Comet Bennett 1969i

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A report of the Comet Section (Director: Jonathan D. Shanklin)

Introduction

On 1969 December 28, our member Jack C. Bennett in Pretoria, South Africa, discovered a small, diffuse comet of 8.5 magnitude. The discovery was made during a regular programme of sweeping for new comets he had been carrying out over several years. The comet was in Tucana, declination 65° south. Precise positions were soon obtained at the Perth Observatory, Western Australia, by Harris, Candy and Gans. The orbit computed by M. P. Candy, a former Director of the Comet Section, showed the comet to have a perihelion distance of about 0.5AU and an inclination close to 90°. Our Comet Section Director and *Circulars* Editor S. W. Milbourn noted in *BAAC* 515 that comet Bennett was 'likely to become a bright naked-eye object as it moves quickly north at the end of March.' We were not to be disappointed. A list of members who contributed observations on which this report is based is shown in Table 2. In the new-style designation the comet becomes C/1969 Y1 (Bennett).

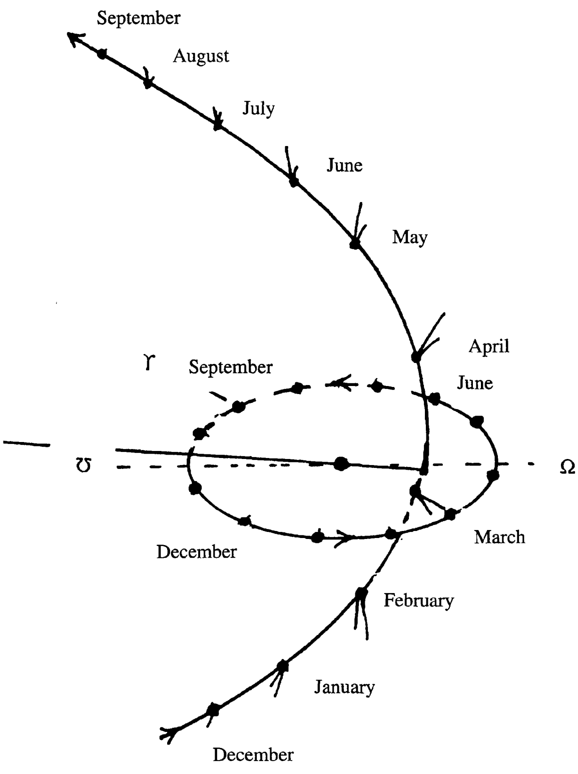


Figure 1. The orbit of comet Bennett, showing continuous visibility from discovery until the last observations. Positions are of the Earth and comet for the 20th of each month. See Table 1 for elements and ephemeris.

Circumstances of the apparition

Figure 1 shows the orbit diagram for comet Bennett. The comet's orbital plane was perpendicular to the Earth's and at perihelion, when it was moving most quickly, it was only 5° south of the ecliptic. After a period following discovery well south of the Sun, it passed quickly through minimum elongation of 32° at perihelion to move rapidly north. It was therefore under continuous observation from discovery at high southern declination in 1969 December until the last Section observations near the north celestial pole in 1970 September. The elements of the orbit and ephemeris are shown in Table 1.

In 1970 February the comet was near the borders of Tucana, Grus and Phoenix. In Grus by early March, comet Bennett moved north to perihelion on the 20th (0.54AU or 80 million km from the Sun), crossing the equator on March 25 when it was near its closest to the Earth (0.69AU or 103 million km). The comet moved centrally through the Square of Pegasus during the last days of March and early April, through Lacerta, Andromeda and into Cassiopeia by early May. In Camelopardalis in August, comet Bennett reached greatest northern declination of 83° in late September in Cepheus where members last observed it.

Highlights of the apparition

Comet Bennett has been described as a great comet.[1] It was certainly one of the most visible of recent times,[2,3] the

Table 1. Elements and ephemeris

Epoch 1970 April 4.0

T	1970 March 20.0446 TDT	ω	354°.1460	
q	0.537606 AU	Ω	224.6574	2000.0
e	0°.996193	i	90.0394	

0h UT	*RA (2000.0)* *h m*	*Dec* ° ′	*Δ* *AU*	*r* *AU*	*Elong.* °	*Mag.*
1969						
Dec 30	01 00.3	−65 25	1.696	1.667	71	8.4
1970						
Jan 24	23 44.5	−60 05	1.569	1.269	54	7.0
Feb 18	22 58.3	−52 14	1.284	0.858	42	4.9
Mar 15	22 10.2	−28 10	0.806	0.550	34	1.9
Apr 9	22 51.5	37 58	0.850	0.704	44	3.1
May 4	00 49.4	61 26	1.437	1.102	50	6.2
May 29	02 31.1	67 38	1.960	1.508	50	8.2
Jun 23	03 44.5	70 49	2.348	1.892	52	9.6
Jul 18	04 34.3	73 55	2.603	2.254	59	10.6
Aug 12	04 55.7	77 48	2.750	2.597	71	11.3
Sep 6	04 06.5	82 10	2.828	2.923	85	11.9

Predicted magnitudes from m = 5.0 + 5 logΔ + 10.0 log r. (Elements from *Catalogue of Cometary Orbits*, 1992 edition; magnitude formula from BAA *Circular* 519, 1970 Mar. 3).

