17. A Working List of Meteor Streams

ALLAN F. COOK
Smithsonian Astrophysical Observatory
Cambridge, Massachusetts

THIS WORKING LIST which starts on the next page has been compiled from the following sources:

(1) A selection by myself (Cook, 1973) from a list by Lindblad (1971a), which he found from a computer search among 2401 orbits of meteors photographed by the Harvard Super-Schmidt cameras in New Mexico (McCrosky and Posen, 1961)

(2) Five additional radiants found by McCrosky and Posen (1959) by a visual search among the radiants and velocities of the same 2401 meteors

(3) A further visual search among these radiants and velocities by Cook, Lindblad, Marsden, McCrosky, and Posen (1973)

(4) A computer search by Lindblad (1971b) among 1827 precisely reduced photographed meteors from all available sources

(5) Visual radiants reported by Hoffmeister (1948)

(6) A report on the Phoenicid shower of December 5, 1956, by Ridley (1962)

(7) A list of visual radiants by McIntosh (1935)

(8) A report on the June Lyrids by Hindley (1969)

(9) Two papers on radar radiants in the southern sky by Weiss (1960a, b)

(10) A paper on radar radiants in the southern hemisphere by Nilsson (1964)

(11) Several compilations of visual, photographic, and radar radiants by Whipple and Hawkins (1959), McKinley (1961), Millman and McKinley (1963), and Jacchia (1963)

This list is restricted to streams that the author is convinced do exist. It is perhaps still too comprehensive in that there are six streams with activity near the threshold of detection by photography not related to any known comet and not shown to be active for as long as a decade. Unless activity can be confirmed in earlier or later years or unless an associated comet appears, these streams should probably be dropped from a later version of this list. The author will be much more receptive to suggestions for deletions from this list than he will be to suggestions for additions to it. Clear evidence that the threshold for visual detection of a stream has been passed (as in the case of the June Lyrids) should qualify it for permanent inclusion.

A comment on the matching sets of orbits is in order. It is the directions of perihelion that should match, a condition clearly met in most cases:

(1) April Lyrids and Comet 1861 I Thatcher
(2) η Aquarids, Orionids, and P/Comet Halley
(3) τ Herculids and Comet 1930 VI Schwassmann-Wachmann 3
(4) Daytime β Taurids, Southern Taurids, Northern Taurids, and P/Comet Encke
(5) June Boötids and P/Comet Pons-Winnecke 1915 III
(6) o Draconids and Comet 1919 V Metcalf
(7) Southern and Northern ι Aquarids
(8) Perseids and Comet 1862 III Swift-Tuttle
(9) Aurigids and Comet 1911 II Kiess
(10) Daytime Sextantids and Geminids
(11) Annual Andromedids and the predicted orbit of P/Comet Biela for 1972
(12) Andromedids and P/Comet Biela 1852 III

https://doi.org/10.1017/S025292110004906X Published online by Cambridge University Press

