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The historical record of η Carinae I. The visual light curve, 1595–2000

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Abstract

Eta (η) Carinae is one of the most massive luminous blue variable stars (LBVs) in the Milky Way. Here a new historic light curve is presented which supersedes earlier works, and is based almost completely on a *critically-assessed* compilation of primary sources. Only observations made relative to unambiguously identified comparison stars are used and, unlike earlier efforts, the data are reduced homogenously to the V scale. The light curve is extended through to the present using a database of photoelectric and CCD measures compiled elsewhere, and totals ∼1500 points, including ∼500 before 1950. A primary motivation for this work is to provide a definitive light curve for η Car over the maximum time-line possible, to be used as a resource for further investigation.

The observation by Keyser leads to an inferred magnitude of $m_V = 3.5 \pm 0.5$ in 1595–96, while new magnitude estimates for 1677, 1687, and 1752 are $m_V = 3.3 \pm 0.3$, $m_V = 3.4 \pm 0.4$, and $m_V = 2.3 \pm 0.3$ respectively. Contrary to accepted wisdom, there is only weak observational evidence to show that η Car was varying markedly prior to the Great Eruption beginning in the 1830s, though this is not ruled out. A slow rise from $m_V \approx 3.5$ at the start of the 17th century to $m_V \approx 2.3$ around 1750, with a further slow brightening to ∼1830, is also a tenable hypothesis. There is, however, no evidence for a *long-duration* eruption having occurred between 1500 and 1800.

The well-known Great Eruption commenced in 1837 and lasted until at least 1856. The brightness declined rapidly between 1858 and 1868, before a small brightening or plateau occurred in 1869–71; there is some evidence for a change in the spectrum in Feb 1871. The Lesser Eruption occurred in 1887–95, the onset of which was within two months of a predicted spectroscopic event, suggesting a causal link. A preliminary look at the photographic magnitudes suggests a marked change in colour index during the Lesser Eruption. Another increase in the integrated brightness is generally believed to have occurred circa 1940, but the exact time and quantum still needs to be ascertained. There is no compelling evidence to suggest there was an eruptive event at this time, but there is good, albeit circumstantial, evidence to indicate that this brightening is simply due to the *lobes* of the Homunculus becoming visible for the first time. Such a brightening would increase the integrated magnitude by a measurable amount.

Keywords: History of astronomy – stars: individual (η Carinae) – stars: mass loss – stars: variables: other – techniques: photometric

1 Introduction

Eta (η) Carinae[1] (HD 93308) is one of the most luminous and massive stars in the Galaxy, having had a long and intriguing history as a variable star (van Genderen & Thé 1984; Davidson & Humphreys 1997; Humphreys, Davidson & Smith 1999). Long assumed to be a single star, Damineli (1996) discovered a 5.5-year periodicity and, based on the spectroscopic and photometric data available, predicted an 'event' at 1998.0. This was observed on schedule across all wavelengths (eg. Ishibashi et al. 1999; Damineli et al. 2000; Duncan & White 2003) adding much support to the binary hypothesis.

The periodicity is manifested in both optical and near infrared photometry, and via spectroscopy; ground-based spectra show that the higher-excitation lines (He I, [N II], [Ne III], [Ar III], [Fe III]) fade for a few months every 5.53 years (Zanella, Wolf & Stahl 1984; Damineli et al. 1998; Feast, Whitelock & Marang 2001). There are also 'eclipse-like' events at visual (van Genderen, Sterken & Allen 2003; van Genderen et al. 2003; Fernandez Lajus et al. 2003) near-infrared (Whitelock et al. 2004) and X-ray wavelengths (Corcoran et al. 2001) at the proposed periastron of the binary orbit. The 2003.5 event was extensively observed and provided yet more evidence for the binary nature of the system (Corcoran 2004; Groh & Damineli 2004; Smith et al. 2004b; Davidson et al. 2004).

[1]Previously known as η Argus, η Navis, or η Roboris Caroli.

Much of η Car's fame stems from its nova-like outburst in the 1840s, now usually referred to as the 'Great Eruption'. For a few years η Car rivalled Sirius and Canopus as one of the brightest stars in the sky, and it must have presented a wonderful sight to a contemporary observer with its orange-red tint, embedded in one of the richest parts of the southern Milky Way. It is now generally recognised as a bona fide luminous blue variable (LBV), albeit an extreme and unusual example of the class (Davidson 1987; Humphreys & Davidson 1994; van Genderen 2001).

Its historic light fluctuations are fairly well known, following publication of the canonical light curve for the 19th century by Innes (1903), which has been reproduced by Ludendorff (1928), Walborn & Liller (1977), and van Genderen & Thé (1984), and here as Figure 1. Müller & Hartwig (1918) updated Innes' bibliography, and since then the light curve has been revised and extended (partly using photographic data) by de Vaucouleurs & Eggen (1952), Gratton (1963), and Feinstein & Marraco (1974). Additional photometry by van Genderen & Thé (1984) allowed them to extend the light curve from the 17th century through to about 1980, and later authors have brought it up nearly to the present day (van Genderen, de Groot, & Thé 1994; Humphreys, Davidson & Smith 1999).

Prior to the 1960s however, there are large systematic errors in almost all of the magnitude estimates, so a complete revision of the historical observations is well overdue. This paper presents a new detailed visual light curve for η Car, based on *critically-assessed primary sources* prior to 1950. A primary motivation is to provide a definitive light curve for η Car as a resource for the astronomical community, to form a starting point for accurate energy budget calculations and theoretical modelling. Future papers will address the earliest visual accounts of the spectrum and telescopic appearance of η Car in more detail, incorporate the large body of more recent photoelectric and CCD measures, investigate the photographic light curve, and discuss the astrophysical implications of the new data.

2 Methodology

2.1 Magnitude reductions

The first attempt to construct an accurate light curve for η Car was by Innes (1903). He reduced the available naked-eye magnitude estimates to the Harvard system (typically $\sim$0.2 mag fainter than Johnson V), while the telescopic estimates were reduced to the scale of the *Uranometria Argentina* (Gould 1879), which is non-linear relative to the modern V system. Rather than apply a correction to Innes' data, as has been done in the past (eg. de Vaucouleurs

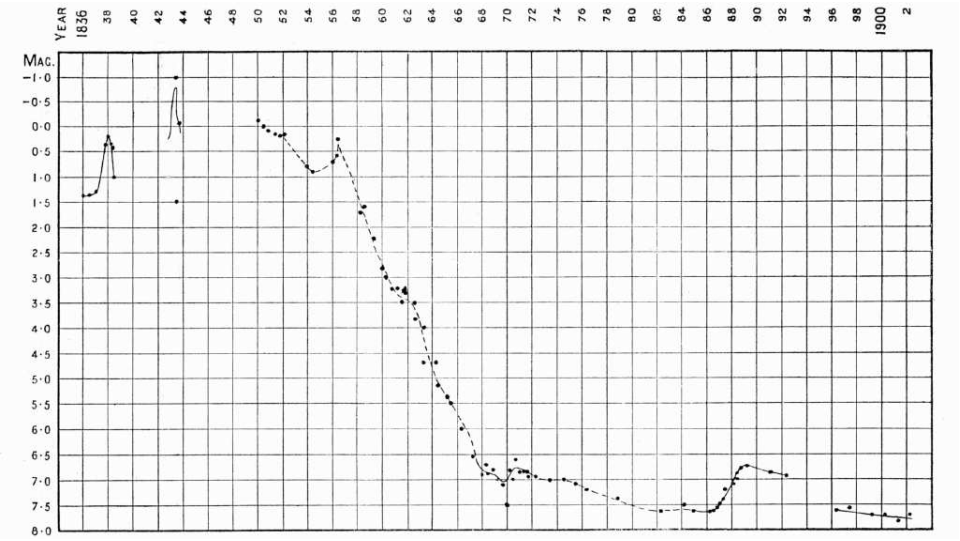

Figure 1: The light curve for η Carinae, reproduced from Innes (1903).

& Eggen 1952), all estimates have been systematically reduced anew, with an attempt made to quantify the errors on each point. Only observations made relative to unambiguously identified comparison stars are used, and unlike earlier efforts, the data are reduced homogenously to the Johnson V scale, with the magnitudes for the comparison stars taken from the Lausanne photometric database (Mermilliod, Mermilliod & Hauck 1997). This has the added advantage of removing the scale errors inherent in Innes' original heterogeneous data set. It was decided not to take mean points (as did Innes) but instead reduce each original measure, along with numerous historical estimates not used by Innes, uncovered by the author after considerable research of archival material. As discussed by Müller & Hartwig (1918), Innes omitted observations by several 19th century workers, and these have been included in the database. Furthermore, John Tebbutt's extensive collection of unpublished manuscripts (held at the Mitchell Library, Sydney) have been examined by the present author to add numerous new data points to the light curve presented here[2]. Additional unpublished manuscripts of H.C. Russell at Sydney Observatory have also revealed observations of note. Only observations made *relative to unambiguously identified comparison stars* are used, so as to minimise noise in the light curve. The light curve presented here has some 500 points prior to 1952, and is combined with a database of ∼1000 photoelectric and CCD measures discussed elsewhere. The greater density of points in the light curve

[2]For biographical information on Tebbutt and a summary of his variable star work, see Orchiston (2000, 2004).