Figure 2. Comet Bennett rising over R. L. Waterfield's observatory on 1970 April 7.06, based on a sketch made while waiting to begin photography. The plasma tail was not prominent visually at this time. *M. J. Hendrie.*

brightest comets often being very close to the Sun in the sky and visible for only a few days. It reached 0 magnitude or brighter and showed a complex and changing tail at least 20° long. Figure 2 shows one impression of how it looked to the unaided eye from a dark site during early April.

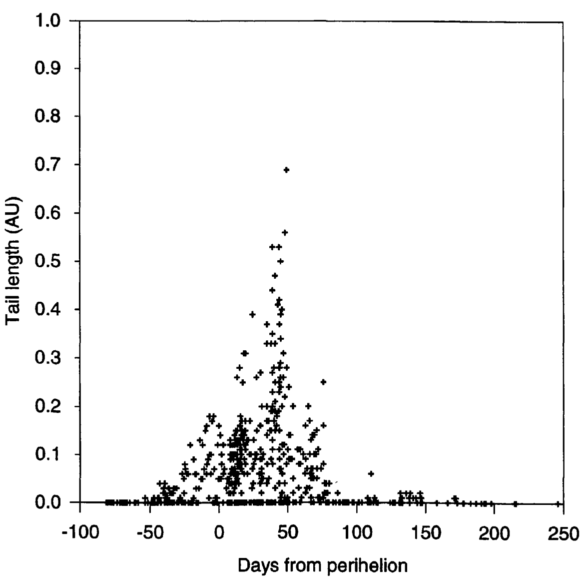


Figure 3. The main tail lengths of comet Bennett in astronomical units. The observed tail lengths are corrected for perspective, assuming the tail was straight.

Significant tail development began around 50 days before perihelion (about 1970 Feb 1) and climaxed about 50 days after perihelion (about May 10). When tail lengths are corrected for the effects of perspective (assuming the tail to be straight), the maximum extent was around 0.6AU (90 million km) when the comet was 1.2AU from the Sun. The tail then rapidly declined and little of significance was seen beyond 80 days after perihelion (mid-June). The linear tail length plotted against the number of days from perihelion is shown in Figure 3.

Comet Bennett was probably the first comet to have the motion of the spiral pattern of jets near the nucleus clearly photographed. It was only the second comet (after C/1969 T1 Tago–Sato–Kosaka 1969g) to be observed by spacecraft. Detection in the ultraviolet of Lyman-alpha radiation at 121.6nm in early April by the NASA OGO-5 revealed a cloud of hydrogen about 13 million km across surrounding the comet's nucleus.

Visual photometry

Magnitude observations taken from the ICQ archives have been used by Jonathan Shanklin to analyse the light curve. Figure 4 shows the plot of 609 individual observations (445

Table 2. List of observers

Observer	*Location*	*Instrument*	*No. of obs.*
Alcock G. E. D.	Peterborough	B	7
Allen W. H.	Wellington, NZ	B	15
Barlow A.	Old Windsor, Bucks	40A	–
Bell M.	Langholm, Scotland	B	1
Bennett J. C.	Pretoria, S.Africa	120R, 250L	14
Bortle J. E.	Stamford, NY, USA	B, 560M	32
Brierley D. M.	Wilmslow & Malvern	B	31
Browning R. P.	Birmingham	B, 100L	3
Buhagier M.	Attadale, W.Australia	B	7
Burch S. F.	Leeds	B, 150L	7
Caunter W. B.	Billingshurst, Kent	43R	3
Clark M.	Bayswater, W.Aust.	B	17
Coates J.	Burnley	75R	1
Collinson E. H.	Ipswich	73A	4
Currie H. J.	Kilmarnock	B	3
Curtis A. C.	Winchester	B	2
Dinwoodie C.	Langholm, Scotland	B	4
Doherty P. B.	Stoke-on-Trent	75R	15
Edelman H. J.	Adelaide, S. Aust.	B	7
Frydman D.	Helsinki	B	1
Gainsford M. J.	Nuneaton	216L	23
Gardiner T.	Belfast	30A?	–
Ginman A.	Sidcup	B	13
Harvey A.	Burnley	200L	1
Hendrie M. J.	Wormingford, Essex	B, 150L	
	Woolston, Somerset	B, 150R, 150A	16
Highley M. G.	Wellington, NZ	B	2
Isles J. E.	London	60R	3
Jones A. F. A. L.	Nelson, NZ	B, 320L	26
Jones M. V.	Maryborough, Aust.	200L	19
Judge E.	Kilkmagh, Ireland	B	1
Kenny F. S.	Mobberley, Cheshire	B	1
Le Moeur A. G.	Jersey, C. I.	B, 160L, 216L	29
Madej P. J.	Huddersfield	50R	2
Matchett V. L.	Brisbane	150L	13
Middleton P.	Rainhill, Lancs	B	1
Milbourn S. W.	Malta	B	4
	Thames Ditton, Surrey		
Morgan H.	Woolston	150R, 150A	1
McMillan S. C.	Brisbane	150L	9
Napper J. W.	Didcot	150L, B	1
Nelson J.	Toronto	B	9
Nightingale H. C.	Mzuzu, Malawi	B	6
Nilsson C.	Gothenburg, Sweden	B	5
Northwood D. J.	Staines, London	B	4
Ollis G. E.	Eston, Tees-side	150L	1
Page A. & B.	Chermside, E. Aust.	B	2
Panther R. W.	Northampton	B	42
Parkin G.	Crook, Durham	B	1
Paul A. R.	Tandragee, N. Ireland	220L	2
Pinnion D.	Southend-on-Sea	B	8
Reeves C.	Lobatse, Botswana	B	8
Simmons K.	Jacksonville, Florida	B	11
Slade H.	Pt Stanley, Falkland Is.	B	6
Smith B.	London	B	3
South R.	Woolston	150R, 150A	2
Sturdy K. M.	Helmsley, Yorks	150L	15
Thompson G.	Brisbane	100L	8
Vince A. W.	Amersham, Bucks	B	2
Warwick R.	Langholm, Scotland	B	1
Waterfield R. L.	Woolston, Somerset	150R, 150A	5
Watkins E.	Braintree, Essex	B	1
Why T.	Portslade, Sussex	70R	7
Young P. J.	Leeds	B, 150L	8
		Total	496