I.—*Working List of Meteor Streams*

Name	Dates[a]	Max.	Longitude of Sun (1950)					Geocentric radiant			
			Beginning (deg)	Half max. (deg)	Max. (deg)	Half max. (deg)	End (deg)	R.A. 1950 (deg)	Decl. 1950 (deg)	Velocity (km s^{-1})	Sun (deg)
Quadrantids	Jan. 1–4	Jan. 3	280.8	282.5	282.7	282.9	283.4	230.1	+48.5	41.5	282.7
δ Cancrids	Jan. 13–21	Jan. 16	293		296		301	126	+20	28	296
Virginids	Feb. 3–Apr. 15		314				25	186	0	35	350
δ Leonids	Feb. 5–Mar. 19	Feb. 26	316		338		359	159	+19	23	338
Camelopardalids	Mar. 14–Apr. 7		353				17	118.7	+68.3	6.8	359.0
σ Leonids	Mar. 21–May 13	Apr. 17	1		27		52	195	− 5	20	28
δ Draconids	Mar. 28–Apr. 17		7				27	281	+68	26.7	14
κ Serpentids	Apr. 1–7		11				17	230	+18	45	14
μ Virginids	Apr. 1–May 12	Apr. 25	12		35		51	221	− 5	29	35
α Scorpiids	Apr. 11–May 12	May 3	21		42		51	240	−22	35	42
α Boötids	Apr. 14–May 12	Apr. 28	24		36		51	218	+19	20	36
φ Boötids	Apr. 16–May 12	May 1	26		40		51	240	+51	12	40
April Lyrids	Apr. 20–23	Apr. 22	30.7	31.2	31.7	32.2	32.7	271.4	+33.6	47.6	31.7
η Aquarids	Apr. 21–May 12	May 3	30	39	42.4	45	51	335.6	− 1.9	65.5	42.4
τ Herculids	May 19–June 14	June 3	58		72		83	228	+39	15	72
χ Scorpiids	May 27–June 20	June 5	65		74		89	247	−13	21	74
Daytime Arietids	May 29–June 19	June 7	67	71	76	83	88	44	+23	37	77
Daytime ζ Perseids	June 1–17	June 7	70	72	76	83	86	62	+23	27	78
Librids	June 8–9, 1937	June 8	77.6		78.2		78.4+	227.2	−28.3	16±2	78.2
Sagittariids	June 8–16, 1957–8	June 11	77		80		82	304	−35	52	80
θ Ophiuchids	June 8–16	June 13	77		82		85	267	−28	26.7	82
June Lyrids	June 11–21, 1969	June 16	79	81	84.5	87.5	90	278	+35	31±3	84.5
Daytime β Taurids	June 24–July 6	June 29	91	93	96	99	103	86	+19	30	96
Corvids	June 25–30, 1937	June 26	94.8	94.9	95.2	97.6	97.9	191.9	−19.1	10±2	95.9
June Boötids	June 28, 1916	June 28	97.5		97.6		97.7	219	+49	13.9	98
July Phoenicids	July 3–18	July 14	101		112		116	31.1	−47.9	47±3	109.6
o Draconids	July 7–24	July 16	104				121	271	+59	23.6	113
Northern δ Aquarids	July 14–Aug. 25	Aug. 12	111		139		152	339	− 5	42.3	139
Southern δ Aquarids	July 21–Aug. 29	July 29	118	121	125	129	155	333.1	−16.5	41.4	125.0
α Capricornids	July 15–Aug. 10	July 30	123		126		138	307	−10	22.8	127
Southern ι Aquarids	July 15–Aug. 25	Aug. 5	112		131		151	333.3	−14.7	33.8	131.0
Northern ι Aquarids	July 15–Sept. 20	Aug. 20	112		147		177	327	− 6	31.2	147
Perseids	July 23–Aug. 23	Aug. 12	120	138	139	141	150	46.2	+57.4	59.4	139.0
κ Cygnids	Aug. 9–Oct. 6	Aug. 18	136		145		193	286	+59	24.8	145
Southern Piscids	Aug. 31–Nov. 2	Sept. 20	158		177		219	6	0	26.3	177
Northern Piscids	Sept. 25–Oct. 19	Oct. 12	182		199		206	26	+14	29	199
Aurigids	Sept. 1, 1935	Sept. 1			157.9			84.6	+42.0	66.3	157.9
κ Aquarids	Sept. 11–28	Sept. 21	168		178		184	338	− 5	16.0	178
Southern Taurids	Sept. 15–Nov. 26	Nov. 3	172		220		244	50.5	+13.6	27.0	220.0

https://doi.org/10.1017/S025292110004906X Published online by Cambridge University Press