(over 4× more than Innes, up to 1902) allows previously unrecognized features to be seen for the first time.

A brief discussion of the main sources of error that affect visual estimates of η Car is useful at this point (see Weaver 1946):

1. Differences between the visual response (and resolution) of observers, compounded by the unusual emission-line spectrum of η Car. There has been some confusion in the literature regarding the effective wavelength of the human eye for variable star work. Almost all observers naturally use photopic (foveal) vision, with an effective wavelength, $\lambda_{\rm eff}$ of 5600Å, only slightly redward[3] of Johnson V. The visual magnitudes so derived are denoted by m_V. Scotopic (peripheral or rod) vision ($\lambda_{\rm eff} \approx 5100$Å) is considerably bluer[4] than V, but is almost never used for variable star work (see Schaefer 1996 for a discussion). However, a handful of observations by Tebbutt in 1866 (see Appendix 1) were made with 'oblique' or averted vision, due to η Car being near the limit of visibility with the unaided eye. It was usually described as an orange or reddish star, but any systematic offset of the 'scotopic' magnitude from 'V' (in the sense η Car being fainter) would be more than countered by light added to the star from the surrounding bright nebulosity of the Carina nebula, because of the much poorer resolution of peripheral vision: $> 3'$, compared to $< 60''$ for foveal vision. This effect is difficult to quantify, but Tebbutt's naked-eye estimate of 1866 Dec 8 was ~ 0.5 mag brighter than a telescopic estimate made on Dec 11. This correction has been applied to his other estimates made with *averted* vision. No correction for background nebulosity has been applied to naked-eye estimates made with foveal vision.

2. When η Car was at its brightest, the comparison stars used were often in widely different locations on the sky, leading to variations in airmass between η Car and its comparison stars. After ∼1865, η Car was almost exclusively measured with comparison stars in its immediate vicinity, so this source of error may be ignored.

3. The position-angle error (Roberts 1897, 1899; Weaver 1946) which is often neglected in visual magnitude estimates (and which can act at the 0.1–0.4 magnitude level), due to the retina of the eye not having uniform sensitivity across its surface. It is best practice to have the line

[3]Furthermore, since the eye's lens becomes slightly yellower with age, the eyes of older observers essentially have a redder effective wavelength than those of younger observers. The effect is expected to be small however.

[4]The origin of the Purkinje effect.

joining the variable and the comparison star parallel to that joining the eyes, used in conjunction with quick glances at the target and then the comparison star (Bateson 1958).

4. Lastly, a source of error peculiar to η Car. If too much magnification is used when observing through a telescope, the eye naturally tends to concentrate only on the central core of the Homunculus as the observer shifts between it and the comparison star. Consequently it is easy to underestimate the contribution from the surrounding Homunculus, making the integrated magnitude too faint. Using binoculars, rather than a telescope, allows the integrated brightness of the Homunculus to be more easily estimated. This effect is a probably a major contributor to the magnitude offset manifest in the database of the American Association of Variable Star Observers (AAVSO) compared to quasi-simultaneous V photometry (see Figure 7 of Martin & Koppelman 2004). However it can be neglected for all the visual observations prior to 1915, due to η Car having an essentially stellar appearance (see however § 3.7).

In order to get a better feel for the visual method and to help quantify the errors present in the old visual observations, 155 magnitude estimates of η Car have been made by the present author[5] between 1997 and 2004 using the classical Argelander step-method (with variable step, typically 0.1 magnitude) and using foveal (photopic) vision. Low-power (8x) binoculars were used for all estimates, with the comparison stars being selected by similar apparent colour, and by being in the same low-power binocular field, so no correction for differential extinction is necessary. The comparison stars have accurately determined B and V magnitudes taken from Mermilliod et al. (1997). Two of the comparison stars (HD 92964 and HD 93070) are micro-variables (amplitude ≤ 0.1 mag) which adds some noise to the data, but this is fortunately not a major source of error in visual observations. An attempt was made, by adjusting the position of the eyes, to negate the position-angle error. Agreement of my estimates with quasi-simultaneous photoelectric and CCD V photometry is good, and a mean error of $0\overset{\mathrm{m}}{.}08$ is deemed realistic. There is no significant colour term in the author's observations for stars in the range $0.2 \leq B-V \leq 1.4$, though redder stars than this appear systematically brighter (by 0.1 mag at $B-V = 1.8$) for foveal vision. Fortunately, most of the comparison stars do not differ greatly in colour from η Car, so this will not be the dominant source of error.

These observations show that, with care, visual observations by a single observer can be made to better than 0.1 mag accuracy, despite η Car currently

[5]A subset of these data were reported to the VSNET database at Kyoto University.

presenting a nebulous aspect. Even though the *proto*-Homunculus was not obviously resolved in the 19th century, with η Car appearing essentially stellar, a conservative error of $\pm 0\overset{\mathrm{m}}{.}2$ is adopted for the individual historic visual estimates unless stated otherwise. This error is deemed appropriate as many of the descriptions are somewhat open to interpretation, with only a minority of observers strictly using a version of the Argelander step method. More typically, qualifiers such as "scarcely brighter than" or "very little different" are used, which I have interpreted to mean a magnitude difference of $0\overset{\mathrm{m}}{.}1$ with respect to the comparison star (the generally accepted limit of precision for foveal vision), while qualifiers such as "considerably" or "markedly" imply a greater difference of $0\overset{\mathrm{m}}{.}5$ or more. Fortunately, in many cases several comparison stars are used, tightening the range of estimated magnitudes for η Car. The position angle effect, which was not recognised by most observers, also contributes to the estimated error. In addition, many of the comparison stars used had yet-to-be discovered small amplitude variability[6], and furthermore, the ability, experience and instrumentation of each observer varied widely.

2.2 The Database

Appendix 1 lists the observer, date (in original format), derived m_V magnitude for η Car at each date, and the detailed descriptions or observer logs (within quote marks) which were used to formulate the magnitudes, along with a reference code (see Appendix 2) listing the source of the original description. All published records from the primary literature have been re-examined for suitability, and a significant number of unpublished manuscript observations, primarily from Tebbutt and Russell, have also been investigated. Table 1 shows the most commonly used comparison stars in the vicinity of η Car. The reader should note the widespread use of old designations for many of the comparison stars in the original descriptions (tabulated in Appendix 1), and they are given here for completeness. For each comparison star, Column 1 of Table 1 lists the HD number, Columns 2 and 3 give the numbers in La Caille's catalogues of 1942 stars (La Caille 1763a) and 9766 stars (Henderson & Baily 1847) respectively. Columns 4–7 give the designations from the British Association Catalogue (BAC; Baily 1845), the Brisbane catalogue (Richardson 1835), the catalogue of Gilliss (1871), and the number from the Uranometria Argentina (Gould 1879); the UA numbers refer to Carina, except for HD 89890 which is in Vela. Columns 8 and 9 give the designations from John Herschel's catalogue of 1216 stars in the Carina nebula (Herschel 1847), and the number from H.C. Russell's list of stars in the Carina nebula (Russell 1871). Columns

[6]One of the main comparison stars used after ∼1868 is QZ Car = HD 93206, an eclipsing binary with an amplitude of ∼0.3 magnitude.

10 and 11 give the number from the Catalogo General Argentino (Gould 1886), and a variable star or double star designation if applicable. Column 12 gives the adopted V magnitude from Mermilliod et al. (1997), with a flag if the star is variable, and Column 13 gives the adopted $B-V$ colour index.

Some observations which are deemed incorrect are kept in the database, but have been omitted from the light curve (e.g. the observations by Kulczycky prior to 1863 discussed in § 3.5; see Polcaro & Viotti 1993; Feast, Whitelock & Warner 1994; Viotti 1995). For example, the observation by Francis Abbott on 1863 Apr 23 is used to illustrate this selection: "Star in the zenith; by the naked eye scarcely recognised, as a star. With a low power it was equal to 951, 954, and 977, Lac" (Abbott 1863). Abbott's estimate is more than a magnitude fainter than two near-simultaneous estimates by Tebbutt[7]. Furthermore, the three comparison stars deemed equal by Abbott span a range of brightness of 0.7 mag; the large magnitude difference between these stars (which are not significantly variable), shows that this estimate is not reliable, probably due to one or more of the comparison stars being misidentified. Such observations are included in Appendix 1, with the magnitudes enclosed in parentheses to indicate they are also omitted from the light curve. Magnitudes with no reference to identifiable comparison stars (e.g. most of the meridian transit observations with rough magnitude estimates) cannot be reduced to V, and remain in the magnitude system of the original observer. These magnitudes are also omitted from the light curves, but are nevertheless useful as they provide supporting data where the light curve is sparse, or if there is disagreement between observers. A selection of the many such estimates investigated by the present author are included in Appendix 1 when deemed relevant, where they are denoted by italics.