Principal instruments used (apertures in mm): R= refractor, L=reflector, M=Maksutov, B=binoculars only, E=naked eye only, A=astrograph or camera. Many observers also used binoculars and the naked eye for the brighter phases. The no. of observations totals the visual report forms received from each observer, one form for each date. Observations with two or more instruments may have been included on a single form. Photographic observations were usually reported separately and are not included.

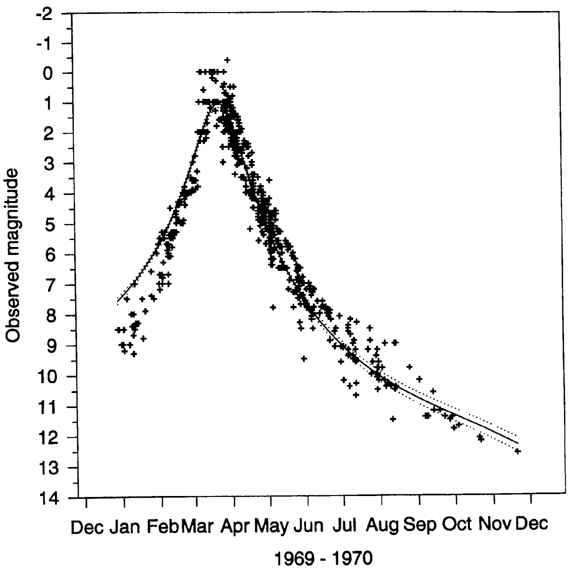


Figure 4. The observed magnitude of comet Bennett. The curve is the best fit over the apparition, with no corrections applied. Tick marks indicate the first of each month from 1969 December.

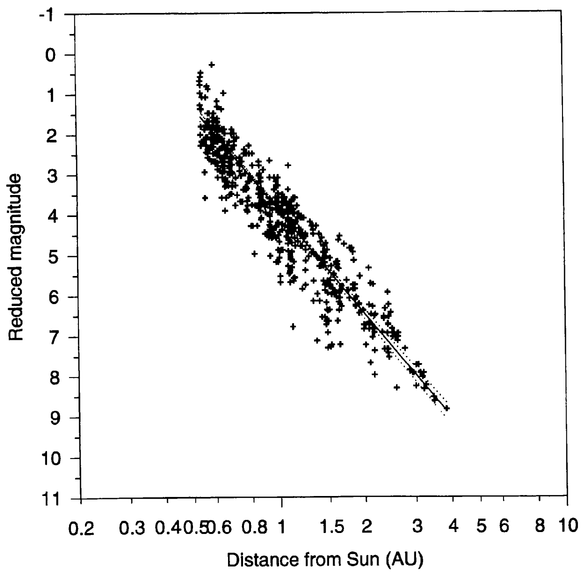


Figure 5. The magnitude of the comet corrected for systematic differences between observers, telescope aperture and varying distance from the Earth, plotted against distance from the Sun.

