Activity of the Delta Aquarides meteor shower in the years 1944-1952

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Abstract. The activity of the Delta Aquarides shower for the years 1944 - 1952 was derived by processing more than 15 000 visual records of meteors, of which 520 refer to the Delta Aquarides, made at the Skalnaté Pleso Observatory in the months of July and August for a period of 8 years, using exponent $\gamma = 1.47$ in reduction factor $\cos^{\gamma} z_R$.

1. Introduction

The Delta Aquarides shower is one of the most discussed meteor showers which can be observed in the Northern Hemisphere. The shower consists of two well-defined streams. The data reported by individual authors regarding the duration of the shower, the time of its maximum, hourly rates, position and spread of radiants differ considerably, as can be seen in the Table 1.

The shower's activity was recorded first time in 1870 when G.L. Tupman recorded 65 meteors between July 27 and August 6. The first radar observations of Delta Aquarides were made by McKinley (1954) in Canada in 1949.

As the results of the separate authors indicate, the Delta Aquarides shower data display a considerable scatter, which can be due to other meteor showers at the time of the former's activity, as well as to their low-inclination orbit, resulting in better observation conditions in the Southern than in the Northern Hemisphere. The quality of the results depends on observation conditions quite considerably. Ideal conditions occur only seldom. The limiting factors are:

a) twilight effects - changes in the brightness of the sky's background related to the Sun's position below the horizon (Slančíková, 1975)

b) moonshine, effective the whole time the Moon is above the horizon, its intensity depending on the Moon's phase and position. When the phase is small, its effect can be neglected, the more so as it only affects observations at dusk and dawn. Close to full moon, the Moon has a disturbing effect nearly throughout the whole night, and the decrease in the observed rate substantially diminishes its statistical weight even if the appropriate corrections factors are applied.

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Authors	DA	Data	max	l_{1950}	geoc. rad.		f_z	o
					α	δ		
				(deg)	(deg)	(deg)		
Cook	S-DA	21.7.-29.8.	29.7	125	333.1	-16.5	30	v
(1973)	N-DA	14.7.-25.8.	12.8.	139	339.0	-5.0	20	v
Kronk	S-DA	14.7.-18.8.	29.7.	125	339	-17.0	15 - 20	v
(1988)	N-DA	16.7.-10.9.	13.8.	139	344	+2	10	v
Tupman	S-DA	27.7.-6.8.						v
Denning (1899)	S-DA		28.7.					v
McIntosh (1934)	S-DA		28.7.					v
Hoffmeister	S-DA		3.8.	130				v
(1948)	N-DA		13.8.	139				v
Hawking Almond (1952)	DA		28.7.	124.5	339	-14	38	r
Lindblad	S-DA	21.7.-8.8.	31.7.		340	-16		ph
(1971)	N-DA	5.8.-25.8.	14.8.	140.5	347	+1		ph
Kashcheyev	S-DA	14.7.-14.8.		126.7	341.2	-16.4		r
Lebedinets	N-DA	7.7.-14.8.	1.8.	127.7	336.8	-4.9		r
Nilsson (1964)	DA		28.7.	125.8	339.4	-17.3		r
Sekanina	S-DA	16.7.-14.8.	30.7.		342.2	-16.9		r
(1970)	N-DA	26.7.-27.8.	13.8.		344.0	+0.3		r
Sekanina	S-DA	14.7.-18.8.	29.7.		341.8	-15.9		r
(1976)	N-DA	28.7.-10.9.	14.8.		345.7	+4.8		r

Table 1. Table 1 gives the name of authors, years for references, abbreviation for Delta Aquarides shower (S-DA = Southern DA, N-DA = North DA), duration of the shower, the time of its maximum, solar longitude l_{1950}, geocentric radiant, maximum of zenithal hourly rate f_z and method of observation (o): v - visual, r - radar, ph - photographic.

c) The third limiting factor is cloudiness which may either prevent observations altogether, or may decrease the observed rate.

Although the weather at the time of the Delta Aquarides activity, i.e. in July and August, is relatively stable, there is no longer, continuous series of observations, with the exception of 1946, even in archives as extensive as those in the Skalnaté Pleso Observatory. The usable material as a whole contains more than 15 000 meteor records (M_C), of which 520 refer to the Delta Aquarides

(DA_c). 411 records of the Delta Aquarides (DA), with net observing time of the separate observers totalling 205.35 hours, were selected for further processing. If the limiting factors mentioned are taken into account, together with the dependence of the observed rate on the zenith distance of the radiant, but little data are left to construct the rate curve (Zvolánková, 1983).

