VELA–PUPPIS METEOR SHOWER ACTIVITY

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[*Manuscript received July* 2, 1964]

Summary

It has become established from radar surveys at Christchurch, New Zealand, in 1953, 1956, and 1960 that very strong meteor shower activity occurs annually in December, with radiants in both the Vela and the Puppis constellations. The Velid group has a mean right ascension of about 134°, and the Puppid group is rather widely spread around 110°. The declination of both showers is about −45°.

I. Introduction

Radar-meteor studies have been made fairly continuously over the past decade near Christchurch, New Zealand. The main effort was directed, during the first few years, in determining southern hemisphere meteor shower occurrence, using narrow-beam aerials. Subsequent work has been concentrated on the determination of all-sky meteor rates with omnidirectional aerials and constant equipment parameters.

During 1953 confused activity was noted in the earlier part of December. This period was closely studied during 1956 and the radiant behaviour was delineated in considerable detail. Results were not published at that time as the declination of the peak activity almost exactly corresponded to the latitude of Christchurch. Activity can be falsely enhanced under such circumstances. An omnidirectional survey in 1960 again gave a picture of high December activity. In 1961 the rate dependence on latitude was clarified.

A comprehensive survey of all reports of the December activity, treated in historical order, has therefore now been undertaken. From this, a picture of quite definite, recurrent annual activity emerges with radiants in the Vela–Puppis constellations. The activity spreads beyond December. Some initial evidence of a new shower in January is also presented.

The Phoenicid shower, detected in 1956, occurs in the midst of the Velid–Puppid activity, and it is necessary to consider the coordinates and activity of this shower, from the point of view of interference with the main activity.

II. Early Visual Observations

The first observations of southern hemisphere December activity would appear to be those of Hoffmeister (1948), who published a list of meteor streams observed during the period 1908–1938. This list contains the Velids, active from December 5 to January 7, with a maximum rate on December 29. The coordinates given were $\alpha = 149°$, $\delta = -51°$.

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III. Christchurch Radar, 1953 Survey

A full account of the 1953 survey was published by Ellyett and Roth (1955). Observations were made at 69 Mc/s for 16 hr each day, with rates adjusted to be comparable with visual rates. The aerial beam had its maximum at 12° elevation, and was 14° in vertical width and 20° in horizontal width between half-power points. Results were obtained with the aerial array facing 22·5° N. of W. and 22·5° S. of W. on alternate days, so that two days were required to delineate a radiant. Daily range–time plots of the echoes were made, and radiants determined by the Clegg (1948) technique.

Table 1

HIGH RATE METEOR OBSERVATIONS (1956) AT CHRISTCHURCH, N.Z.

Observing station; latitude −43° 37′, longitude 172° 24′ E.

Date		Puppids-I				Puppids-II				Velids			
		Radiant				Radiant				Radiant			
		Daily		Mean		Daily		Mean		Daily		Mean	
		α°	δ°	α°	δ°	α°	δ°	α°	δ°	α°	δ°	α°	δ°
October	26/27	100	−47			117	−39						
	27/28	99	−43			113	−41						
	28/29	103	−41	102	−42	116	−39			128	−42		
	29/30	102	−41	grade C		115	−38			Nil			
	30/31	103	−38			111	−40	115	−38	131	−39	128	−39
November	31/1	Nil				115	−36	grade B		130	−41	grade D	
	1/2	105	−44			Nil				Nil			
	2/3	⋮				Nil				123	−42		
	3/4	⋮				117	−37			126	−39		
	4/5	⋮				Nil				⋮			
	5/6	⋮				116	−35			⋮			
	6/7	⋮				⋮				⋮			
	7/8	⋮				⋮				⋮			
	8/9	⋮				⋮				⋮			
	9/10	⋮				⋮				⋮			
	10/11	⋮				⋮				⋮			
	11/12	⋮				⋮				⋮			
	12/13	⋮				⋮				⋮			
	13/14	⋮				⋮				⋮			
	14/15	⋮				⋮				⋮			
	15/16	⋮				⋮				⋮			
	16/17	⋮				↓				⋮			
	17/18	⋮				122	−44			⋮			
	18/19	⋮				121	−44	122	−45	⋮			
	19/20	⋮				121	−49	grade D		⋮			
	20/21	⋮				122	−42			⋮			
	21/22	⋮				Tx off				⋮			
	22/23	⋮				↑				⋮			
	23/24	⋮				⋮				⋮			
	24/25	⋮				⋮				⋮			
	25/26	⋮				↓				⋮			
	26/27	⋮				Tx off				↓			