by BAA observers) and the least-squares fit of the data (solid line) which has the equation of m = (4.30±0.03) + 5 logΔ + (9.31±0.14) log r. Correcting the brightness estimates to a standard comet–Earth distance of 1AU removes the effect on the perceived brightness of the comet's varying distance from the Earth. This reduced magnitude curve is shown in Figure 5 which also includes the correction for aperture and the observer; for this comet the aperture correction is 0.040 ± 0.005. This full analysis gives the overall formula of m = (4.06±0.04) +5 logΔ + (8.30±0.19) log r, or m = (4.72±0.10) +5 logΔ + (12.31±0.43) log r for the pre-perihelion branch and m = (3.96±0.04) + 5 logΔ + (8.28±0.17) log r for post-perihelion. A detailed explana-

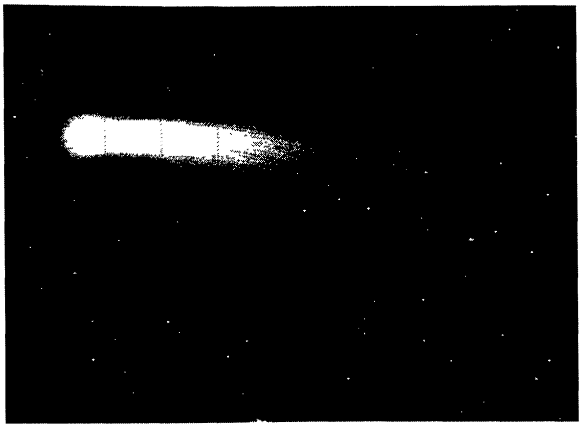


Figure 6. 1970 March 17.76, Hopelands Observatory, 200mm f/2.9 astrograph, observer unknown.

tion of the methods used in processing magnitude observations has been given by Shanklin.[4]

The comet brightened steadily from its discovery magnitude of 8.5^m to around 1^m at perihelion and faded quickly at first, but then faded more slowly and was finally seen at around 12^m. The light curve clearly shows that the comet was relatively fainter before perihelion than after, suggesting that the amount of active surface on the nucleus increased after perihelion. Although several observations are brighter than 1st magnitude near the time of perihelion there is no evidence for an outburst at this time and these observations reflect the difficulty of making magnitude estimates of a bright object in twilight when there are few comparison stars. Although the absolute magnitudes of the comet (i.e. the magnitudes the comet would have if it were 1AU from both the Earth and Sun) derived for the pre- and post-perihelion phases are significantly different, the resulting difference between the two light curves is not significant around the time of perihelion.

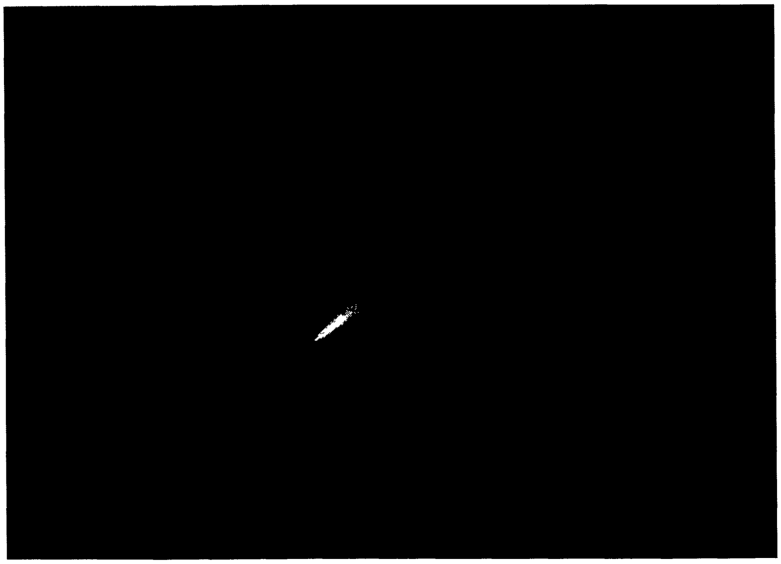


Figure 7. 1970 March 30.18. G. Parkin, Crook, Durham.

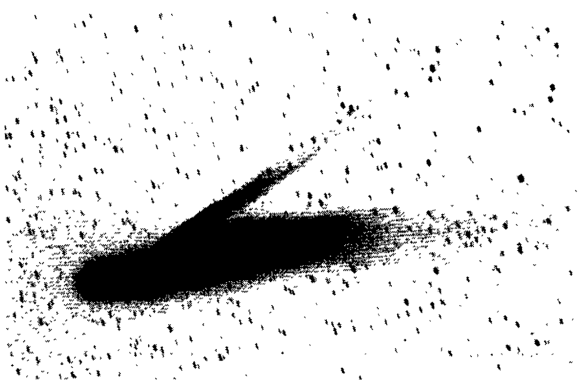
Figure 8. 1970 April 4.2. H. R. Soper, Archallagan Observatory, Isle of Man.