I.—*Working List of Meteor Streams*—Continued

Name	Dates[a]	Max.	Longitude of Sun (1950)					Geocentric radiant			
			Beginning (deg)	Half max. (deg)	Max. (deg)	Half max. (deg)	End (deg)	R.A. 1950 (deg)	Decl. 1950 (deg)	Velocity (km s^{-1})	Sun (deg)
Northern Taurids	Sept. 19–Dec. 1	Nov. 13	176	206	230	240	249	58.3	+22.3	29.2	230.0
Daytime Sextantids	Sept. 24–Oct. 5	Sept. 29	179		184		190	152	0	32.2	183.6
Annual Andromedids	Sept. 25–Nov. 12	Oct. 3	182	184	190	195	230	5	+ 8	23.2	190
								20	+34	18.2	228
Andromedids	Nov. 27, 1885	Nov. 27	246.6	246.65	246.7	246.75	246.8	25	+44	16.5	247
Orionids	Oct. 2–Nov. 7	Oct. 21	189	206.7	207.7	208.3	225	94.5	+15.8	66.4	208.0
October Draconids	Oct. 9	Oct. 9	196.25		196.3		196.35	262.1	+54.1	20.43	196.3
ϵ Geminids	Oct. 14–27	Oct. 19	201		206		214	104	+27	69.4	209
Leo Minorids	Oct. 22–24	Oct. 24	209		211		211	162	+37	61.8	211
Pegasids	Oct. 29–Nov. 12	Nov. 12	215		230		230	335	+21	11.2	230
Leonids	Nov. 14–20	Nov. 17	231	234.447	234.462	234.477	237	152.3	+22.2	70.7	234.5
Monocerotids	Nov. 27–Dec. 17	Dec. 10	245		258		265	99.8	+14.0	42.4	257.6
σ Hydrids	Dec. 3–15	Dec. 11	251		259		263	126.6	+ 1.6	58.4	259.0
Northern χ Orionids	Dec. 4–15	Dec. 10	252		258		261	84	+26	25.2	258
Southern χ Orionids	Dec. 7–14	Dec. 11	255		259		262	85	+16	25.5	259
Geminids	Dec. 4–16	Dec. 14	252	260.6	261.7	262.1	264.2	112.3	+32.5	34.4	261.0
December Phoenicids	Dec. 5, 1956	Dec. 5	253.18	253.45	253.55	253.65	253.70	15	−55	21.7	253
								15	−45	11.7	254
δ Arietids	Dec. 8–14		256				262	52	+22	13.2	257.6
Coma Berenicids	Dec. 12–Jan. 23		260				303	175	+25	65	282
Ursids	Dec. 17–24	Dec. 22	265	269	270	271	272	217.06	+75.85	33.4	270.66

[a] Unless otherwise indicated, all calendar dates are for the year 1950.

II.—*Working List of Meteor Streams*

Name	Daily motion of radiant		Number in sample of McCrosky and Posen (1961)	Maximum visual zenithal rate (hr^{-1})	Maximum radar echo rate (hr^{-1})
	R.A. (deg)	Decl. (deg)			
Quadrantids			17	140	
δ Cancrids			7		
Virginids	+0.81	−0.33	6		
δ Leonids	+0.75	−0.50	24		
Camelopardalids	+1.35	+0.51	4		
σ Leonids	+0.44	+0.11	19		
δ Draconids			4		

https://doi.org/10.1017/S025292110004906X Published online by Cambridge University Press