Table 2 summarises the m_V magnitudes from Appendix 1, excluding the italicised and parenthetical estimates described above. The columns in Table 2 sequentially list the observer, UT date (as decimal year), the original magnitude estimate if available, the transformed m_V magnitude, and a flag denoting the adopted error on the magnitude, which is nominally $\pm 0\overset{\mathrm{m}}{.}2$ though often better. A colon denotes a larger error of $\pm 0\overset{\mathrm{m}}{.}3$ and a double colon, an error of perhaps $\pm 0\overset{\mathrm{m}}{.}4$ – $0\overset{\mathrm{m}}{.}5$. A question mark associated with an upper or lower limit is taken to mean the magnitude is indicative only. The light curves (presented as Figures 2, 3, 4, and 7) are based on the data listed in Table 2, with error bars (and upper/lower limits) excluded for clarity. The light curve from 1596

[7]It is clear from published accounts that Abbott was a less careful (and reliable) visual observer than Tebbutt. Abbott was at the centre of the 'Eta Argus' controversy of the 1860s, when debate raged about perceived changes in the nebulosity surrounding the star (Frew & Orchiston, in preparation; see also Bok 1932; Gratton 1961, 1963; Walborn & Liller 1977). For a detailed biography of Abbott, refer to Orchiston (1992).

Table 1: Cross-identifications and adopted magnitudes of comparison stars near η Car. Magnitudes for other comparison stars can be found in Table 3.

HD	Lac1	Lac2	BAC	Bris	Gillis	UA	JH	R	CGA	Other	V	$B-V$
89388	922	4249	3526	2935	...	187	...	...	14054	q Car	3.38v	1.55
89890	926	4272	3546	2972	1243	*203*	...	...	14145	J Vel	4.50	−0.12
90853	935	4314	3594	3031	1266	196	...	...	14304	s Car	3.82	0.32
91465	943	4348	3619	3072	...	203	...	...	14392	p Car	3.32v	−0.09
91942	947	4373	3635	3099	1295	208	...	...	14478	r Car	4.45	1.63
92063	950	4380	3642	3112	...	210	...	...	14504	t^1 Car	5.08	1.17
92207	951	4388	3648	3121	1305	211	...	...	14528	V370 Car	5.49v	0.50
92397	952	4396	3655	3127	...	213	...	...	14558	t^2 Car	4.71	1.56
92436	954	4401	3657	3133	1312	215	...	...	14566	Gli 152a	5.96	1.64
92740	957	4422	3673	3162	...	220	2	65	14626	V429 Car	6.38v	0.08
92741	...	4420	...	3159	1322	...	1	...	14623	...	7.25	−0.01
92964	960	4435	3680	3175	...	222	...	...	14656	V519 Car	5.38v	0.25
93070	963	4446	3688	3185	...	224	...	...	14673	w Car	4.57v	1.70
93030	964	4447	3686	3184	...	223	...	...	14667	θ Car	2.76	−0.23
93129A	...	4449	...	3188	1327	225	403	51	14686	h 4356a	7.26	0.25
93129B	...	4449	...	3188	1327	225	404	50	14687	h 4356b	8.84	0.23
93131	...	4448	3689	3187?	...	226	387	105	14684	...	6.49	−0.03
93160	...	...	...	3190	1329	...	452	38	14689	h 4360c	7.84	0.16
93161A	...	...	...	3190	1330	...	455	39	14690	h 4360b	8.56	0.20
93161B	...	...	...	3190	1330	...	458	39	14690	h 4360a	8.60	0.23
93162	...	...	...	3191	...	...	468	15	14691	...	8.10	0.42
93206	...	4451	...	3193	...	227	522	101	14698	QZ Car	6.30v	0.13
93204	...	...	...	3194	...	...	571	19	14707	Brs 4b	8.42	0.10
93205	...	...	...	3194	...	...	575	18	14708	Brs 4a	7.75	0.05
93249	...	...	...	...	...	...	619	63	14715	...	8.36	0.14
93250	...	...	...	3196	1332	...	630	43	14717	...	7.38	0.15
93281	...	...	...	...	...	...	693	81	CC 121	...	7.80v	1.74
93308	968	4457	3695	3198	1334	231	723	...	14720	η Car	var	var
303308	...	...	...	...	1335	...	736	28	14723	...	8.16	0.13
93403	...	...	...	3202	...	...	844	59	14741	...	7.28	0.22
93420	...	...	...	3204	1337	...	862	69	14744	BO Car	7.30v	1.94
93469	...	...	...	3207	...	...	953	...	14750	R 156	7.88	0.27
93502	971	4464	3703	3208	...	235	...	...	14754	Rst 463	6.26	0.04
93695	...	4479	...	3225	1344	239	1183	71	14788	...	6.47	−0.12
93737	...	4484	...	3229	1345	240	1203	72	14797	V522 Car	6.01v	0.27
94367	977	4507	3734	3263	...	244	...	...	14886	V524Car	5.26v	0.15
94510	979	4515	3740	3274	...	246	...	...	14910	u Car	3.78	0.94
96566	993	4611	3805	3402	...	257	...	...	15222	z^1 Car	4.60	1.03
96918	997	4627	3818	3416	...	260	...	...	15266	x Car	3.92v	1.25

to the present day is illustrated as Figure 2, and an enlargement from 1820 to the present is given as Figure 3. The light curve for the 19th century is illustrated as Figure 4 and can be directly compared with Innes' (1903) light curve (Figure 1).

While the author has tried to locate all published records of the historic brightness of η Car, there remain some unpublished archives that have not yet been examined. Despite an extensive search, the wedge-photometer measures described by Russell (1888) have not been found and the archive is either lost or misplaced. Nor have I located the unpublished observations of Thome and Roberts that were mentioned by Innes (1903, p. 77B), though a search for Roberts' observations is ongoing (M. Saladyga, pers. comm, 2004; M. Hoffman, pers. comm, 2004). Besides the archived correspondence of Sir John Herschel, other observers who might have unpublished records worth following up (if still extant) are Moesta and Jacob. Further investigation is warranted.

3 The photometric record

3.1 The record before 1500

These earliest observations of η Car are the least known and have received little serious attention. Inconsistencies have been noted between different authors, especially when reliance is placed on secondary sources. This Section will examine each of the early accounts in turn, with an emphasis on examining the veracity of the source material.

Firstly, there do not seem to be any observations of η Car from antiquity. Possible pre-Incan observations from Bolivia of η Car in outburst are speculative at best (Teames 2002) and Green & Orchiston (2004) have identified a possible transient source in the southern Milky Way, recorded by the Maori of New Zealand or their Polynesian ancestors. Their preferred position (and identification as a supernova) is in the Centaurus–Crux section of the Milky Way, probably far enough away to exclude an observation of η Car in eruption. In addition, Davidson et al. (1986) and Humphreys & Davidson (1994) indicated there is little concrete evidence that η Car was known in Babylonian times (cf. Jensen 1890, Allen 1899).

There is no mention of η Car in Ptolemy's *Almagest* (Grasshoff 1990, Toomer 1998), compiled for the epoch AD 132. Ptolemy seemed to have relied heavily, if not completely, on the putative lost catalogue of Hipparchus (see Duke 2002, and references within). Neighbouring third- and fourth-magnitude stars such as φ Vel and p, q, u, and s Car are also omitted from the *Almagest*, as is 2.7-magnitude μ Vel, 10° to the north, though Rawlins (1994) has argued that μ Vel was indeed seen by the ancient observer. On the assumption that

Table 2: Magnitudes (including limits) of η Carinae, taken from Appendix 1. The original magnitudes (where available from the references in Appendix 2) are in each observer's magnitude system, and may be compared with the mean magnitudes adopted by Innes (1903), and the m_V magnitudes reduced here to the V system. The complete table (`table2.txt` in ascii format) is provided separately. The following table is given to provide guidance on form and content.

Observer	Date (UT)	m_{old}	m_V	
Hues	1592	..	>2.0	?
Keyser	1596	4	3.5	::
Houtman	1600	..	>4.0	?
Richer	1673	..	>2.0	?
Halley	1677	4	3.3	:
Nöel	1687	4	3.4	::
Feuillée	1710	..	>2.0	?
La Condamine	1738	..	>1.0	?
La Caille	1752	2	2.3	:
Pingré	1761.5	..	<2.7	?
Bayly	1773.4	..	<3.0	?
Humboldt	1800	..	>0.8	?
Fallows	1823	2	2.0	::
Burchell	1827.087	1	0.8	:
Burchell	1828.163	2	1.5	::
Rümker	1828.5	2	<1.8	?
Herschel, J.	1834.1	1.4	1.2	:
Herschel, J.	1836.114	1.5	1.1	:
Herschel, J.	1836.125	1.5	1.2	
Herschel, J.	1836.16	1.6	1.2	
Herschel, J.	1836.223	1.4	1.1	:
Herschel, J.	1836.256	..	1.1	
Herschel, J.	1836.259	..	1.2	
Herschel, J.	1836.322	..	1.3	
Herschel, J.	1836.415	1.5	1.2	
Herschel, J.	1836.866	1.4	1.2	:
Herschel, J.	1836.904	1.5	1.3	:
Herschel, J.	1836.986	..	1.2	
Herschel, J.	1837.188	1.4	1.1	:
Herschel, J.	1837.273	..	1.5	
Herschel, J.	1837.92	1.4	1.2	::
Herschel, J.	1837.958	0.8	0.0	:
Herschel, J.	1837.967	..	−0.2	:

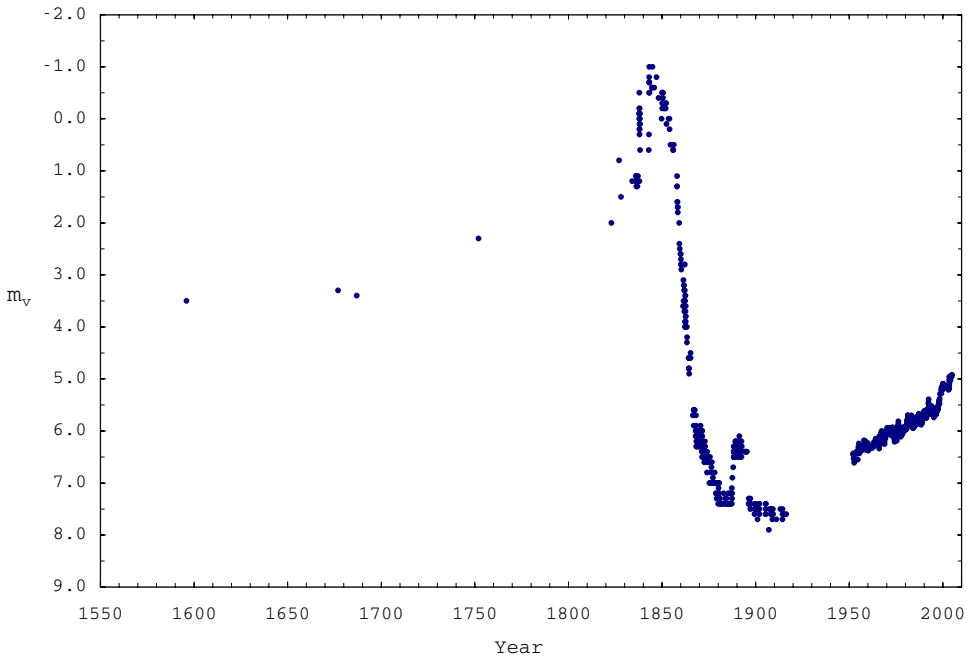

Figure 2: Visual light curve, 1596 to present. Each point has been independently reduced to the modern V system. For clarity, error bars are omitted.

the *Almagest* data were originally due to Hipparchus (circa 130 BC) who observed from Rhodes (36°.1 N), η Car culminated at an altitude (corrected for atmospheric refraction) of only 4.6° and so would have been affected by atmospheric extinction of at least $1\overset{\mathrm{m}}{.}7$, even through an extremely clear atmosphere on the best nights ($k_V < 0\overset{\mathrm{m}}{.}15$ airmass^{-1}). Based on the observed brightness range of η Car during the 17th and 18th centuries (§ 3.2), the expected post-extinction magnitude at Rhodes would be in the range $4.0 < V < 5.0$, though it may have appeared as bright as third magnitude during an S Doradus-type event. So not a great deal may be inferred from its absence in the ancient star catalogue,[8] other than it was *not* in outburst at the time the catalogue(s) were compiled (cf. Henderson 1838; Müller & Hartwig 1918; Thackeray 1955).

The next great star catalogue to be assembled was by the Arabic astronomer Abd al-Rahman Al-Sufi, for the epoch AD 964. This was a careful revision of the *Almagest*, with newly determined magnitudes, and with some

[8]It should be noted that the classical constellation of Argo extended no further eastward than the modern-day False Cross. At best, η Car would have been considered an unformed star (one outside of the classical constellation figures), midway between Argo and Centaurus, and the ancient astronomer may not have considered it worthy of inclusion in the catalogue, even if seen dimly on the meridian above the southern horizon.

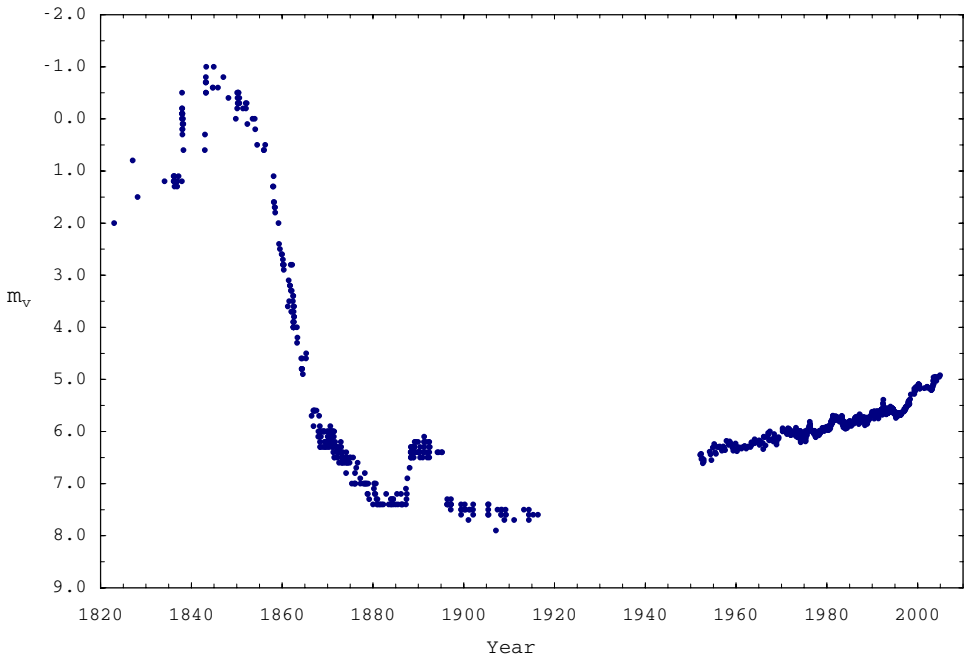

Figure 3: Visual light curve, 1820 to present. Note the absence of accurate visual magnitude estimates between 1916 and 1952.

additional stars. Schjellerup (1874) in his edited translation identifies ε Car ($V = 1.86$), the southernmost star of the False Cross, as being observed by Al Sufi, so if this is correct, η Car's absence implies that it was probably fainter than ε Car at this time. It is also telling that μ Vel was not added, so perhaps Al Sufi paid little attention to the unformed stars outside the classical constellation figures. The last of the great classical star catalogues was compiled by Ulugh Beg who observed from Samarkand in the early 15th century. However η Car was too far south to have been recorded (see Baily 1843).

3.2 AD 1500–1800

As Portuguese and Spanish navigators started charting the southern skies during the Age of Exploration in the late 15th and early 16th centuries, the Southern Cross, the Pointers, the Magellanic Clouds and Coalsack nebula were all noted and described, albeit often cryptically or poorly (see Dekker 1990 for a review). There are no stars in any of the various accounts which can be unambiguously identified with η Car, though limits to its brightness can perhaps be inferred from contemporary observations of other stars in these accounts,

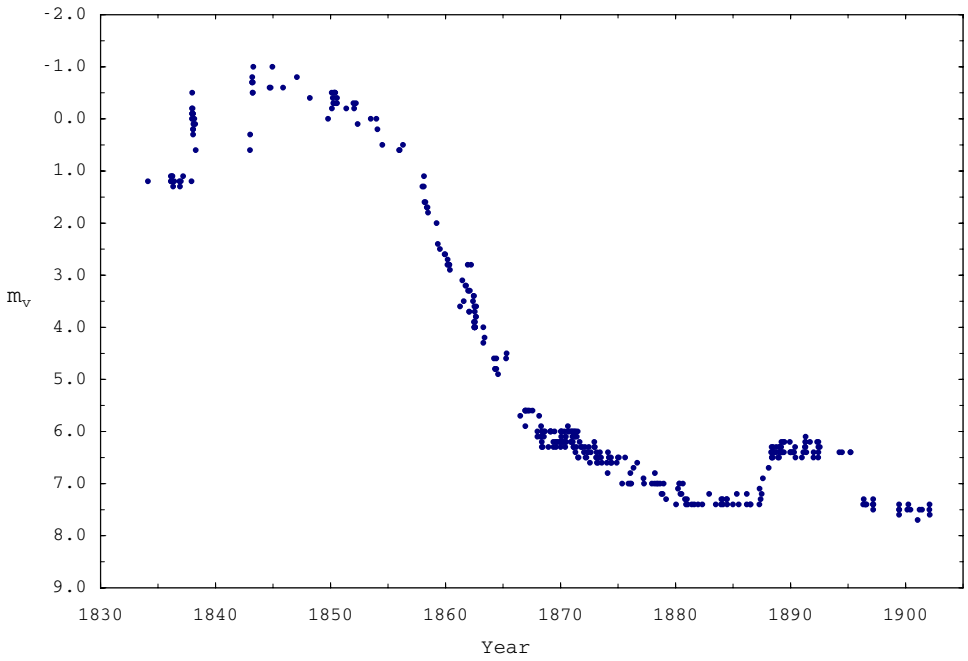

Figure 4: Visual light curve covering the period 1830–1910, to be compared with Fig. 1. The Great Eruption extended from 1837 to ∼1856. Note the constant rates of decline over the intervals 1845–56, 1858–68, and 1872–82, the plateau (or slight brightening) around 1870, and the Lesser Eruption of 1887–95.

as well those by Dutch and English navigators[9]. For example, the English explorer and mathematician Robert Hues wrote the following description in 1591–92 (Hues 1592; see also Knobel 1917) from which we can conclude that η Car was almost certainly fainter than magnitude 2:

> Now, therefore, there are but three Stars of the first magnitude that I could perceive in all those parts which are never seene here in England. The first of these is that bright Star in the sterne of Argo which they call Canobus. The second is in the end of Eridanus. The third is in the right foote of the Centaure. To which if you will add for a fourth that which is fixed on the Centaures left knee, I shall not much stand against it. But other stars of the first magnitude than those which I have named that part of the world

[9]Such limits are relevant to any discussion of possible eruptive events suggested by the data of Walborn, Blanco & Thackeray (1978) in the early 15th century and Morse et al. (2001) circa 1770.