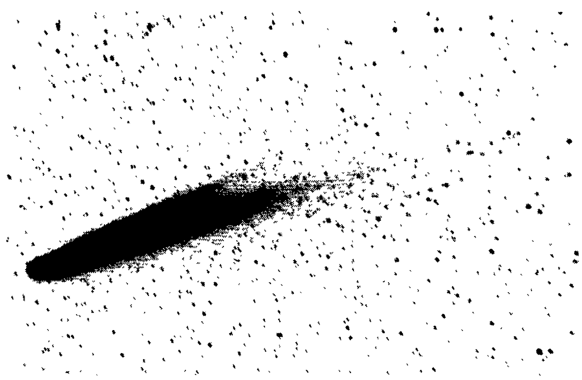
Descriptive notes on comet Bennett

1969 December–1970 February

On the night following his discovery, Dec. 29.8, Bennett described the comet as seen in 10×60 binoculars as 8.5^m with a circular coma 2′ across and degree of condensation (DC) 3, that is a diffuse coma with brighter centre. V. L. Matchett at Brisbane was next to see it on Dec. 31.5, describing it as diffuse, about 9^m. On 1970 Jan. 2.5 A. F. Jones in New Zealand noted a small almost stellar nucleus of 12.9^m in a moderately condensed coma but saw no tail. The nucleus had brightened to 11.8^m by 1970 January 14. On Jan 17 Bennett reported the coma noticeably larger and was the first to note a short tail, in p.a. 100° using his 120mm refractor ×20: this was also reported by A. F. Jones on Jan 20. The comet had brightened to about 7.0^m by the end of January (A. F. Jones, M. Clark, Bennett and W. H. Allen).

During February several observers noted the tail up to 1 degree in length in p.a. 115° to 125° and by Feb 9 comet Bennett was just visible to the naked eye at 5.3^m (A. F. Jones, G. Thompson). The comet was now moderately condensed DC 5 with a 5′ coma, the tail moving round towards p.a.150°. By Feb 25 Allen observed in twilight with a 150mm reflector making it 4.0^m, DC 6 with a 2.5° long fanned tail. By the 28th A. F. Jones gave 3.6^m with a 6.2^m nucleus with the head parabolic, sweeping into a 2° tail in p.a. 170–175°, his observations being in twilight.



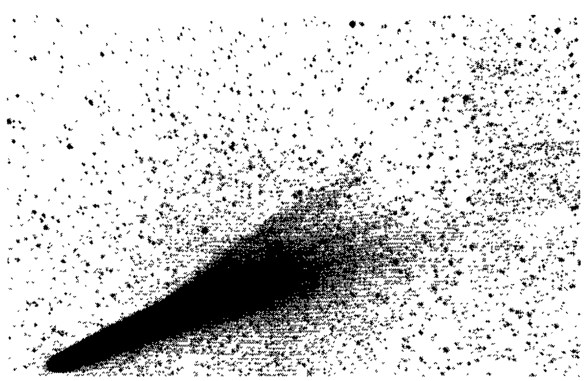


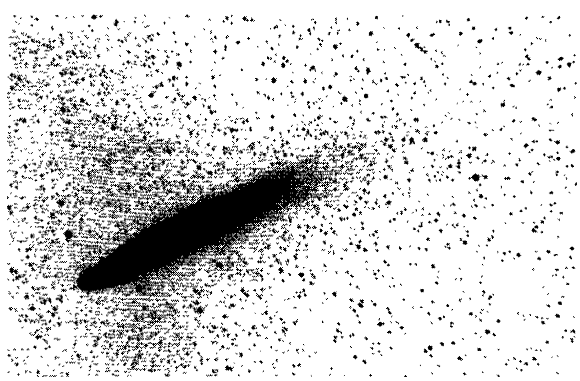
1970 March

On March 1 Allen described the tail as broad and 3° to 4° long in 7×50 binoculars, and on March 6 Clark was reporting 7 degrees of tail with the naked eye and by the 13th 12° with the comet 1.7 magnitude. The first observation by a member in the British Isles was on March 26.2: R. W. Panther described the comet seen low in the dawn sky with the Moon above the horizon as strongly condensed, coma 4′ across DC 7 and a 4° tail in p.a. 260°. Several observers saw it the next morning giving a similar description and magnitudes ranging from 1.0 to 2.3 (M. J. Gainsford, P. J. Young, D. M. Brierley, S. F. Burch, A. C. Curtis and Panther). That the head of the comet was by then at least 1.0^m and probably brighter is supported by the observation of M. J. Hendrie on the morning of March 28 using a 150mm reflector. The false nucleus was followed into the daylight sky until 2 minutes before local sunrise at 05.42 UT.[5] The presence of the Moon and twilight no doubt restricted the length of tail seen by northern observers during these first few days for by March 30–31 Young, G. Parkin, A. Ginman and Milbourn were recording 8 degrees of tail towards p.a. 280°, A. G. Le Moeur (10°) and Panther (11°) all with the naked eye and as much as 18° by G. E. D. Alcock (type 2 dust tail) and 9° (type 1 ion or plasma tail). Parkin's photograph on March 30 records the naked eye appearance very well (Figure 7). The position angle of the tail was such that although taken with a stationary camera, all the trailing during the exposure was along the axis of the tail.

