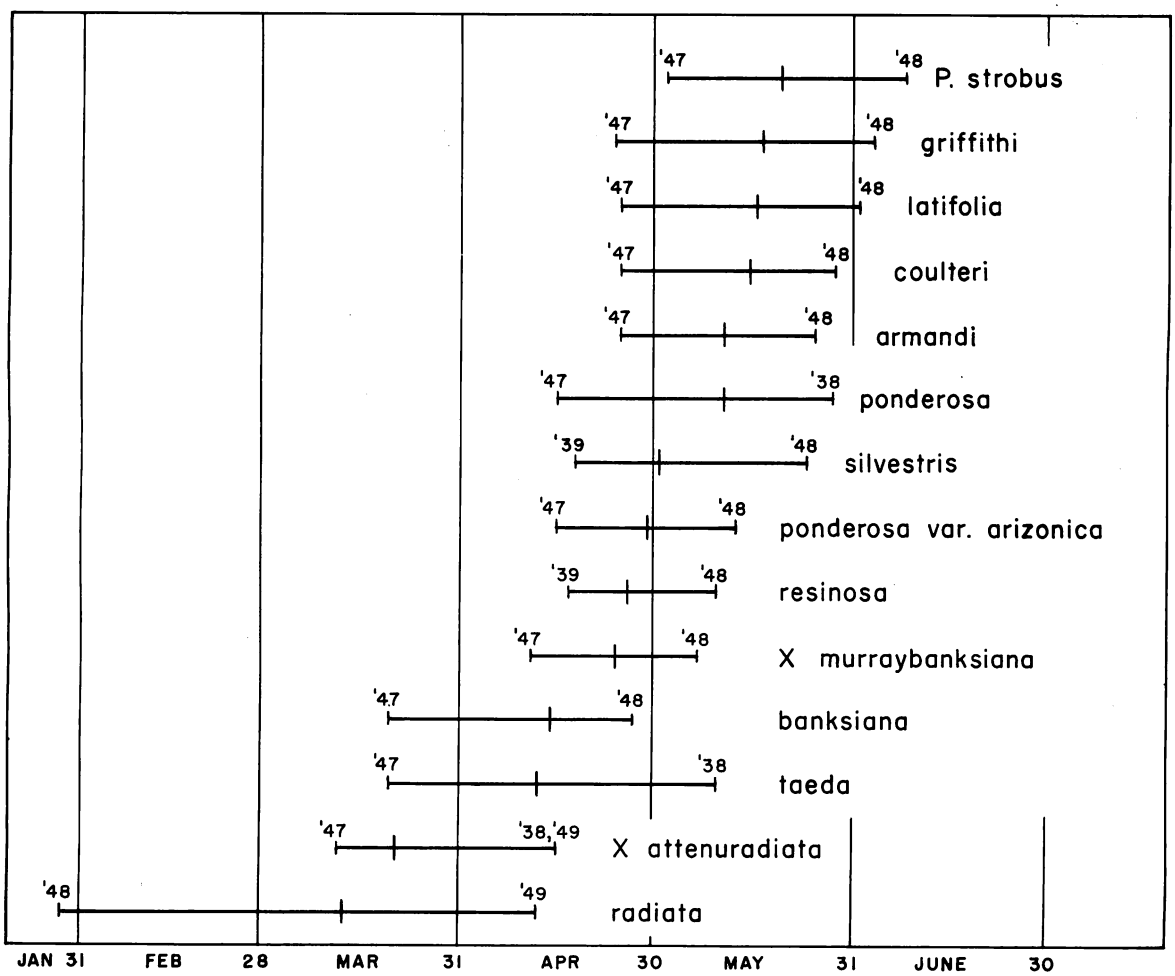

Figure 1.- Pollen collection dates for species collected for five or more years in the Eddy Arboretum.