> cannot shew us. Neither is there to be found scarcely two or three at the most of the second magnitude but what Ptolomy had seene.

It seems that the first reasonably accurate observations of the southern stars, including those in southern Argo, are attributed to the Dutch navigator Pieter Keyser around 1595–96. These observations were depicted on the 1598, 1600 and 1601 globes of Petrus Plancius and Jodocus Hondius (Dekker 1987a, 1987b; van der Krogt 1993), and were in turn used by Bayer (1603) in his celebrated *Uranometria*[10] (see Dekker 1987a). These globes (and Bayer's chart) plot a fourth magnitude star very close to the position of η Car, and its identity seems secure.

To estimate a more precise magnitude for η Car at the time of Keyser, stars within 20° of η Car recorded by Hondius and Bayer were tabulated according to magnitude, and the modern V magnitudes of the stars were averaged by magnitude bin (see Table 3). Keyser's magnitudes are fairly consistent for small regions of sky,[11] but were systematically too faint compared to V. The average V magnitude for a Keyser 4th-magnitude star (and hence for η Car) is $m_V = 3.26 \pm 0.41$ (1σ error, $n = 14$).

However, the 1603 star catalogue of Frederick de Houtman (see Marre 1881, Knobel 1917) does not seem to contain it, though the surrounding asterism of fairly prominent stars (p, q, u, s and x Car, and x Vel) seem to be all included. Houtman probably gathered his data around 1600, from Sumatra, and his catalogue seems to be an independent data-set to that of Keyser, as plotted by Hondius and Bayer (Zinner 1926; Dekker 1987a, 1987b, 1990; cf. Knobel 1917). Table 3 shows all stars with V<4.25 within 20° of η Car, with the magnitudes from Houtman's catalogue. Also included are the magnitudes on Bayer's chart (assumed to be from Keyser via Hondius) and those from Halley and Noël (see below). Note that some of these stars are low-amplitude (<0.1 mag) variables so mean V magnitudes are given, but the conclusion here is not affected. Within 5° of η Car, Houtman's catalogue is complete to the 4th magnitude, so it can be argued that this is an upper limit for the brightness of η Car, and that it had faded since ∼1596. This is one of the richest portions of the southern Milky Way, so it seems reasonable to assume that the Dutch navigators would have taken some care when mapping this area.

[10]Bayer's Argo chart has η Car as one of seven fourth-magnitude stars marked as 'd'. Curiously, Bayer's η Argus corresponds to no star in the sky, and sits north of the False Cross. La Caille re-lettered all the bright stars of Argo in 1751–52.

[11]Stars outside the Milky Way are consistently given brighter magnitudes in all the pre-telescopic star catalogues. A region of 20° radius around η Car is adopted as a compromise, and gives a sample of 50 stars for analysis (brighter than V = 4.25). Also note that some magnitudes recorded by Bayer are derived from Ptolemy, and have not been included in the analysis.

As a caveat however, the bright star φ Velorum ($V = 3.54$, B5 II) is not shown on any of the globes of Hondius (nor therefore in Bayer's atlas), nor is it present in Houtman's catalogue, and since there is no reason to suspect any long-term variability in this star, this seems to be a case of accidental omission; φ Vel lies well clear of the bright Carina nebula in a sparser region of the sky and, from my own experience, is fairly easy to overlook, especially by someone concentrating on charting the immediate environs of η Car. However, it is quite possible that η Car was also accidentally omitted by Houtman. So any evidence for variability between the epochs of Keyser and Houtman ($m_V = 3.3$ in 1595–96 and $m_V > 4.0$ in 1600) is tantalising but not very secure. I have taken a conservative position, adopting $\mathrm{m}_V = 3.5 \pm 0.5$ for η Car at 1596.0. This is the approximate limit at which the old catalogues become incomplete.

A planisphere of the southern sky was produced at Peking by Schall von Bell around 1634 (see d'Elia 1959); η Car seems to be plotted, but the southernmost stars on the chart seem to be derived from Bayer's charts or a related source[12]. Soon after, in 1637–43, Georg Markgraf (accompanied by Willem Piso) made a number of astronomical observations from Brazil (see Pingré 1901), but there are none of η Car, nor of a sufficient sample of other stars so as to draw any conclusions on η Car's visibility. The catalogue of Richer (1679, 1729),[13] based on observations made at Cayenne (in the West Indies) in 1672–73, does not include η Car; however all of the second magnitude stars in Argo were noted (except for λ Vel, and possibly δ Vel), so η Car was unlikely to be brighter than second magnitude at this time.

A definitive observation of η Car was made in 1677 by Edmund Halley, a renowned observer who accurately recorded the positions and magnitudes of most of the brighter southern stars (Halley 1679; see also Baily 1843). He observed η Car as a star in his new constellation Robur Carolinum (Charles' Oak), noting it at 4th magnitude. However, how bright was a star described by Halley as 4th magnitude? Halley was quite consistent in his magnitude estimates for small regions of sky (more so than his Dutch predecessors), but he also tended to systematically underestimate the magnitudes compared to V (see Table 3). The average magnitude of all the 4th-magnitude stars catalogued by Halley within 20° of η Car is $\mathrm{m}_V = 3.31 \pm 0.34$ ($n = 12$), and I have adopted this value for η Car.

[12]In particular the southernmost stars of Centaurus have the same erroneous positions on both maps.

[13]Olmsted (1942) gives a discussion of Richer's scientific work, as well as a brief account of Markgraf & Piso's earlier expedition.

Table 3: Magnitudes of stars (brighter than $V = 4.25$) within 20° of η Car, taken from Bayer's chart (Ba) and from the catalogues of Houtman (Ho), Halley (1679, Ha), and Noël (1710). Halley's magnitudes are the most internally consistent, at least for this region of the southern sky. Note that most of Bayer's magnitudes in Centaurus and Crux are taken from Ptolemy, and are marked in italics. The V magnitudes are from Mermilliod et al. (1997) and the average is given for variable stars.

Name	V	Ba	Ho	Ha	Noël	Name	V	Ba	Ho	Ha	Noël
α Cru	0.75	*2*	2	2	2	l Car	3.70v	5	5	5	5
β Cru	1.25	*3*	3	2	2	μ Cru	3.71	?	..	..	4
γ Cru	1.63	*3*	3	2	2	c Vel	3.75	..	4	5	5.5
β Car	1.67	3	3	2	3	β Vol	3.77	6	..	5	6
ε Car	1.86	3	3	2	2	u Car	3.78	5	5	..	4.5
δ Vel	1.96v	2	3	2	2	s Car	3.82	5	4	5	6
ι Car	2.25	3	3	2	2	c Car	3.84	6	..	5	6
κ Vel	2.50	4	3	2.5	2	p Vel	3.84	..	4	4	5
δ Cen	2.60v	1	3	3	2	q Vel	3.85	..	4	4	3.5
μ Vel	2.69	4	4	3	3	γ Mus	3.87	5	4	5	4.5
α Mus	2.69	4	4	4	4	π Cen	3.89	..	4	..	5
θ Car	2.76	4	3	3	3	σ Cen	3.91	*5*	5	5	..
δ Cru	2.80	*4*	3	3	3	x Car	3.92v	..	5	..	..
υ Car	2.96	4	3	4	3	ρ Cen	3.96	4	5	5	..
β Mus	3.05	5	4	4	4	i Car	3.97	..	..	5	5
λ Cen	3.13	4	4	4	4.5	I Car	3.99	..	4	5	6
N Vel	3.14v	4	5	4	3.5	α Vol	4.00	5	..	5	6
ω Car	3.32	4	3	4	3.5	ζ Cru	4.04	..	5	..	..
p Car	3.32v	4	4	4	4.5	h Car	4.08	5	5	5	6
q Car	3.38v	4	4	4	4.5	x Vel	4.10	..	5	..	..
a Car	3.44	5	4	4	6	γ Cha	4.11	6	5	5	5?
φ Vel	3.54	..	..	4	4	ε Mus	4.11	..	..	..	..
ε Cru	3.59	..	5	..	5	HR 4522	4.11	..	..	..	..
o Vel	3.62	5	4	4	5	η Cru	4.15	..	5	..	..
δ Mus	3.62	5	4	5	4						
λ Mus	3.64	4	4	5	5.5	η Car	var	4	..	4	4

In the following decade, the Jesuit priest Francois Noël observed η Car from the Far East,[14] and compiled two separate star catalogues dating from circa 1685–89. The first catalogue contains ∼225 southern stars observed at Macao and Rachol by the Jesuit expedition to India and China (Gouye 1692; Noël 1729); η Car is listed as 2nd magnitude and described as "Une audessus du second Tetragone", the tetragon being the modern "Diamond Cross" comprised of β, θ, υ and ω Car[15]. Winnecke (1859) gives an extract from this catalogue,[16] and gives the date of observation no later than 1689.