April

By April 1 and 2 visual magnitude estimates ranged between 1.3^m and 2.3^m with tail lengths depending much on observing conditions: H. C. Nightingale (10°), Le Moeur (12°) and Hendrie (17°). The false nucleus was described by Nightingale as 10′ across and planetary in appearance (a small disc rather than starlike). The main tail left the head in p.a. 275°–290°. Many observers described the central condensation, some 2′ across, as yellowish in colour. On April 4 tail lengths reported were Hendrie (17°), and





Figures 9–13. Photographs taken on Kodak 103a-0 blue-sensitive plates with the 150mm aperture f/4.5 Cooke triplet at Waterfield's Woolston Observatory near Wincanton in Somerset. The prints are from positives made from these plates by Hendrie to show maximum tail detail. Dates, observer and exposure times were:

Figure 9. 1970 April 2.2. R. L. Waterfield, 21 minutes.
Figure 10. 1970 April 4.2. M. J. Hendrie, 40 minutes.
Figure 11. 1970 April 7.2. M. J. Hendrie, 25 minutes.
Figure 12. 1970 April 9.15. R. L. Waterfield, 18 minutes.
Figure 13. 1970 April 11.2. H. Morgan, 22 minutes.

Figure 14. 1970 April 4.2. From the same plate as Figure 10 but printed to show maximum extent of tail.

J. E. Bortle (15°) in p.a. 285°–290° and on the 6th Bortle (17° and 12°) for the two tails. On the morning of April 7 in an excellent dark sky at Woolston, Somerset, R. L. Waterfield and Hendrie noted the main tail extending 19° eastwards to merge with the Milky Way near τ and ν Cygni. Other observers recorded comparable tail lengths, for example Alcock (15°). On April 8 Bortle recorded 19° for the main tail and Alcock 14°; on April 9 K. Simmons in Florida (24°) with Bortle again on April 13 reporting 19° in p.a. 300°–305°.

By April 16 the comet was 2.5^m to 3.0^m and Bortle was recording 12° of tail, on the 17th Alcock (12°), on the 19th Bortle (11°) and by April 23–24 despite moonlight, P. B. Doherty (11°), C. Dinwoodie (12°) and Alcock (12°). Long tail lengths were reported to the end of April, on the 27th by Doherty (13°) and on the 29th Doherty (12°) and Curtis (12°).

Photographically the comet was at its most interesting during the first half of April and with new Moon on the 6th, long exposures could be made after midnight as it rose into the eastern sky. By April 10 it was circumpolar. The weather was not always helpful but there were some very good nights at Woolston in Somerset where Waterfield operated his twin 150mm refractor and astrograph. It was a very dark site with an unobstructed view towards the field of the comet. I was fortunate to be there to assist for four nights, two of which were clear. Good plates were secured at Woolston on April 1, 2, 4, 7, 9 and 11 (Figures 9–13).

Dr Waterfield's notes, prepared for a report to the Royal Astronomical Society's April meeting, described the main features shown on these plates. 'Plates on the 1st and 2nd show in addition to the main curved tail numerous fine long streamers of lesser curvature and one, essentially straight, along the radius vector. The April 2 exposure shows 8.5 degrees of tail. That of the 4th shows a remarkable outburst, a very strong secondary tail jutting out from the main tail about a degree from the head, with very irregular shape and wavy structure.It was unfortunate that the next two nights were cloudy. (For plates taken on the 1st, 2nd and 4th guiding was on the nucleus because of passing clouds: this limited the maximum recordable tail length to about 8.5 degrees).

'On April 7th, and by guiding on a star 5 degrees preceding the head, 13.5 degrees of tail were recorded. All the distortions and irregularities have gone.' However, on plates exposed on April 9 the secondary (ion or plasma) tail again showed a sharp change in position angle at a distance from the head but this was either very faint or absent by April 11. The distortion and detachment shown on the April 4 photograph and probably that of the 9th also would now be classed as disconnection events, due to encounters between the comet and sector boundaries in the solar wind magnetic field where polarity reverses.

Dr Soper secured a fine photograph of the main and plasma tails on April 4, taken about the same time as that by Hendrie at Woolston (Figure 8). By the end of April Comet Bennett's tail was essentially straight and narrow as is well shown in Soper's photograph of April 28 (Figure 15).