TABLE 1 (*Continued*)

Date	Puppids-I				Puppids-II				Velids			
	Radiant				Radiant				Radiant			
	Daily		Mean		Daily		Mean		Daily		Mean	
	α°	δ°	α°	δ°	α°	δ°	α°	δ°	α°	δ°	α°	δ°
November 27/28	⋮				116	−42			130	−45		
28/29	⋮				Nil				129	−47		
29/30	⋮				Tx off				Tx off			
December 30/1	⋮				112	−44			Nil			
1/2	⋮				Interf.		120	−43	Interf.			
2/3	⋮				126	−41	grade D		Interf.			
3/4	⋮				Tx off				Tx off			
4/5	⋮				123	−44			137	−43		
5/6	⋮				124	−42			134	−45		
6/7	⋮				Interf.				Interf.			
7/8	⋮				118	−45			135	−49		
8/9	⋮								130	−41		
9/10	⋮				Tx off				Tx off			
10/11	⋮				Tx off				Tx off			
11/12	↓								Nil			
12/13	101	−49							132	−54	134	−45
13/14	104	−47							133	−53	grade A	
14/15	Nil								137	−49		
15/16	Nil								Nil			
16/17	106	−46							Tx off			
17/18	106	−49	104	−46					132	−49		
18/19	103	−46	grade B						Nil			
19/20	104	−48							132	−44		
20/21	105	−48							138	−41		
21/22	Tx off								Tx off			
22/23	104	−40							140	−40		
23/24	Nil								133	−39		
24/25	107	−42							137	−47		
25/26									139	−46		
26/27									135	−43		
27/28									130	−45		
28/29									134	−43		

Radiants were grouped, and resulting showers were graded on a scale from A (certain) to D (possible). For the method of grading see Ellyett *et al.* (1961).

Forty groups or subgroups were found during the year. December shower activity, after slight subsequent correction in right ascension (Ellyett *et al.* 1961), included the Puppids:

$$\text{December } 2\text{–}10, \quad \alpha = 117^\circ, \quad \delta = -25^\circ \text{ (grade C)},$$

$$\text{December } 12\text{–}19, \quad \alpha = 113^\circ, \quad \delta = -16^\circ \text{ (grade D)}.$$

In the light of subsequent results, these declinations are low. The rates, however, were also low and it was difficult to sort out any clear-cut activity. All that can be said from the 1953 survey is that some Puppid activity was probably present.

IV. Christchurch Radar, 1956 Survey

For this survey two fixed Yagi arrays were used, spaced 45° apart about the easterly direction and having beam widths of 4·4° in azimuth between half-power points. Echoes were selected from alternate aerials on alternate pulses (Ellyett *et al.* 1961). Equipment improvements gave rates averaging 70/hr over the 16-hr daily period of observation. Rate counts in the maximum sensitivity band from 350 to 450 km were recorded for every 10-min interval. The rates were smoothed in a sliding $\frac{1}{2}$-hr group, weighted 1 : 2 : 1 for the successive 10-min intervals. This process is necessary for shower identification as the meteor rate fluctuates even within a shower grouping. The minimum duration of a significant radiant peak, using narrow-beam aerials, is in excess of 1 hr, so peaks will not be obscured by the small amount of smoothing used. Maxima in the partial-rate curves, obtained from the two differently oriented aerial arrays, were then paired to obtain radiant coordinates by the Keay (1957) method. A new method of assessing the reliability figure was devised for the partial-rate method (Ellyett *et al.* 1961), and grouped radiants on successive days were again given a shower reliability rating from A to D. The complete results for the Puppid and Velid activity are given in Table 1.