In the definitive star catalogue (dated 1687) in the *Observationes Mathematicae et Physicae in India et China* (Noël 1710), η Car is listed as 4th magnitude and described as "parva supra secundu quadranguli" or small [star] above the second quadrilateral; the label 'parva' suggests the magnitude is correct (and not a misprint), so we can assume that η Car was mag 4 on Noël's scale at this time. This catalogue is an expanded version of the first, containing 352 stars, and extends to more southerly declinations. The planisphere accompanying this catalogue is reproduced as Figure 5.

Noël's magnitude scale is fairly similar to Halley's scale (see Müller & Hartwig 1918; Zinner 1926; Lundmark 1932). In a similar way to the Halley data (Table 3), a straight mean of the stars listed as fourth magnitude[17] gives $m_V = 3.41 \pm 0.35$ ($n = 13$). The error is fortuitously small, given the inconsistent magnitudes tabulated in Table 3. Zinner (1926) suggested that the fainter estimate in the second catalogue refers to w Car (HD 93070, $V = 4.6$), but a preliminary analysis of the two catalogues (Frew, unpublished) does not support this assertion, and I have identified this star with η Car. The relationship between the two catalogues is not clear, but most of the additional stars in the second catalogue are fainter and/or at southerly declinations. Excluding those stars added to the second edition, many of the star positions differ slightly, but it is not obvious whether new observations were made (perhaps as late as 1708) or if editing was undertaken following new reductions of the original data. So it is unclear at this stage if there is an error in the magnitude for η Car in the first catalogue, or if it provides real evidence for variability of

[14]There are no observations of η Car in the earlier account by the Jesuit scientist Antoine Thomas in 1681–82 (Gouye 1688; Thomas 1729), nor by de Fontaney and Tachard in 1685 (Tachard 1686).

[15]The first tetragon (in RA order) is the False Cross, made up of ε Car, ι Car, δ Vel and κ Vel.

[16]Winnecke has made a typographic error in his text, describing the star as "au-dessous" (underneath) the Diamond Cross.

[17]There are only four stars described by Noël as fourth magnitude within 20° of η Car, so I have included stars marked as '3 vel 4' and '4 vel 5' in the sample.

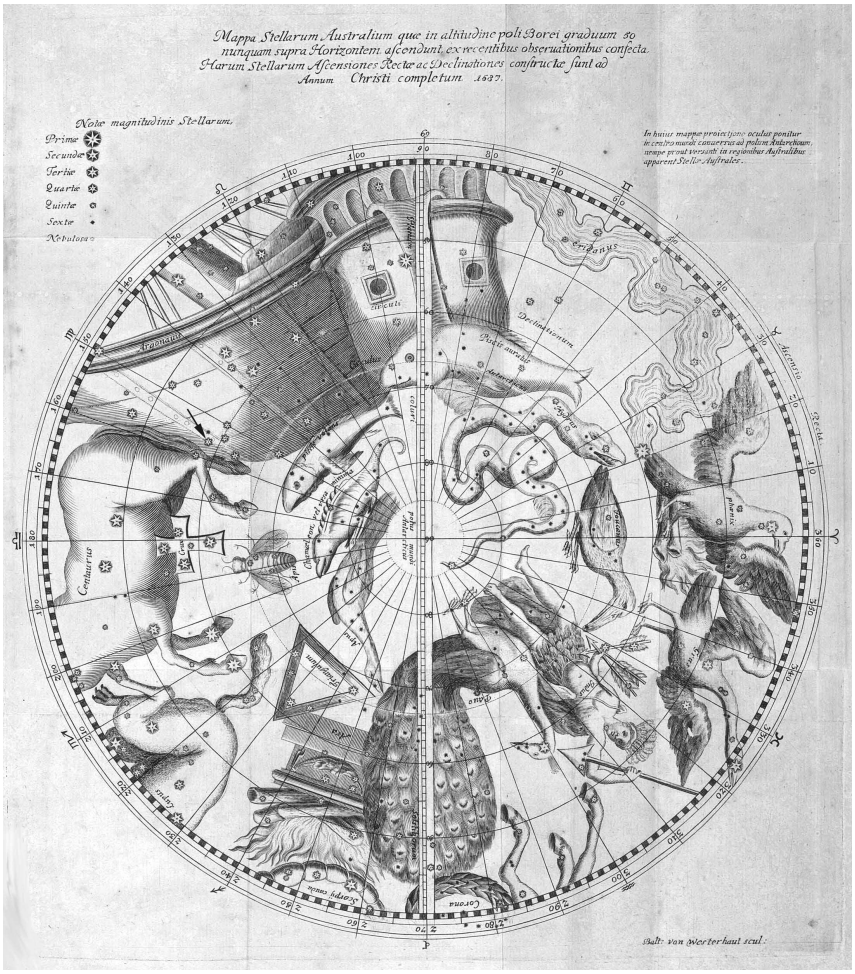

Figure 5: The planisphere of the southern sky published by Noël (1710). An arrow shows the position of η Car, marked as a 4th magnitude star near the hind legs of Centaurus. Courtesy of the Mitchell Library, State Library of New South Wales.

η Car[18]. Again I take a conservative approach and adopt $m_V = 3.4 \pm 0.4$ at 1687.0.

Louis Feuillée, during his explorations of South America, made numerous astronomical observations of interest, including meridian measurements of Sirius, Canopus, α and β Cen, and the three brightest stars of the Southern Cross.

[18]One could argue that if η Car was as bright as magnitude 2, it might have been included with β, θ and υ Car to make a figure different to the Diamond Cross, rather than being described as a star above it.

Of interest is the following quote written in February 1710 (Feuillée 1714):

> ...Argo-Navis, dans la partie australe du Ciel, composée de 66 etoiles, quatre desquelles sont de la sixième grandeur, 22 de la cinquième, 25 de la quatrième, 7 de la troisième, & Canopus de la première.

It seems the sheer brightness of Canopus led Feuillée to classify the next brightest stars in Argo as being of the 3rd magnitude. Since there are seven stars in Argo with $1.7 < V < 2.2$ at present, we can conclude that η Car was probably no brighter than 2nd magnitude, and it might have been fainter. In 1738, La Condamine (1749) observed the declinations and magnitudes of Canopus, α and β Centauri and the four main stars of the Southern Cross, but no other stars. Perhaps η Car might have been observed had it been 1st magnitude or brighter? Soon after, in 1751–52, the Abbé de La Caille records η Car as a second magnitude star,[19] and a fairly accurate estimate of its magnitude can be inferred from the following lines of evidence:

1. La Caille invented a new star nomenclature for the southern constellations that were poorly mapped by Bayer. It is obvious that La Caille, unlike Bayer, took some care to designate (with Greek and Roman letters) all the main stars of the new southern constellations according to brightness, as well as the brighter stars of Argo, Centaurus, Lupus and Ara (La Caille 1756, 1763b), though Gould (1879) has been critical of this attempt. I have included a chart (Figure 6), similar to one formulated by Allen (1988), that shows the run of stars by magnitude in Argo. The stars θ Car and o Vel seem too faint until one realizes that the brightness of these stars to La Caille's eyes were likely increased by unresolved stars of the open clusters they inhabit (IC 2602 and IC 2391, respectively). Figure 6 is graphic evidence that La Caille was remarkably good in ordering the stars in Argo by brightness. A smooth curve drawn through the run of magnitudes gives an estimate for η Car of $m_V = 2.3 \pm 0.3$ (internal error).

2. Another line of evidence is supplied by the following passage from La Caille's journal for 1751 Oct 24 (La Caille 1763b, in translation by Evans 1992):

> Having examined the ship constellation, I saw that M. Halley had evidently truncated it to make his Charles' Tree... is it

[19] η Car is given as 2nd mag in the star catalogues in both the *Astronomiae Fundamenta* (La Caille 1757), where the details of a number of meridian altitude measurements made in 1752 are also given, and the *Coelum Australe Stelliferum* (La Caille 1763a).

> possible that those who have formed the new constellations near the south pole have not taken into account those stars as brilliant as those of his Oak, among which are one of the first magnitude [β Car], two of the second magnitude [η & θ Car], several of the third and fourth magnitudes...

So η Car seemed to have been noticeably fainter than β Car ($V = 1.67$) at the time of observation. If a half-magnitude increment is assumed, so as to force La Caille to put η Car in a different magnitude class, then η had $m_V > 2.2$.

3. Lastly, I have looked at the individual zone observations (zone XII) for η Car as recorded in the *Coelum Australe* (La Caille 1763a) for Jan 4, Mar 5 and Mar 14, 1752, where the magnitudes are given as 2.5, 2.5 and 3 respectively. By comparing La Caille's magnitudes for a number of stars in this zone with modern photometry, I infer $2.5 \leq m_V \leq 2.0$ for η Car. Müller & Hartwig (1918) arrived at essentially the same conclusion. In summary, the three magnitude estimates are consistent, and I adopt $m_V = 2.3 \pm 0.3$ for η Car at 1752.0.

There were no systematic surveys of the southern sky for the next seven decades, though intense scientific activity was being generated due to the upcoming 1761 and 1769 transits of Venus. A number of expeditions were sent to southerly latitudes, so it might be expected that if η Car was particularly bright it would have been noticed. However, nothing can be concluded from Maskelyne's astronomical observations at St. Helena in 1761–62 (Maskelyne 1764). The transit at St. Helena was clouded out, and the remainder of his report is weighted heavily to observations of lunar occultations and phenomena of Jupiter's satellites. The only observations of the far southern sky are restricted to an account of the duplicity of α Centauri, and two brief paragraphs on the Magellanic Clouds. The report of Mason & Dixon (1762) likewise adds nothing on η Car.