2. Data and their analysis

In this paper visual observations of the Delta Aquarides meteor shower are analysed as obtained in the years 1944, 1946 - 1952 as a part of the program of systematic visual observations of sporadic and shower meteors conducted at the Skalnaté Pleso Observatory. There were no substanial changes to the method of observation for the whole period in question. The observing group usually consisted of the recorder and four observers who observed the sky at an elevation of 45° above the horizon in the four main directions (E, S, W, N). The cloudiness was recorded in each of these directions every 10 minutes; if it changed rapidly, then every 5 minutes. Each observer reported the percentage of the sky he was observing covered by clouds. The limiting stellar magnitude was not recorded since, as proved by Kresáková (1966), it is nearly constant at a high-mountain observatory like Skalnaté Pleso. All observations where the cloudiness exceed 30%, as well as observations affected by the moonlight were eliminated from further processing. Observations made by random observers were not taken into account either.

Year	M_c	DA_c	DA
1944	1327	16	14
1946	6066	254	231
1947	873	65	52
1948	2570	95	44
1949	698	32	27
1950	1373	11	10
1951	1352	17	9
1952	1103	30	24
$\sum$	15362	520	411

Table 2.

Table 2 gives the total number of meteor records made during the whole period of observing the shower in the individual years M_c, the total number of records of the Delta Aquarides DA_c, and the number of records of the Delta Aquarides DA, selected for further processing according to the criteria mentioned.

Table 3 gives the name and abbreviation for each observer, their personal coefficients k_{1p}, for each year as determined by Štohl (1969), the sum of all meteor records of the individual observers for the individual years N_{pc}, used in this study, and their net observing time in minutes t_{pc}.

Table 3.

Observer	Abbr.	Year	k_{1p}	N_{pc}	t_{pc}
Ambruš	Am	1944	1.00	1	120
Bajcár	Bj	1949	1.14	4	295
		1950	1.14	0	90
Bakoš	Bk	1946	1.91	3	155
Bečvář	T	1944	0.99	5	127
		1946	1.20	55	1152
		1947	1.10	2	36
		1948	1.14	7	151
		1951	1.06	2	50
Blahová	Ba	1947	1.16	15	278
		1949	1.36	0	83
Ceplecha	Ce	1949	1.63	3	83
Drozd	D	1944	0.91	0	30
Dzubák	M	1944	0.91	8	161
		1946	1.19	37	1464
		1947	1.19	15	278
		1948	1.06	3	115
		1950	0.95	3	90
Forgáč	F	1948	1.00	5	106
Frajová	Fo	1951	1.05	0	50
Hartmanová	H	1946	1.54	3	226
Hájková	Ha	1951	1.38	1	60
Ivan	I	1949	1.28	0	53
Jančík	J	1950	1.51	0	104
Kresák	K	1946	1.03	50	1661
		1947	1.13	12	262
		1949	1.05	0	15
		1951	0.97	2	100
		1952	1.16	7	115
Kresáková	Ka	1952	1.11	2	165
Kvíz	Q	1951	2.14	0	15
Letfus	Le	1948	1.59	1	240

Table 3. - continued

Observer	Abbr.	Year	k_{1p}	N_{pc}	t_{pc}
Maleček	Mk	1946	1.99	0	124
Malovec	Mc	1951	1.77	1	30
Mrkos	A	1946	0.87	37	728
		1948	1.24	0	20
		1949	1.02	20	338
		1950	0.86	3	44
Pajdušáková	L	1944	1.00	0	11
		1946	1.00	46	1501
		1947	1.00	6	111
		1948	1.00	5	75
		1950	1.00	4	104
		1951	1.00	3	90
Paroubek	Pa	1952	1.50	3	152
Plavec	Pc	1948	1.04	5	216
Podstanická	Po	1952	1.62	2	165
Rajchl	Ra	1948	1.43	3	30
Sitar	S	1948	1.26	15	240
Štohl	St	1952	0.96	10	165
Vadovič	V	1947	1.44	2	187
Vránová	Vr	1951	1.31	0	60
				411	12321