The daily radiant values fell into three groups, two in the constellation Puppis and one in Vela. As would be expected, the time of peak rate drifted steadily with date. The peak for the Puppid-I stream was at $06^{h}\,10^{m}$ L.T. on October 27, but was $03^{h}\,00^{m}$ on December 13, and $02^{h}\,40^{m}$ on December 25. Puppid-II drifted from $07^{h}\,10^{m}$ on October 27 to $05^{h}\,00^{m}$ on December 8; and the Velid peak changed from $07^{h}\,50^{m}$ on October 29 to $04^{h}\,10^{m}$ on December 29.

Typical results are given in Figure 1, which shows marked Velid activity, and Figure 2, which shows both weak Puppid-II activity and very strong Velid activity. (It was commonly observed that the south of east aerial recorded higher rates than the north of east one. This was possibly due to the fact that the north of east aerial faced towards the city of Christchurch and hence acquired a higher noise background.)

The activity found in late October and the beginning of November has not been recorded by other workers. The Puppid-II activity, being grade B, is fairly definite, but the rest of the activity during this time is weak. The November gap is large, and although the coordinates agree with later activity, this earlier activity must, in the meantime, be regarded as separate.

Weak Puppid-II activity begins on November 18 and dies out by December 8. New and stronger grade B activity begins as Puppid-I on December 13 and continues through to December 25.

The nature of the rate curves makes it possible in some cases to pair incorrect peaks. This possibility is always present when the wanted peaks are comparable in size with what appear to be random fluctuations, but such errors lead to scattered radiant values. A continuing series of nearly identical radiant values on successive nights, as is found for Puppid-I, largely removes the chance factor. Furthermore, the presence of very strong peaks enhances the significance of weak peaks of similar radiant value on nearby nights. The grading figure takes this into account.

Velid activity commenced on November 27 and continued through to December 29. This was a grade A shower.

V. Adelaide Radar, 1956–58

A similar survey for shower detection was carried out by Weiss (1960) over the periods December 1956 to December 1957 and April to August 1958. Narrow-beam arrays were used and the equipment operated at 67 Mc/s. Intermittent activity was found over the period December 1–9, with maximum activity on December 6. The radiant was ill-defined, so the Velids and Puppids could not be resolved. A tentative radiant of $\alpha = 140°$, $\delta = -50°$ was given. (This differs appreciably from Weiss's (1957) earlier figure of $\alpha = 124°$, $\delta = -36°$, given from wind equipment data.)