Name	Daily motion of radiant		Number in sample of McCrosky and Posen (1961)	Maximum visual zenithal rate (hr^{-1})	Maximum radar echo rate (hr^{-1})
	R.A. (deg)	Decl. (deg)			
κ Serpentids			4		
μ Virginids	+0.53	−0.30	7		
α Scorpiids	+0.50	−0.19	5		
α Boötids	+0.7	+0.2	8		
φ Boötids			6		
April Lyrids	+1.1	0.0	5	12 96(1922)	
η Aquarids	+0.9	+0.4	7	30	
τ Herculids	−0.1	+0.9	14		
χ Scorpiids	+0.9	+0.5	11		
Daytime Arietids	+0.7	+0.6			60
Daytime ζ Perseids	+1.1	+0.4			40
Librids				10(1937)	
Sagittariids					30
θ Ophiuchids			4	2	
June Lyrids				9	
Daytime β Taurids	+0.8	+0.4			30
Corvids				13(1937)	
June Boötids				100(1916)	
July Phoenicids	+1.04	+0.53			30
o Draconids			3		
Northern δ Aquarids	+1.0	+0.2	9	20	
Southern δ Aquarids	+0.80	+0.18	13	30	
α Capricornids	+0.9	+0.3	21	30	
Southern ι Aquarids	+1.07	+0.18	12	15	
Northern ι Aquarids	+1.03	+0.13	3	15	
Perseids	+1.35	+0.12	45	70	
κ Cygnids	0.0	0.0	8	5	
Southern Piscids			14		
Northern Piscids			9		
Aurigids				30	
κ Aquarids			5		
Southern Taurids	+0.79	+0.15	46	7	
Northern Taurids	+0.76	+0.10	45	<7	
Daytime Sextantids					30
Annual Andromedids	+0.38	+0.66	23		
Andromedids				13 000(1885)	
Orionids	+1.23	+0.13		30	
October Draconids			2	30 000(1933)	
ε Geminids	+0.7	0.0	7		
Leo Minorids			3		
Pegasids			6		
Leonids	+0.70	−0.42	5	14 000(1833)	
Monocerotids			3		
σ Hydrids	+0.7	−0.2	8		
Northern χ Orionids			4		
Southern χ Orionids			8		
Geminids	+1.02	−0.07	77	70	
December Phoenicids				100	20
δ Arietids			7		
Coma Berenicids	+0.88	−0.45	11		
Ursids				20 110(1945)	

https://doi.org/10.1017/S025292110004906X Published online by Cambridge University Press