The observed Delta Aquarides were divided roughly into half-hour intervals. For each of these intervals and for each observer p the number of observed Delta Aquarides N_p, the net time t_p for which he observed and the average cloudiness were determined. The depression of the Sun was determined for the middle of each interval at twilight. These data and the personal coefficients were used to calculate the corrected hourly rates per one observer according to the formula

$$f_o = 60\tau \sum_1^{\epsilon} N_p \left[\sum_1^{\epsilon} t_p / k_{op} k_{1p} \right]^{-1} \tag{1}$$

where f_o is the corrected hourly rate, N_p the number of meteors observed by observer p within the given interval, t_p the net observing time, k_{op} the cloudiness coefficient, k_{1p} the personal coefficient, ϵ the number of all observers who observed in the given interval, and τ the twilight coefficient as determined by Slančiková (1975).

In this study we used the cloudiness coefficients k_{op} calculated by Guth (1941). For various types of clouds the coefficients are the same up to the cloudiness of 30%. Since the records do not specify the type of cloudiness, all observations at which the cloudiness exceeded 30% were eliminated from further analysis.

The corrections mentioned above were used to calculate the hourly rates f_o for all intervals. To be able to compare these hourly rates with one another, they had to be reduced to the radiant in the zenith. If the zenithal hourly rate per one observer is denoted as f_z and the reduction factor as cos z_R,

$$f_z = f_o / \cos^{\gamma} z_R \tag{2}$$

Table 4 gives the zenith hourly rates f_z for the separate intervals calculated using exponent $\gamma = 1.47$, as determined by Zvolánková (1983). Besides hourly rates, the table also gives the following data: ordinal number, date, the middle of time interval T in UT, longitude of the Sun l_{1950}, the total number of meteor records $\sum N_p$ observed in a given interval by all observes, the net observing time $\sum t_p$ of all observes in this interval, and the abbreviations of the individual observers observing in that particular interval. The date is given only for the first interval of a particular day and applies until the next date given.

Table 4.

No	Date	T	l_{1950}	$\sum N_p$	$\sum t_p$	f_z	Observers
1	44.7.25	21:15	122.85	1	33	17.16	TLM
2	44.7.26	22:45	123.86	1	41	6.17	TMAm
3		23:15	123:88	2	90	5.01	TMAm
4		23:45	123.90	2	90	4.65	TMAm
5	44.7.27	00:15	123.92	3	90	6.73	TMAm
6		00:45	123.94	4	45	17.97	TMAm
7	44.8.6	20:15	134.28	1	60	7.81	DM
8	46.7.24	21:45	121.42	4	146	13.65	MKBkLT
9		22:45	121.46	2	80	8.87	MKBk
10		23:15	121.48	1	78	4.03	MKBk
11	46.7.25	00:15	121.52	2	60	7.93	MK
12		21:45	122.37	9	150	29.24	MKLTBk
13		22:15	122.40	3	134	8.78	MKLTBk
14		23:45	122.46	1	55	4.44	MK
15	46.7.26	00:15	122.48	3	84	8.16	MKL
16		00:45	122.50	2	90	5.01	MKL
17		21:45	123.33	1	124	3.56	MKLTBk
18		22:45	123.37	4	91	12.50	MKTA
19		23:15	123.39	1	100	2.58	MKTAL
20		23:45	123.41	5	95	12.29	MKLT
21	46.7.27	00:15	123.43	1	90	2.49	MKL
22		00:45	123.45	3	75	8.98	MKL