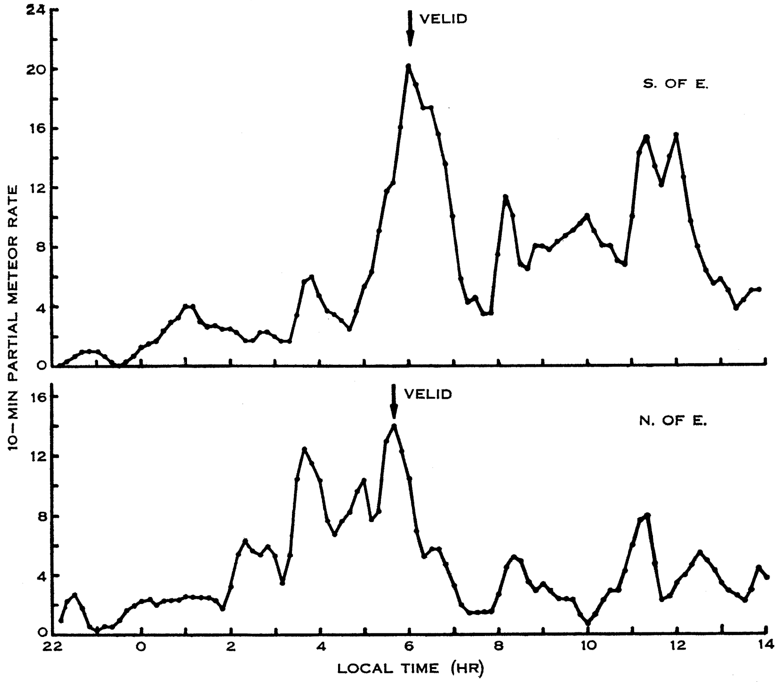

Fig. 1.—Velid meteor shower activity observed at 10-min intervals on the night of November 28/29, 1956, using narrow beam aerials and a count rate in the 350–450 km range band.

VI. Latitude Dependence of Meteor Showers

Radiants of all the November and December Puppid and Velid activity measured at Christchurch in 1956 lay between $-43°$ and $-46°$. The latitude of the Christchurch field site is $-43° 37'$. Meteor shower rates obtained with the narrow-beam aerials are strongly dependent on the geographical location of the observing station; the observed rate being enhanced for showers which transit close to the zenith. Thus there was a strong possibility that the observed rates for these particular showers were giving too high an indication of the true flux of meteors incident on the Earth.

To overcome this difficulty, recognition factors were obtained by Keay and Ellyett in 1961, and were applied to the Christchurch and Adelaide radar surveys. In both cases the results indicated that the Puppid and Velid shower rates, while not as great absolutely as some occurring at other times of the year, were real and significant.

VII. Visual Observations

New Zealand visual observations have been coordinated by McIntosh, who advises (personal communication) that over a number of years, including 1956, the Puppid activity has been recognized over the period November 28 to December 12, with coordinates $\alpha = 114°$, $\delta = -46°$. These figures closely fit the mean of the Puppids I and II observed by the Christchurch radar in 1956.

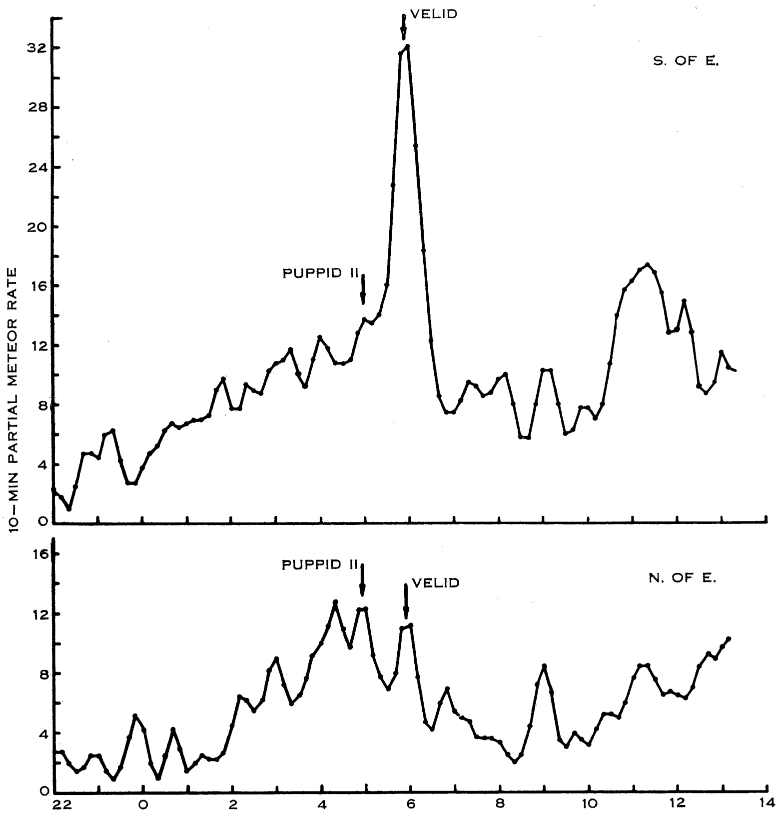

Fig. 2.—Strong Velid and weak Puppid meteor shower activity observed at 10-min intervals on the night of December 4/5, 1956, using narrow beam aerials and a count rate in the 350–450 km range band.