However, A.-G. Pingré observed the 1761 transit from the island of Rodrigues in the Indian Ocean, and in order to determine the latitude of the island, made two meridian observations of η Car in June 1761 (Pingré 1763). The other stars observed in June were Arcturus, α Cru, β Cru, β Leo, δ Cen, and ϵ Vir. These were obviously the most convenient stars to use at the time of observation so not a lot can be deduced regarding η Car's brightness. Yet, it is interesting that besides Canopus (measured in July), the only other Argo star observed was η Car, so it was almost certainly brighter than θ Car and μ Vel (stars with near-identical right ascensions), both of which have $V \approx 2.7$.

Furthermore, James Cook's expeditions of discovery commencing with his historic first voyage to the Pacific to observe the 1769 transit, were notable as

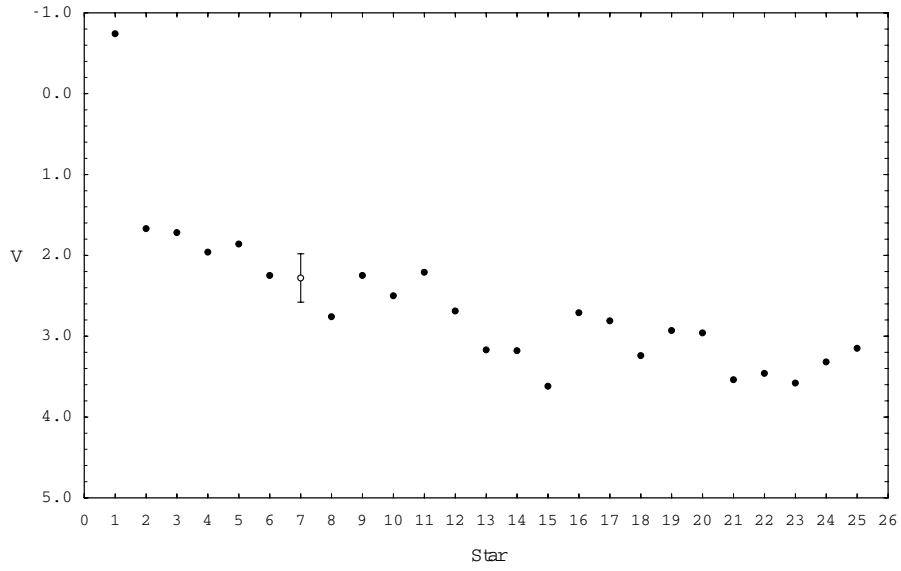

Figure 6: A plot showing the magnitudes of La Caille's Greek-lettered stars in Argo (now subdivided into Carina, Puppis, and Vela). Canopus ($V = -0.74$) is the brightest star (numbered 1) and ω Car ($V = 3.32$) is star number 24. The 25th star is the brightest Roman-lettered star in Argo (N Velorum). This chart shows La Caille was quite consistent in labelling the stars in order of brightness; η Car is the seventh star in this plot (marked with an open circle), and is estimated to have $m_V = 2.3 \pm 0.3$ in 1752.

they included qualified astronomers on each voyage (see Orchiston 1998 and references therein). There are no records of η Car from the first or third voyages (Wales 1788; Cooke, King & Bayly 1782). However, η Car was observed for positional determination (along with many of the brighter southern stars) on Cook's second voyage of discovery. There were two meridian observations of η Car (amongst a number of observations of stars in Argo), by Bayly in May 1773 from Queen Charlotte's Sound, New Zealand and three meridian altitude measurements by Wales in Apr 1775 from the Cape of Good Hope (Wales & Bayly 1777). There are no comments on any unusual brightness of η Car, and furthermore it was observed fairly sparingly relative to a number of conspicuous stars ($V \leq 2.0$) in the southern Milky Way, suggesting it was not overly bright. The faintest Argo star measured by Bayly was υ Car ($V = 2.96$), so we can assume this to be a rough lower limit to η Car's brightness at the time[20]. Note that Morse et al. (2001) concluded that the ejection of some

[20]Considerably fainter *zodiacal* stars were observed frequently, for obvious reasons. An observation of o Argus is a misprint for θ Argus.

of the knots in the south debris shell exterior to the Homunculus, preceded the Great Eruption by several decades or more (i.e. around 1770) but there is no supporting evidence from the photometric record, which, unfortunately, is rather too sparse. To summarise, the brightness of η Car between 1760 and 1775 is consistent with that observed by La Caille in 1751–52.

The explorer Alexander von Humboldt journeyed to South America in the years 1799 to 1803, and made numerous astronomical observations. Brightness estimates of 27 southern stars are given in a series of works (Humboldt 1802, 1810, 1814), which were further discussed by Humboldt (1839). Acrux (α Cru) at $V = 0.75$ is the brightest star not included in any of his lists, so we can tentatively conclude that η Car was fainter than this limit.

A number of star atlases were in wide use around this time. Fortin (1776) produced a French edition (*Atlas Céleste*) of Flamsteed's famous atlas, including two planispheres of the southern stars in the backmatter. One, by Le Monnier, is derived from the data of Halley (via Senex), and the other is a version of La Caille's planisphere, where curiously, η Car is plotted as a 4th-magnitude star[21]. Bode (1782), in his *Vorstellung der Gestirne*, adopted the maps from the Fortin-Flamsteed atlas, thereby including η Car at mag 4 (cf. Müller & Hartwig 1918) while, in his monumental *Uranographia* star atlas (Bode 1801), η Car is recorded as a 3rd-magnitude star[22] (see Warner 1979 for details on these works). Since these atlases are secondary sources, no reliance can be placed on them regarding η Car's magnitude at these dates.

Halley's original estimate of 4th magnitude, Noël's possibly incorrect estimate of 2nd magnitude, La Caille's estimate of 2nd magnitude in the 1750s, and an 'estimate' of 4th magnitude attributed to Burchell in ∼1815 (see § 3.3, below) have led a number of authors (van Genderen & Thé 1984; Davidson 1987, 1989; Humphreys & Davidson 1994; Davidson & Humphreys 1997) to conclude that η Car fluctuated fitfully in the 150 years leading up to its outburst in the 1840s. I have concluded that there is only weak observational evidence to suggest that η Car was varying markedly between magnitudes 2 and 4 over this interval, though this is not ruled out. The presence of small (< 0.5 mag) fluctuations (which are intuitively expected, based on its recent behaviour) cannot be determined from the available data, and brief spikes in brightness similar to those observed by Burchell in 1827 (§ 3.3) would be missed due to the sparse coverage. However, a sustained maximum like the Great Eruption (∼20 years duration) not being noticed seems very unlikely, as the southern sky was being increasingly monitored in the 17th and 18th

[21] I surmise that the engraver altered the magnitude to 4, to agree with Halley's and Noël's planispheres. There is no indication to suggest Lacaille ever observed η Car as anything other than mag 2.

[22] Probably a mean of the earlier 2nd and 4th magnitude estimates.

centuries. A secular rise in brightness from $m_V \approx 3.5$ at the start of the 17th century to $m_V \approx 2.0$–2.5 at the end of the 18th is an equally tenable hypothesis based on the body of available evidence. Indeed, such behaviour may have an interesting parallel with the observed secular increase in the brightness of P Cygni since 1700 (de Groot & Lamers 1992; Lamers & de Groot 1992).

3.3 Early 19th century observations

The first definitive observation of the *variability* of η Car came from the explorer and naturalist William Burchell in 1827. Writing from Brazil on 1827 July 17, he commented (Herschel 1847, p. 35):

> I am curious to know whether any one has hitherto noticed that the star η Navis which is marked as being of the fourth magnitude (and which was always so when I was in Africa) is now of the first magnitude, or as large as α Crucis.

Writing much later, in a letter to M. Johnson dated 1845 June 9, Burchell stated (Herschel 1847, p. 36):

> I now find on reference to my journal of Astronomical Transactions under the date of February 1, 1827, when I was in the city of St. Paulo in Brazil, that the star η *Navis*, marked as a star of the fourth magnitude by La Caille, [? Halley] then appeared to be of the first and as large as α Crucis: and that there was no star of this magnitude in that part of the heavens when I was in Africa (in 1811–15): nor, as I believed when I was at Rio de Janeiro (in 1825–26) as I think it would not have escaped my notice in the latter place.

Some authors (eg. Herschel 1847, Lynn 1907) have regarded these statements as evidence that η Car was at $V \approx 4$ circa 1811–15, but this claim has little certainty associated with it,[23] and it seems that it was only seen by Burchell after it brightened to be equal with α Crucis in 1827. Had η Car been at say, $V = 2.0$–2.5 in 1811–15, it would have been just one of the dozen or more conspicuous stars in the Vela-Carina-Centaurus Milky Way, and I suspect that Burchell never specifically noticed the star. To account for his lack of observation at this time, Burchell simply noted the magnitude from the Fortin-Flamsteed atlas, assuming this to be correct; Burchell explicitly stated that he used this atlas on his African expedition (Burchell 1822, p. 165).

[23]Examining Burchell's original account of his South African expedition adds little. His only comments on the southern stars were restricted to the brightest: Canopus, Achernar, the Pointers and the stars of the Southern Cross (Burchell 1822, p.80).