Table 4. - continued

No	Date	T	l_{1950}	$\sum N_p$	$\sum t_p$	f_z	Observers
23		22:15	124.31	2	90	7.28	MKL
24		22:45	124.33	1	90	3.08	MKL
25		23:15	124.35	2	90	5.49	MKL
26		23:45	124.37	1	90	2.55	MKL
27	46.7.28	21:45	125.24	3	180	7.13	MKLTAMk
28		22:15	125.26	12	176	23.03	MKLTAMk
29		22:45	125.28	10	150	17.77	MKLTA
30		23:15	125.30	11	150	17.53	MKLTA
31		23:45	125.32	3	150	4.43	MKLTA
32	46.7.29	00:15	125.34	18	145	26.71	MKLTA
33		00:45	125.36	11	148	15.93	MKLTA
34		01:15	125.38	15	136	26.04	MKLTA
35	46.7.30	20:45	127.12	2	79	20.38	MKL
36		21:15	127.14	1	83	6.25	MKL
37		22:15	127.18	1	66	4.79	MKL
38		22:45	127.20	2	88	6.36	MKLT
39		23:15	127.22	3	125	5.79	MKLTA
40		23:45	127.24	6	120	11.42	MKLT
41	46.7.31	00:15	127.26	6	120	11.63	MKLT
42		00:45	127.28	3	120	5.81	MKLT
43		01:15	127.30	2	68	7.40	MKLT
44		21:15	128.09	4	108	20.57	MKLH
45		22:15	128.13	7	138	15.94	MKLAMk
46		22:45	128.15	8	125	16.89	MKLAMk
47		23:15	128.17	2	120	5.21	MLAH
48	46.8.2	21:15	130.01	1	142	3.72	MKLTH
49		21:45	130.03	8	150	21.13	MKLTH
50	46.8.2	22:15	130.05	2	150	4.29	MKLTH
51		22:45	130.07	2	149	3.72	MKLTH
52		23:15	130.09	4	135	7.31	MKLTH
53		23:45	130.11	1	140	1.67	MKLTH
54	46.8.4	22:15	131.09	1	65	4.39	MKLTA
55		23:15	132.00	4	150	6.25	MKLTA
56		23:45	132.02	1	150	1.47	MKLTA
57	46.8.5	00:15	132.04	2	150	2.75	MKLTA
58		01:15	132.08	10	150	14.22	MKLTA
59		22:45	132.94	1	120	2.39	MLTMk
60	46.8.7	23:15	134.88	2	120	3.39	TLAK
61		23:45	134.90	3	120	4.83	TLAK
62	46.8.8	00:15	134.92	3	120	4.73	TLAK
63		00:45	134.94	1	120	1.60	TLAK
64		22:45	135.81	2	113	4.05	TLAK
65		23:15	135.84	3	120	5.06	TLAK

Table 4. - continued

No	Date	T	l_{1950}	$\sum N_p$	$\sum t_p$	f_z	Observers
66		23:45	135.86	1	120	1.60	TLAK
67	46.8.11	01:45	137.85	1	120	1.92	TLAK
68	47.7.25	23:15	122.19	1	48	6.21	BaMV
69	47.7.26	00:15	122.23	2	120	4.33	BaMVK
70		00:45	122.25	2	120	4.33	BaMVK
71	47.7.27	23:15	124.10	3	75	10.74	BaMK
72		23:45	124.12	2	90	5.59	BaMK
73	47.7.28	00:48	124.16	6	144	10.03	BaMK
74		23:45	125.08	5	150	8.35	BaMKLV
75	47.7.29	00:15	125.10	6	150	9.61	BaMKLV
76		00:45	125.12	18	150	29.03	BaMKLV
77		01:15	125.14	7	105	16.94	BaMKLV
78	48.7.27	21:15	124.73	1	70	9.12	FLePc
79		21:45	124.75	3	120	10.82	FLePcM
80	48.7.29	21:12	126.62	5	144	20.26	FPcMT
81		21:45	126.66	6	120	21.28	FLeMT
82	48.7.30	21:45	127.62	6	119	22.42	RaMLeTPc
83	48.8.2	21:15	130.47	7	105	33.98	TLAS
84		21:45	130.49	4	80	18.88	TLS
85		22:15	130.51	1	75	4.19	TLS
86	48.8.3	00:45	130.61	1	60	3.73	SPc
87	48.8.6	21:45	134.32	1	60	7.28	SLe
88		22:15	134.34	1	60	6.01	SLe
89		22:45	134.36	3	90	9.35	SLePc
90		23:15	134.38	5	90	14.16	SLePc
91	49.7.25	22:15	122.61	2	50	13.63	ABj
92		22:45	122.63	3	60	14.41	ABj
93		23:15	122.65	3	60	12.78	ABj
94		23:45	122.67	3	60	11.85	ABj
95	49.7.26	00:15	122.69	2	50	9.21	ABj
96		00:45	122.71	1	30	8.04	Bj
97		22:15	123.57	2	60	11.11	ABj
98		23:15	123.61	2	60	8.36	ABj
99	49.7.26	23:45	123.63	1	60	3.92	ABj
100	49.7.27	00:15	123.65	4	60	15.04	ABj
101	49.8.2	22:15	130.26	2	120	5.91	ACeBaI
102		23:15	130.30	1	92	3.00	ACeBaI
103	49.8.3	22:45	131.24	1	105	2.76	ACeBaK
104	50.7.25	23:45	122.43	1	125	1.87	MLABjJ
105	50.7.26	00:15	122.45	7	145	10.89	MLABjJ