VIII. Christchurch radar, 1960–61 Omnidirectional Rate Survey

Full details of the constant-parameter high gain apparatus used for this survey, with complete hourly tabulations covering every hour of the day for 12 consecutive months, have been published by Ellyett and Keay (1963). The two main active groups were in late July and from mid November till near the end of January. Over a period of several weeks from mid November, the activity lead up to a peak and took a comparable time to die away. This is in agreement with the present Table 1, where activity spreads over many weeks.

From the omnidirectional survey, days have now been extracted where the rate exceeded 2640 meteors for the day. The results are given in Table 2.

Clearly December has high activity. The highest rate per day for the whole year was recorded on December 6. This agrees with the high Velid peak shown in Figure 2 for December 5, 1956, and with Weiss's maximum activity for Adelaide on December 6, 1960.

Omnidirectional results do not lend themselves to the calculation of radiants, but the presence of radiants can be shown by plotting the average hourly meteor rates, commencing on each hour L.T., for $\frac{1}{3}$-month intervals, as in Figures 3(*a*) and 3(*b*). The δ-Aquarid shower, for example, which is the greatest single shower impinging on the Earth (Keay and Ellyett 1961), shows up clearly in the third part of July between 21^{h} and 05^{h} L.T. The December activity is present at all hours of the day. Except for the 13^{h} and 14^{h} intervals, when it appears to be more prominent in mid December, it peaks in the first third of December and is almost certainly the Vela–Puppis complex, which is above the horizon for the whole day at the latitude of Christchurch.

Sections III–VIII therefore, when combined, indicate that the Vela–Puppis shower complex is one of the major recurrent meteor events in the southern hemisphere.

Table 2

Days per month with meteor count exceeding 2640

	1960											1961
Month	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.
Number of Days	2	4	1	0	0	0	0	0	0	1	16	12

IX. Adelaide Radar, 1960–61

Nilsson (1964) has recently reported in detail further Adelaide observations of the individual orbits of 2200 meteors measured in 1960–61. During the period December 8–11, 1960, four similar orbit meteors were detected with a mean radiant 138°, −53°; and in the period December 7–10, 1961, three further meteors were found with a mean radiant of 143°, −54°. These are called the Puppid stream, but are strictly Velids, and agree quite well with the 1956 Christchurch Velid coordinates listed in Table 1.

It is interesting to note that the seven orbits observed at Adelaide enabled the shower to be identified as a special one of low eccentricity and a very high inclination of 70°.

X. January Activity

The January period is always difficult to observe visually in the southern hemisphere, owing to the limited hours of darkness. Consequently no visual showers have been reported for this month. Figures 3(*a*) and 3(*b*), however, show a small January peak for every hour except possibly 21^{h} L.T., which would indicate a declination well into the southern hemisphere. The peak is in mid January for all hours except 03^{h}–05^{h}, when it is in the first third of the month. This may indicate a new meteor shower.