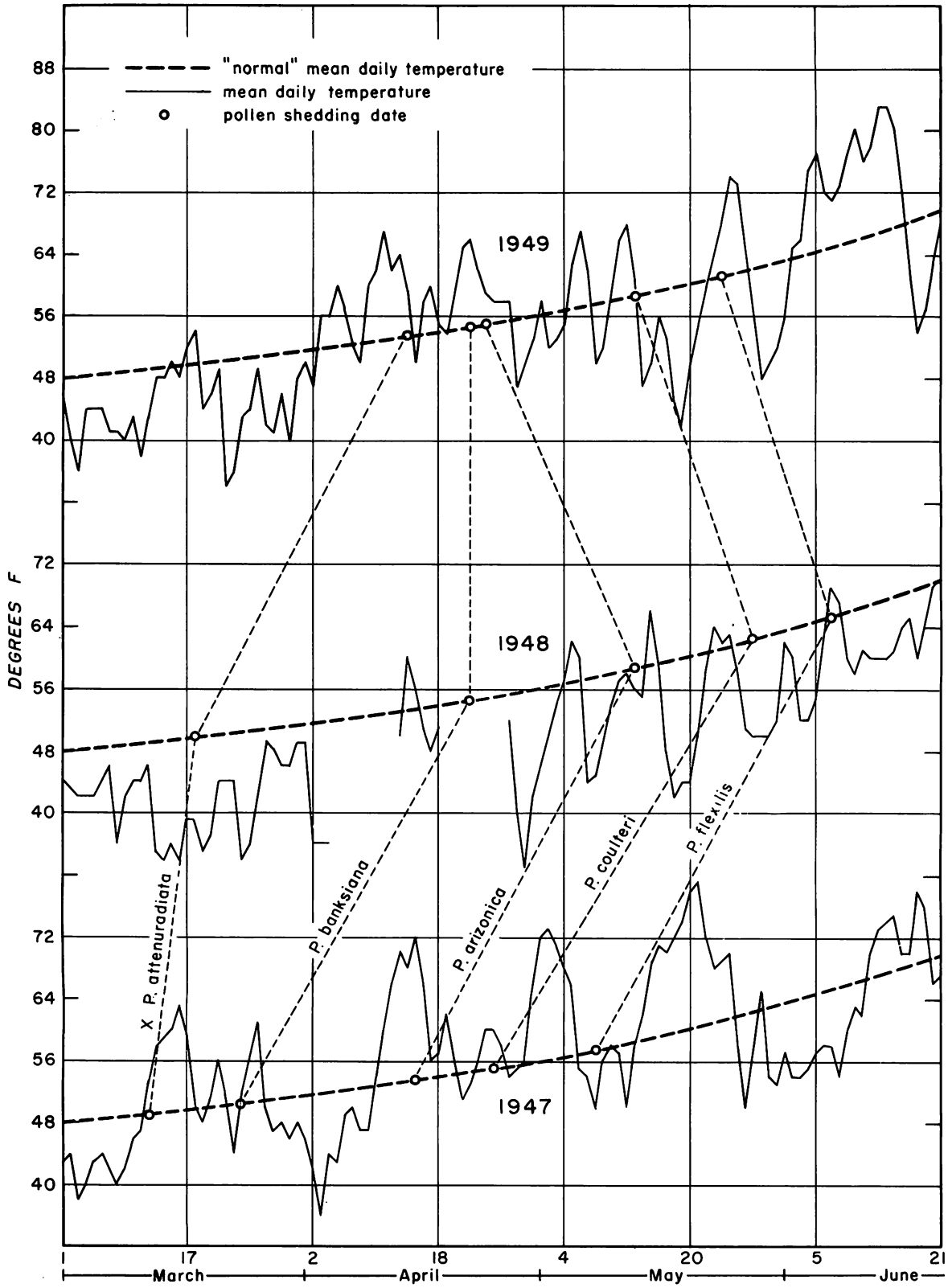

Figure 2.- Pollen shedding dates and mean daily temperatures in 1947, 1948, and 1949; and "normal" mean daily temperatures (see page 3 for derivation of normal curves).