III.—*Working List of Meteor Streams*

Name	Orbital elements						
	a	e	q	ω (deg)	Ω (deg)	ι (deg)	π (deg)
Quadrantids	3.08	0.683	0.977	170.0	282.7	72.5	92.8
δ Cancrids	2.3	0.80	0.45	283	296	0	219
Virginids	2.63	0.90	0.26	304	350	3	294
δ Leonids	2.62	0.75	0.64	259	338	6	237
Camelopardalids	1.534	0.352	0.974	185.0	359.0	8.2	184.0
σ Leonids	2.35	0.66	0.75	248	28	1	276
δ Draconids	2.770	0.640	0.996	171.1	13.7	37.5	184.8
κ Serpentids	∞	1.00	0.45	275	14	64	289
μ Virginids	3.12	0.83	0.48	280	35	10	315
α Scorpiids	2.15	0.90	0.21	134	222	3	356
α Boötids	2.65	0.71	0.75	247	36	18	283
ϕ Boötids	1.25	0.24	0.95	226	40	19	266
April Lyrids	28	0.968	0.919	214.3	31.7	79.0	246.0
Comet 1861 I	55.7	0.983	0.921	213.4	31.2	79.8	244.6
η Aquarids	13	0.958	0.560	95.2	42.4	163.5	137.6
Orionids	15.1	0.962	0.571	82.5	28.0	163.9	110.5
P/Comet Halley 1835 III	18.0	0.967	0.587	110.7	56.8	162.3	167.5
τ Herculids	2.70	0.63	0.97	204	72	19	276
Comet 1930 VI	3.09	0.673	1.011	192.3	77.1	17.4	269.4
χ Scorpiids	3.11	0.77	0.68	257	74	6	331
Daytime Arietids	1.6	0.94	0.09	29	77	21	106
Northern δ Aquarids	2.62	0.97	0.07	332	139	20	111
Southern δ Aquarids	2.86	0.976	0.069	152.8	305.0	27.2	97.8
Daytime ζ Perseids	1.6	0.79	0.34	59	78	0	137
Southern Piscids	2.33	0.82	0.42	107	357	2	104
Northern Piscids	2.06	0.80	0.40	291	199	3	130
Librids	2.5/10	0.65/0.92	0.88/0.85	46/49	258.2	4/5	305/308
Sagittariids	∞	1.00	0.10	142	260	99	42
θ Ophiuchids	2.90	0.84	0.46	101	262	4	4
June Lyrids	2.5/10	0.67/0.92	0.83/0.84	237/231	84.5	44/50	321/315
Daytime β Taurids	2.2	0.85	0.34	246	276.4	6	162
Southern Taurids	1.93	0.806	0.375	113.2	40.0	5.2	153.2
Northern Taurids	2.59	0.861	0.359	292.3	230.0	2.4	162.3
P/Comet Encke 1970l	2.217	0.847	0.339	185.9	334.2	12.0	160.1
Corvids	2.5/10	0.60/0.90	1.013/1.012	7.6/7.9	274.9	3/4	282.5/282.8
June Boötids	3.27	0.69	1.02	180	98	18	278
P/Comet Pons-Winnecke 1915 III	3.261	0.702	0.971	172.4	99.8	18.3	272.2
July Phoenicids	2.5/∞	0.62/1.00	0.96/0.97	31/24	289.6	82/87	321/313
o Draconids	∞	1.00	1.01	190	113	43	303
Comet 1919 V	∞	1.000	1.115	185.7	121.4	46.4	307.2
α Capricornids	2.53	0.77	0.59	269	127	7	36
Southern ι Aquarids	2.36	0.912	0.208	131.8	311.0	6.9	82.8
Northern ι Aquarids	1.75	0.84	0.26	308	147	5	95
Perseids	28	0.965	0.953	151.5	139.0	113.8	290.5
Comet 1862 III	24.3	0.960	0.963	152.8	138.7	113.6	291.5
κ Cygnids	3.09	0.68	0.99	194	145	38	339
Aurigids	∞	1.000	0.802	121.5	157.9	146.4	279.4
Comet 1911 II	153	0.996	0.684	110.3	158.0	148.4	268.3
κ Aquarids	3.20	0.74	0.81	236	178	2	54

https://doi.org/10.1017/S025292110004906X Published online by Cambridge University Press

III.—*Working List of Meteor Streams*—Concluded

Name	Orbital elements						
	a	e	q	ω (deg)	Ω (deg)	ι (deg)	π (deg)
Daytime Sextantids	1.25	0.87	0.16	213	3.6	22	217
Geminids	1.36	0.896	0.142	324.3	261.0	23.6	225.3
Annual Andromedids	3.22	0.82	0.58	267	190	4	97
	3.29	0.76	0.79	238	228	12	106
P/Comet Biela (1972)	3.54	0.77	0.82	255	213	8	108
Andromedids	3.53	0.76	0.86	222	247	13	109
P/Comet Biela 1852 III	3.52	0.756	0.861	223.2	247.3	12.6	110.4
October Draconids	3.51	0.717	0.996	171.8	196.3	30.7	8.1
P/Comet Giacobini-Zinner 1946 V	3.51	0.717	0.996	171.8	196.3	30.7	8.1
ϵ Geminids	26.77	0.97	0.77	237	209	173	86
Leo Minorids	58.6	0.99	0.65	106	211	124	317
Comet 1739	∞	1.00	0.674	104.8	210.3	124.3	315.1
Pegasids	3.86	0.75	0.97	196	230	8	65
December Phoenicids	2.96	0.68	0.98	0	73	16	74
	2.96	0.67	0.99	359	74	13	72
Comet 1819 IV	2.96	0.699	0.892	350.2	79.2	9.1	69.4
Leonids	11.5	0.915	0.985	172.5	234.5	162.6	47.0
P/Comet Tempel-Tuttle 1965 IV	10.27	0.904	0.982	172.6	232.4	162.7	45.7
Monocerotids	42	0.997	0.14	135.8	77.6	24.8	213.4
Comet 1917 I	27.65	0.993	0.190	121.3	88.0	32.7	209.6
σ Hydrids	30.0	0.992	0.244	120.7	79.0	125.5	199.8
Northern χ Orionids	2.22	0.79	0.47	281	258	2	179
Southern χ Orionids	2.18	0.78	0.47	101	79	7	180
δ Arietids	2.13	0.605	0.838	232.8	257.6	1.8	130.4
Coma Berenicids	∞	1.00	0.58	258	282	134	180
Ursids	5.70	0.85	0.9389	205.85	270.66	53.6	116.51
P/Comet Tuttle 1939 X	5.70	0.821	1.023	207.0	269.8	54.6	116.8