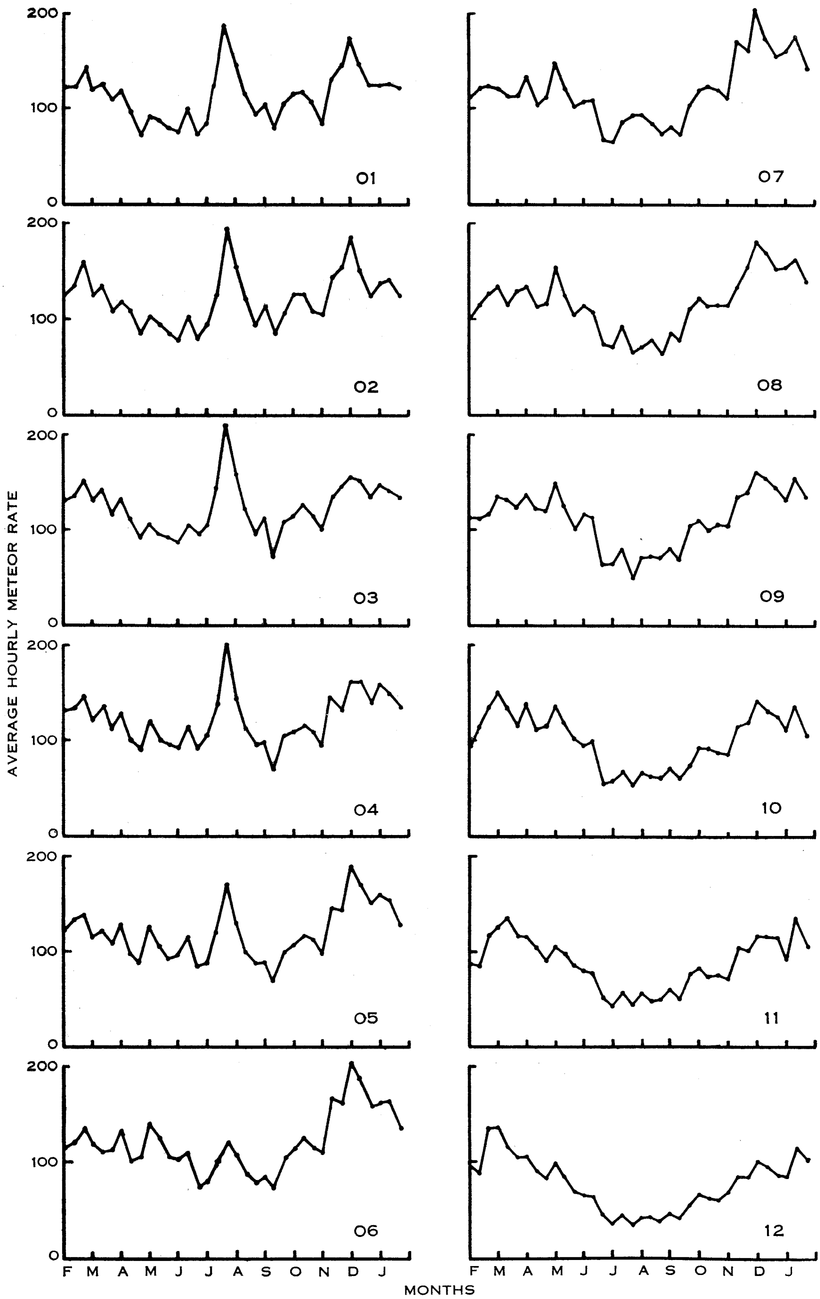

Fig. 3(*a*).—Average hourly meteor rates, commencing on each hour L.T., plotted at $\frac{1}{3}$-month intervals from February 1960 to January 1961, from 01^h to 12^h L.T.

XI. Phoenicid Shower, 1956

This shower occurred on the night of December 5/6, 1956. The question immediately arises as to whether the Phoenicids could have been confused with the Vela-Puppids on this night. Results of the Phoenicid activity have been coordinated by