Table 4. - continued

No	Date	T	l_{1950}	$\sum N_p$	$\sum t_p$	f_z	Observers
106		00:45	122.47	1	120	1.98	MLBjJ
107	50.7.27	00:15	123.41	1	42	5.93	LBjJ
108	51.8.1	00:15	127.95	4	80	10.98	KLQT
109		01:15	127.99	1	45	4.82	KTFo
110		22:45	128.84	2	180	2.98	KTFoKaHaL
111	51.8.6	23:45	133.67	2	150	3.16	KKaLHaMc
112	52.7.27	22:15	124.75	1	60	6.27	PoStKaPa
113		22:45	124.77	3	120	7.98	PoStKaPa
114		23:15	124.79	9	132	18.90	PoStKaKPa
115		23:45	124.81	3	150	5.24	PoStKaKPa
116	52.7.28	00:15	124.83	4	150	6.77	PoStKaKPa
117		00:45	124.85	4	150	6.77	PoStKaKPa

Table 5 gives the mean zenith hourly rates $\overline{f}_z$ in one-degree intervals in dependence on the solar longitude, and the number of intervals n from which the averages were calculated. These values are shown in the histogram in Fig. 2.

l_{1950}	$\overline{f}_z$	n
121° – 2°	8.62	4
122° – 3°	9.57	18
123° – 4°	7.96	16
124° – 5°	7.78	15
125° – 6°	16.88	12
126° – 7°	20.72	2
127° – 8°	9.84	12
128° – 9°	12.32	5
129° – 130°		
130° – 1°	9.29	12
131° – 2°	3.58	2
132° – 3°	5.42	5
133° – 4°	3.16	1
134° – 5°	6.57	9
135° – 6°	3.57	3
136° – 7°		
137° – 8°	1.92	1

Table 5.

Figure 1 shows the zenith hourly rates of the Delta Aquarides for $\gamma = 1.47$, all years and solar longitude $l_{1950} = (121^o - 138^o)$. The individual years are distinguished by symbols.