(13) October Draconids and P/Comet Giacobini-Zinner 1946 V

(14) Leo Minorids and Comet 1739 Zanotti

(15) Pegasids, December Phoenicids, and Comet 1819 IV Blanplain

(16) Leonids and P/Comet Tempel-Tuttle 1965 IV

(17) Monocerotids and Comet 1917 I Mellish

(18) Northern and Southern χ Orionids

(19) Ursids and P/Comet Tuttle

In the case of the Sextantids and the Geminids, the temporary character of the Sextantids and the concentration and strength of the Geminids suggest two parent bodies for the streams. The similarities in the directions of perihelion, distances at perihelion, and semimajor axes then imply that these two parent bodies separated from a common body at an earlier time. In the case of the Pegasids, December Phoenicids, and Comet 1819 IV Blanplain, the strength, concentration, and single apparition of the December Phoenicids suggest that a small comet still exists; the presence of meteors in the orbital plane of the Pegasids suggests that another comet separated long ago from Comet 1819 IV. If we were in the presence of a broad distribution of meteoroids, there would be continuous activity from northern and southern radiants in October, November, and December.

In two cases some serious failure to match occurs. Among the Daytime Arietids, Northern δ Aquarids, and Southern δ Aquarids, it is clear

that the Northern δ Aquarids do not fit and are dubious members of the system; and in the case of the Daytime ζ Perseids, Southern Piscids, and Northern Piscids, it is clear that the Southern Piscids do not fit and are dubious members of the system. The traditional association between the α Capricornids and P/Comet Honda-Mrkos-Pajdušáková is rejected, as the directions of perihelia diverge by nearly 30°.

Of the 57 entries in the list, two are additional radiants associated with P/Comet Encke and six more are associated with another radiant, each in the sense that they appear to come from the same parent body. One of these pairs is the η Aquarids and Orionids associated with P/Comet Halley. Another is the pair of Andromedid radiants, one that of the great showers, the other that of the current weak annual stream matching the current predicted orbit of P/Comet Biela. The remaining four pairs are not associated with a comet; two are pairs of daylight and night showers—the Daytime Arietids with the Southern δ Aquarids and the Daytime ζ Perseids with the Northern Piscids. The remaining two are merely northern and southern branches of the same streams; these two cases are the ι Aquarids and the χ Orionids. Thus, we deal here with 49 separate streams. Two additional pairings appear to be at the level of parent meteoroid-shedding bodies having separated from a larger body at an earlier time. These pairings are the Daytime Sextantids with the Geminids and the Pegasids with the December Phoenicids, which in turn apparently came from Comet 1819 IV Blanplain. It appears that 47 initial parent bodies are required to explain the present list of streams. Some 15 of the 49 currently required parent bodies have been observed as Comets. Two are lost, and P/Comet Biela is perhaps the best target for an effort at recovery. Small asteroids might be searched for along the orbits of the Geminids and Sextantids, and comets might be searched for along the orbits of the highly concentrated Quadrantids, Librids, and Corvids. The other 29 parent objects are associated with weak or diffuse stream systems, so a search for them would be tantamount to a general search of the sky.