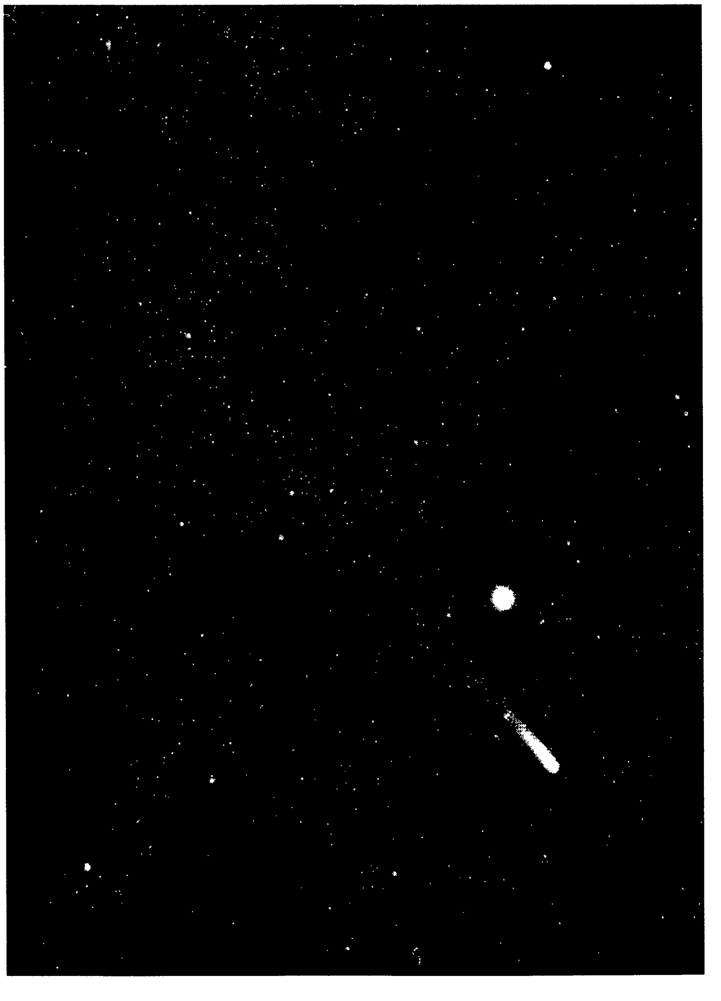


Figure 15. 1970 April 28.1. H. R. Soper, Isle of Man.

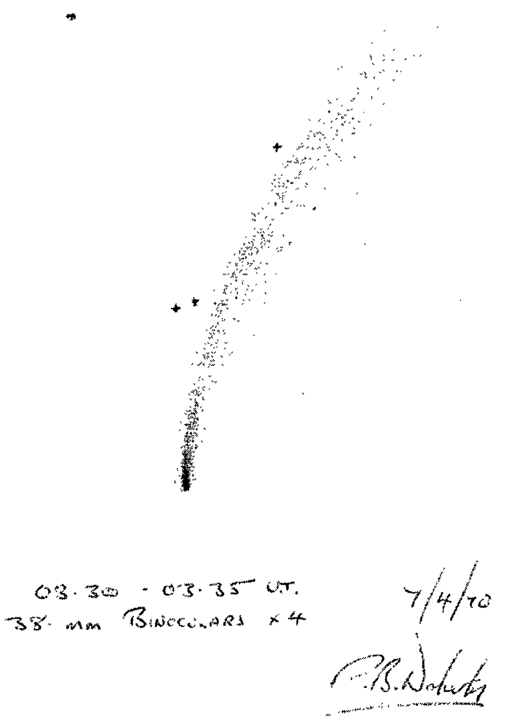


Figure 16. 1970 April 7.15. P. B. Doherty, 4×38 binoculars, Stoke-on-Trent.

May–September

In May Doherty again reported a tail length of 12° on the 2nd but more typical values over May 3–5 were Panther (9°) in p.a. 320° and Hendrie (7°), but Bortle was again recording lengths of 11°–12° on May 7 and 8.

Thereafter reported tail lengths were much reduced to about a degree by mid-May when the comet was 6.5^m and less than a degree by late May, when it had fallen to about 8.0^m. A short tail 30′ long in p.a. 350° was recorded by Bortle on July 8 and a suspected tail on the 29th. The last observation of the comet by a member was by Bortle on September 13 when he estimated the comet to be 10.6 magnitude.

Comparison with some other bright comets

Since I started to look at the comet Bennett observations again with a view to this publication, we have been treated to two more bright comets, each comparable with comet Bennett, though in different ways. Comet C/1996 B2 (Hyakutake) passed very close to the Earth (15 million km) and was so impressive partly for this reason.[6] Comet C/1995 O1 (Hale–Bopp) on the other hand owed its long period of visibility at least partly to the fact that it did not pass close to the Earth (197 million km minimum distance).[7] Comet Bennett's orbit gave it a least distance from the Earth of 103 million km, about half way between the two.

I have often been asked how comets Arend–Roland, Bennett, West, Hyakutake and Hale–Bopp compare. Figures and photographs do not convey all of one's impressions of the event and many years separate these apparitions, making it hard to be objective. Arend–Roland was the first bright comet I saw; indeed there had been no easily visible northern comet of comparable brightness since 1910. Urban skies were still remarkably dark in 1957 and the comet seemed to stand out from the stars, hanging vertically above the northern horizon in the spring sky. I am not really in a position to judge comets West and Hyakutake as I did not see comet West at a good altitude in a clear dark sky and Hyakutake was closest during a long spell of cloudy weather in East Anglia. By the time the weather improved there was bright moonlight but the comet was still a conspicuous object, though lacking a bright dust tail at that time, so it did not compare then with comets Arend–Roland and Bennett as I saw them.