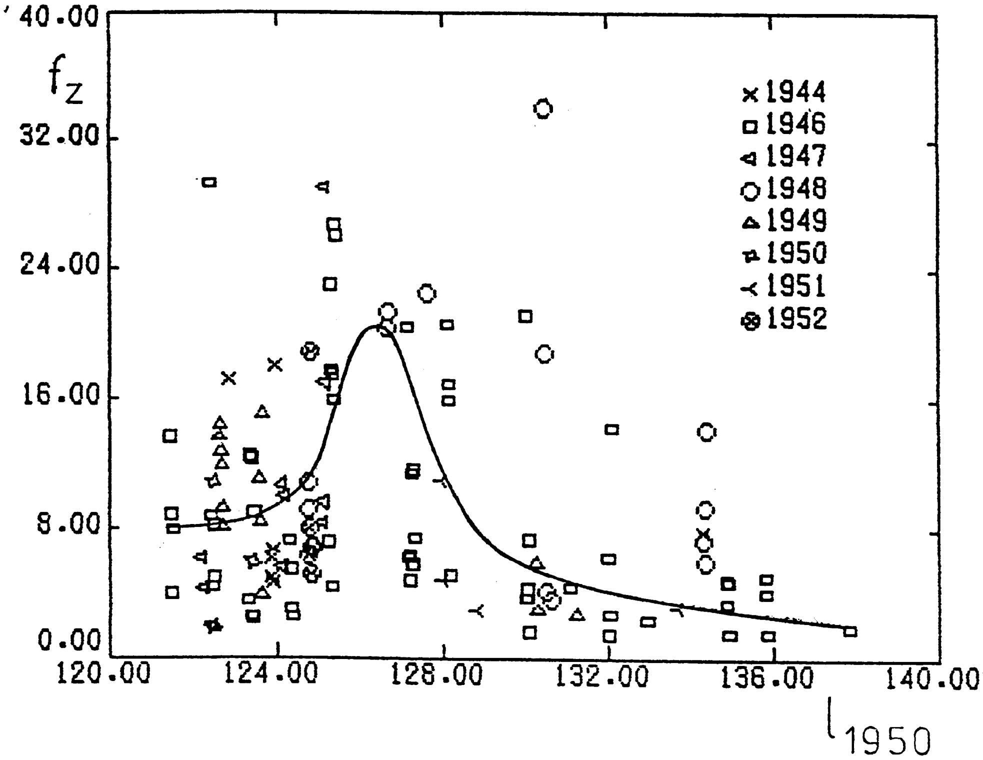

Figure 1. Zenith hourly rates of the Delta Aquarides shower for $\gamma = 1.47$ and all years in dependence on the solar longitude.

3. Conclusion

Due to the low elevation of the radiant above the horizon and lack of continual observations, it is difficult to determine the total hourly rate curve reliably from the data mentioned. There are no observations for sum solar longitudes (2) (or they had to be discarded due to the disturbing effects of the Moon or cloudiness), and for a number of solar longitudes only observations from a single year are available (6); there is only one solar longitude for which observations are available for 5 years.

As can be seen in the histogram in Fig. 2, maximum shower activity occurs at solar longitude in the interval of $126^o - 127^o$ with an average zenith hourly rate of $\overline{f}_z = 21$ meteors per hour. The maximum zenith hourly rate per one

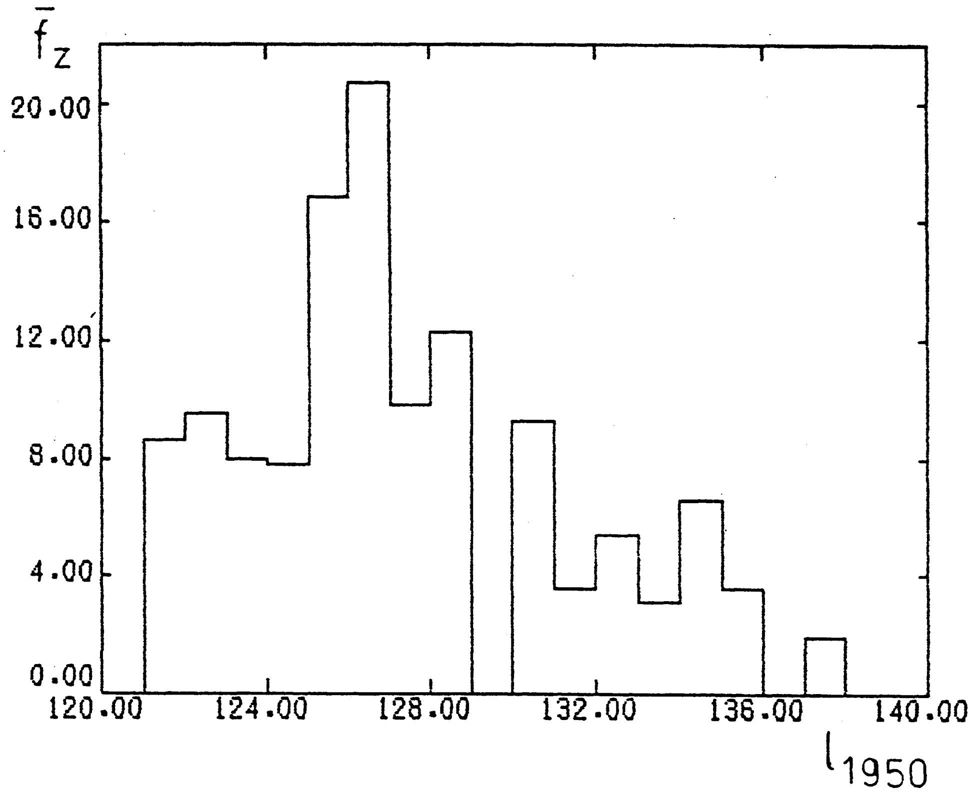

Figure 2. Mean zenith hourly rates of the Delta Aquarides shower for $\gamma = 1.47$ in dependence on the solar longitude.

observer under, undisturbed observations conditions for $\gamma = 1.47$ is 34 meteors at solar longitude 130.47° (2.8.1948).

The comparison of the results reported in this paper with the results of the authors mentioned in the Introduction indicates that the processed observations refer to the meteor shower of the southern Delta Aquarides.

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