The author is grateful for access to B. G. Marsden's (1972) catalog of orbits of comets in advance of publication, and also for the predicted orbit of P/Comet Biela in 1972. This work was supported in part by contract NGR 09–015–033 from the National Aeronautics and Space Administration.

NOTES ON INDIVIDUAL STREAMS

Virginids, σ Leonids, and μ Virginids	These streams are contributors to Hoffmeister's (1948) visual Virginids.
α Scorpiids	This stream is a contributor to Hoffmeister's (1948) Scorpius-Sagittarius system.
April Lyrids	This stream is a weak annual one at the threshold of detection for visual observers but has given stronger displays in 1884 (22 hr^{-1}), 1922 (96 hr^{-1}), and 1948 (20 hr^{-1}).
η Aquarids and Orionids	At this inclination, $\Omega-\omega$ should be compared between orbits, not π. The three values are 307.4°, 305.5°, and 306.2° for the η Aquarids, the Orionids, and P/Comet Halley, respectively.
τ Herculids	Some evidence exists that this stream was detected visually, its radiant being regarded as early activity of the June Boötids (Olivier, 1916; Smith, 1932).
χ Scorpiids	This stream is a contributor to Hoffmeister's (1948) Scorpius-Sagitarrius system.
Librids	This shower was observed only in 1937. Two sets of elements are given to present likely extremes.
Sagittariids	This shower was observed only by radar and only in 1958. It was absent in the years 1952 to 1956.
θ Ophiuchids	This stream is the maximum of Hoffmeister's (1948) Scorpius - Sagittarius system.

June Lyrids	This weak visual stream has appeared only from 1966 onward (Hindley, 1969). Two sets of elements are given to present likely extremes.
Corvids	This shower was observed only in 1937. Two sets of elements are given to present likely extremes. Hoffmeister's Orbit I (1948, p. 122) for $a=2.5$ is incorrect.
June Boötids	This shower was strong only in 1916 (100 hr^{-1}) and showed 6 hr^{-1} in 1921 (Hoffmeister, 1921).
July Phoenicids	This shower was observed only by radar from 1953 through 1958. It does not appear in visual lists, although it should if it is not a recent arrival at the Earth's orbit. Two sets of elements are given to present likely extremes.
α Capricornids	These are Weiss' (1960b) Capricornids. They are not resolvable visually from the Southern δ Aquarids.
Southern ι Aquarids	These are Weiss' (1960b) Piscis Austrinids. They are not resolvable visually from the Southern δ Aquarids.
Northern ι Aquarids	Early on, this shower is not resolvable visually from the Southern δ Aquarids, and in its feeble late stages, it contributes to Hoffmeister's (1948) visual Piscids.
Southern Piscids and Northern Piscids	These streams contribute to Hoffmeister's (1948) visual Piscids.
Aurigids	This shower was strong for 1 hr before morning twilight on one night only.
Southern Taurids and Northern Taurids	These streams cannot be resolved from one another visually.
Annual Andromedids	This stream begins its activity by contributing to Hoffmeister's (1948) visual Piscids and then moves northward toward the radiant of the famous Andromedid showers. Two radiants and sets of elements are given to display the changes during the Earth's passage through the stream.
Andromedids	Strong showers occurred on December 5, 1741; December 7, 1798 (~400 hr^{-1}); December 7, 1830; December 6, 1838 (~100 hr^{-1}); December 6, 1847 (~150 hr^{-1}); November 30, 1867; November 27, 1872; November 27, 1885 (~13,000 hr^{-1}); November 23, 1892 (~300 hr^{-1}); November 24, 1899 (~100 hr^{-1}); November 21, 1904 (~20 hr^{-1}); and November 15, 1940 (~30 hr^{-1}).
October Draconids	Strong showers occurred in 1927 (17 hr^{-1}), 1933 (30 000 hr^{-1}), 1946 (10 000 hr^{-1}), and 1952 (200 hr^{-1}).
Leonids	Strong showers occurred in 1799, 1832, 1833, 1834, 1839, 1866, 1867, 1868, 1898, 1901, 1903, 1961, 1965, 1966, and 1969. In other years, activity was very feeble.
December Phoenicids	This shower appeared only in 1965. The northern radiant is visual; the southern is from radar observations.
Coma Berenicids	The December portion of this stream is called the December Leo Minorids by Cook et al. (1972), but Lindblad (1971b) found bridging meteors that connect the December Leo Minorids to Coma Berenicids in January.