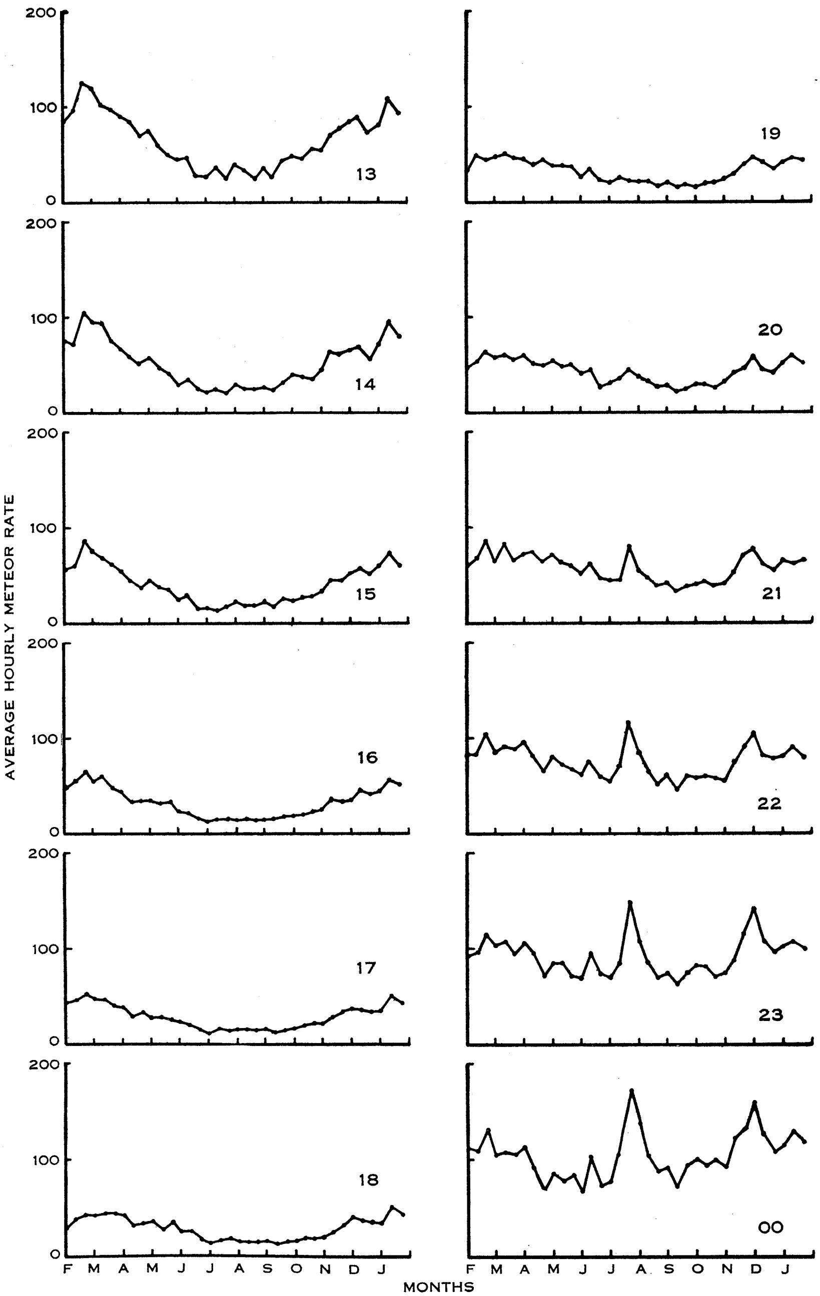

Fig. 3(*b*).—Average hourly meteor rates, commencing on each hour L.T., plotted at $\frac{1}{3}$-month intervals from February 1960 to January 1961, from 13^h to 00^h L.T.

Ridley (1962). The shower was first observed visually in New Zealand for 10 min only, then in Australia, and finally in South Africa, as the sunset progressed. Its coordinates were evaluated as $\alpha = 15°$, $\delta = -45°$. With these coordinates it would have gone through transit in the two Christchurch narrow-beam aerials at

$21^h\,41^m$ and $21^h\,53^m$ L.T. The radar was not switched on until 22^h. No appreciable activity was noticed in the next two hours, so clearly it did not interfere with the Puppids or Velids, which went through transit some hours later. One of the two Adelaide radar aerials was operational at the time, and the relatively low rate of 30/hr was recorded. The shower has not been seen again since 1956.

XII. Acknowledgments

The authors wish to thank Mr. C. S. L. Keay for his helpful comments.

This work has been completed under Grant No. NSF-G24444 from the National Science Foundation, U.S.A. Assistance with apparatus was obtained from the New Zealand Universities Research Grants Committee.

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