My recollection of comet Bennett is of the first few days of 1970 April. The comet displayed a long, gently curving dust tail merging with the Milky Way in a pre-dawn sky, not unlike comet Donati of 1858 in appearance. I think it must rank as the most beautiful comet I have seen.

Figure 17. 1970 April 17.15. G. E. D.Alcock, Farcet, Peterborough.

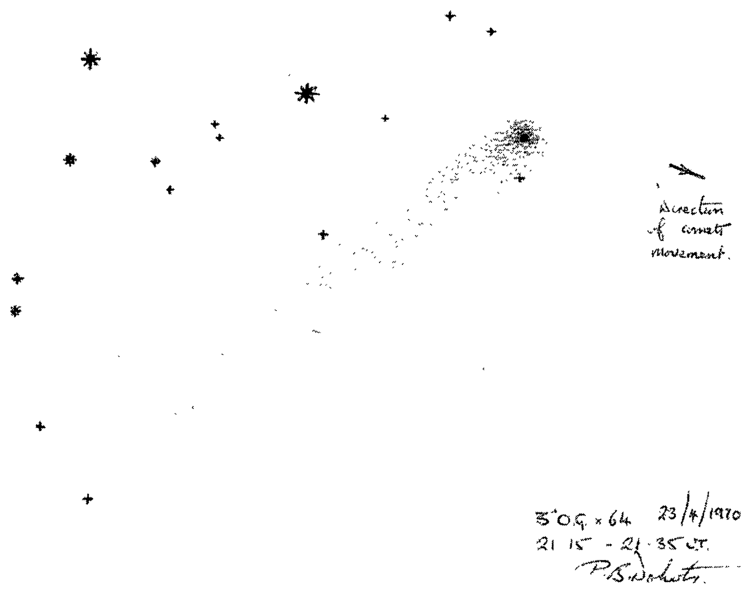


Figure 18. 1970 April 23.89. P. B .Doherty, 75mm refractor ×64.

Hale–Bopp could be seen immediately on leaving a lighted room and from town centres. I did not see it under conditions as good as those for Bennett in 1970. Hale–Bopp was probably the most visible and most observed comet of our age and at its brightest was above the horizon all night. There must be few people in the northern hemisphere who did not see it. Comet Bennett on the other hand was only really conspicuous for two or three weeks and then it was a before-dawn object, making it much less noticeable to the casual observer. Any ranking based on visual appearance must be a personal choice, very much dependent on the prevailing observing conditions.

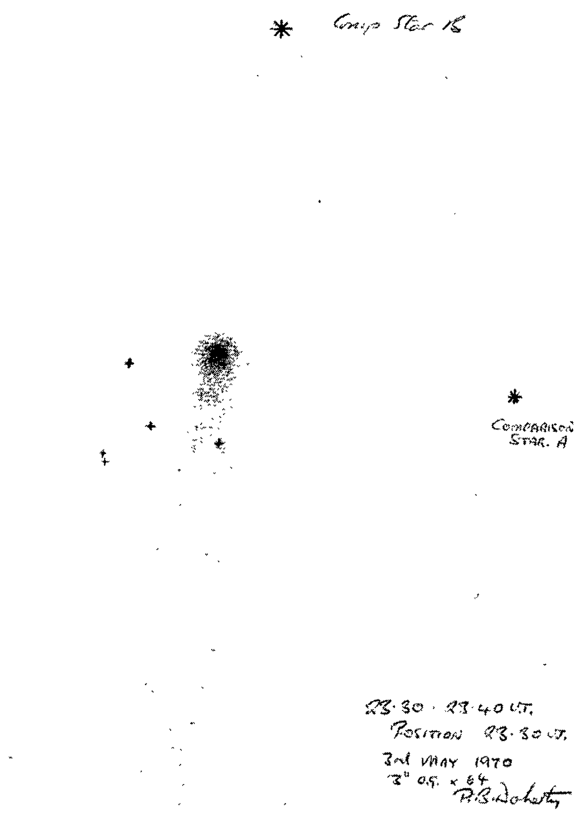


Figure 19. 1970 May 3.98. P. B. Doherty, 75mm refractor ×64.

Acknowledgments

I should like to thank J. D. Shanklin for providing the section on Visual Photometry for which he analysed the magnitude estimates and provided the light curves, for valuable comments on the tail development and for his suggestions and help in the preparation of this report. Also R. J. McKim for help in reproducing Figure 2.

In passing it should be mentioned that many drawings and photographs in the Section's archives of this and other comets have little or no information on the back, often not even the observer's name. Sending this information by accompanying letter is insufficient as in order to sort by date, compare and select items for analysis or publication the two have to be separated. The Section officers cannot be expected to copy all the details onto dozens of photographs and drawings immediately on receipt. Though less of a problem now in the age of self-adhesive labels, observers should ensure each item carries full details including the name of the object, date, time and place of observation, instrumentation and the name of the observer. Otherwise good observations may not be used or full credit given.

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