REFERENCES

Cook, A. F., 1973. Discrete levels of beginning height of meteors in streams, *Smithson. Contrib. Astrophys.*, in press.

Cook, A. F., Lindblad, B. A., Marsden, B. G., McCrosky, R. E., and Posen, A., 1973. Yet another stream search among 2401 photographic meteors, *Smithson. Contrib. Astrophys.*, in press.

Hindley, K. B., 1969. The June Lyrid meteor stream in 1969, *J. Brit. Astron. Assoc.*, **79,** 480–484.

Hoffmeister, C., 1921. Die Beobachtung von Meteoren des Winneckeschen Kometen, *Astron. Nachr.*, **215,** 455–466.

——, 1948. *Meteorströme*, Johann Ambrosius Barth, Leipzig.

Jacchia, L. G., 1963. Meteors, meteorites, and comets: Interrelations, in *The Moon, Meteorites and Comets*, edited by B. M. Middlehurst and G. P. Kuiper, Univ. of Chicago Press, Chicago, 774–798.

Lindblad, B. -A., 1971a. A computerized stream search among 2401 photographic meteor orbits, *Smithson. Contrib. Astrophys.*, **12,** 14–24.

——, 1971b. Meteor streams, in *Space Research XI*, 287–297.

Marsden, B. G., 1972. *Catalogue of Cometary Orbits*, Smithson. Astrophys. Obs., Cambridge, Mass., 1–70.

McCrosky, R. E., and Posen, A., 1959. New photographic meteor showers, *Astron. J.*, **64,** 25–27.

McCrosky, R. E., and Posen, A., 1961. Orbital elements of photographic meteors, *Smithson. Contrib. Astrophys.*, **4,** 15–84.

McIntosh, R. A., 1935. An index to southern meteor showers, *Mon. Not. Roy. Astron. Soc.*, **95,** 709–718.

McKinley, D. W. R., 1961. *Meteor Science and Engineering*, McGraw-Hill Book Co., New York, 145–157.

Millman, P. M., and McKinley, D. W. R., 1963. Meteors, in *The Moon, Meteorites and Comets*, edited by B. M. Middlehurst and G. P. Kuiper, Univ. of Chicago Press, Chicago, 674–773.

Nilsson, C., 1964. A southern hemisphere radio survey of meteor streams, *Australian J. Phys.*, **17,** 205–256.

Olivier, C. P., 1916. The meteor system of Pons-Winnecke's comet, *Mon. Not. Roy. Astron. Soc.*, **77,** 71–75.

Ridley, H. B., 1962. The Phoenicid meteor shower of 1956 December 5, *J. Brit. Astron. Assoc.*, **72,** 266–272.

Smith, F. W., 1932. A discussion of meteor orbits connecting with the Pons-Winnecke comet, *Mon. Not. Roy. Astron. Soc.*, **93,** 156–158.

Weiss, A. A., 1960a. Radio-echo observations of southern hemisphere meteor shower activity from 1956 December to 1958 August, *Mon. Not. Roy. Astron. Soc.*, **120,** 387–403.

——, 1960b. Southern hemisphere meteor activity in July and August, *Australian J. Phys.*, **13,** 522–531.

Whipple, F. L., and Hawkins, G. S., 1959. Meteors, in *Handbuch der Physik*, Springer-Verlag, Berlin, **52,** 519–564.