According to Innes (1903), Reverend Scully, an assistant at the Cape Observatory, noted η Car as a 6th-magnitude star on 1822 Feb 20. This estimate is discordant with all other contemporary assessments and is assumed to be unreliable. Fearon Fallows (1824) estimated it at 2nd magnitude[24] in his star catalogue compiled at the Cape, based on observations made in 1822–23. The mean of Fallows' 2nd magnitude stars is $m_V = 2.1 \pm 0.4$ ($n = 6$), and including stars denoted 2+ and 2–, gives a very similar mean, $m_V = 2.0 \pm 0.4$ ($n = 12$). Yet overall, Fallows' magnitudes are rather erratic, and may be only a partly independent data set, having taken over many of La Caille's magnitudes. Innes (1903, p. 77B) also quotes two manuscript observations by Fallows: on 1822 Mar 15, Fallows estimated η Car at 2nd magnitude, noting it was brighter than θ and μ Argus, and another estimate on 1823 Mar 17 gives the same magnitude for η Car. Therefore I have arbitrarily adopted $m_V = 2.0 \pm 0.5$ for η Car at this epoch.

Rümker (1829) made positional observations of η Car in May 1822 and June 1828 from the Paramatta[25] Observatory, west of Sydney, NSW. He noted that the "south polar distance of η Argus, β Crucis, and α Eridani, would probably be more correctly deduced from their upper culminations... whilst their lower culminations may serve to establish the law of refraction in the southern hemisphere." This last phrase is quite interesting, for at lower culmination, atmospheric absorption would select for only the brightest stars to be used in this way, especially at the near-sea level site of Paramatta. I hypothesize that the three stars mentioned were the brightest in the declination band near $-59°$, with η being likely brighter than ε and ι Car which were not mentioned by Rümker. So an approximate magnitude of 1.2–1.8 is inferred,[26] somewhat brighter than estimated by Fallows, but in agreement with Burchell. In a follow-up publication where η Car is given as mag 2, Rümker (1832, p. 17) wrote that "I have therefore not altered the magnitudes given by La Caille to the stars observed by him..." Similarly the magnitudes given in the Paramatta (Brisbane) catalogue (Richardson 1835) are basically identical (with few exceptions) to those in La Caille's catalogue of 9766 stars (Henderson & Baily 1847), so the magnitude in the Paramatta Catalogue is not an independent estimate (Gould 1879).

James Dunlop, also at Paramatta, observed η Car and its nebula, as part of his surveys of the southern sky (Dunlop 1828, 1829). He noted it as a third magnitude star, but there is reason to believe that this magnitude was

[24]Fallows misnamed η as σ in this catalogue.

[25]The modern spelling is Parramatta.

[26]However if η Car was much brighter than β Cru, it is likely that this would have been remarked upon, considering that Bode's *Uranographica* was a source known to be used by Rümker.

simply taken from Bode (1801) and was not an original estimate. Dunlop made measurements of the magnitudes and colours of many southern stars (Dunlop 1833, Franks 1909), but I failed to find any *original* magnitude or colour estimates for η Car in the manuscript material held at the Mitchell Library, Sydney. Despite Dunlop observing η Car on numerous occasions with a mural circle between ∼1825 and 1840, no firm estimates of its brightness (made relative to comparison stars) have been located, nor was any mention made of variability in the star. One rather vague descriptor of "blazing" suggests that η Car was bright in 1838, but little more can be said (see Appendix 1).

Johnson (1835) also gives a magnitude of 2 for η Car, based on observations made primarily between 1831 and 1833. However, like Rümker, Johnson's magnitudes should not be considered as independently derived data[27]. Nonetheless, had η Car differed greatly from its catalogued magnitude of 2 (i.e. $V = 1.0$–2.0) this probably would have been noticed. There were also positional observations from Madras Observatory in ∼1831 and 1833 (Taylor 1832, 1835) when η Car was again recorded as a 2nd magnitude star. The brightness is thus consistent with the observations of Fallows, Rümker, Burchell (in Feb 1828) and Herschel in 1834. A best guess is that η Carwas around magnitude 1.5–2.0 in the early 1820s (somewhat brighter than it was at the time of La Caille) and a little brighter by 1830, ignoring the brief rise to $V = 0.8$ in early 1827.

Observations of η Car since the 1830s are more frequent, and usually compared to one or more comparison stars, so deducing the magnitude is straightforward (see Appendix 1). The first *accurate* estimates of η Car's brightness are by John Herschel between the years 1834 and 1838 (Herschel 1847). The magnitude of η Car seemed surprisingly constant over the latter part of this interval, and the derived magnitude, based on Hershel's observations both by naked-eye sequences, and with his 'moon astrometer' (Herschel 1847, Warner 1992) was $V \approx 1.2$. The total range between 1836.1 and 1837.9 was only ∼0.2 mag, consistent with no variation as seen by eye. Herschel himself commented on its constancy between 1834 and 1838 (Herschel 1838a,b, 1847).

3.4 The Great Eruption of 1837–56

At the close of 1837, η Car suddenly brightened (probably in less than two weeks) by more than a magnitude to $m_V \approx 0$ before fading again to $m_V \approx 0.6$ by years' end. This is the start of the famous 'Great Eruption', of nearly 20 years duration. I find that η Car probably reached $m_V \approx -1.0$ (or slightly

[27] "The stars' magnitudes and annual variations are chiefly taken from the Catalogue of the Royal Astronomical Society. In a few instances, where it appeared requisite, the magnitudes have been altered."

brighter) in April 1843 based on an observation by Maclear,[28] and it was at least as bright as Canopus ($V = -0.74$) in March and April according to Mackay, Smyth, and Leps (see Appendix 1). It was also as bright as $m_V \approx -1.0$ in December 1844. Unfortunately I have not located any observations between 1839 and 1841, nor in 1846, so there may have been other short-duration peaks in brightness that were missed.

There exists fairly good evidence for strong fluctuations in brightness (amplitude up to 1 mag on time scales of days to weeks) during the peak (1843–45) of the Great Eruption, as noted by Maclear and C.P. Smyth (see Appendix 1). Such rapid fluctuations are difficult to explain on theoretical grounds, but might be due to flaring or some other phenomenon in the photosphere of the star. Jacob and Gilliss also suspected variations (over periods of weeks) towards the end of the Great Eruption. These fluctuations are superposed on a slow decline; between 1845 and 1856 η Car faded at an approximate rate of 0.1 mag/year, and was still as bright as $V \approx -0.5$ in 1850. A peak at ∼1856.2 based on a single observation by Abbott is very doubtful, and has been excluded from the light curve.

Damineli (1996) had already noted the apparent coincidence of the 1838 and 1843 brightenings with predicted spectroscopic event times, as well as the brightening in 1827. This lends support to the hypothesis that eruptive events are triggered by a close passage of the proposed companion with the primary star, by altering the structure of its extended wind.

3.5 The Decline, 1857–86

η Carinae was still a star of the first magnitude at the close of 1857, before the rate of fading suddenly increased, most likely due to the onset of dust condensation from the prodigious stellar wind (Davidson & Humphreys 1997). Between 1858 and 1869, the rate of decline was remarkably constant, at ∼0.4 mag yr^{-1}. Polcaro & Viotti (1993) have pointed out the little-known observations of Kulczycky (1865), who observed η Car in the 1860s to be brighter than other observers have recorded. However, Feast, Whitelock & Warner (1994) cast doubt on the veracity of this report, and their conclusions are confirmed here. In summary, observations by Powell, Tebbutt, Abbott, Moesta, Jacob, Heelis, Tupman, and T. Maclear are both frequent and consistent enough to show that η Car faded regularly over the interval 1860–65, and rule out Polcaro & Viotti's assertion that η Car was as bright as 1st magnitude in 1860–62 (see Appendix 1). Furthermore, the numerous positional observations (with as-

[28]There are inconsistencies in Herschel's (1847) summary of the magnitudes from ∼1828–43, pointed out by Müller & Hartwig (1918), so the adopted magnitudes of Maclear may be in error.

sociated rough magnitude estimates) made at Sydney, Melbourne, Cape, and Madras Observatories agree with a steady decline in brightness of the star over this interval.

The rather complete mid-to-late 19th century light curve is a legacy of dedicated visual observers, with the Australian 'amateur' astronomer John Tebbutt providing the backbone of the observations, having regularly monitored the star for over half a century. His observations show a slight brightening of the star around 1870 ($m_V \approx 6.2$), or a least a levelling out of the fading that was present throughout the previous decade. It is tempting to mark this event as equivalent to the plateau seen in the light curves of some other η Car analogues such as V12 in NGC 2403 and SN 1961V in NGC 1058 (cf. Humphreys, Davidson & Smith 1999). Furthermore, this brightening brackets Le Sueur's pioneering visual spectroscopic observations in 1869/70 (Le Sueur 1870a, b; Walborn & Liller 1977), when an *emission-line* spectrum was noted (cf. the Lesser Eruption when an absorption-line spectrum dominated). A possible spectrum change observed by MacGeorge (1874) in February 1871, when the emission lines were no longer obvious (Frew 2002), may coincide with a spectroscopic event, assuming the 5.5-year periodicity was present back then, though this is rather speculative. MacGeorge's observations are at phase 0.09 using the ephemeris of Corcoran (2004), which adopts a period of 5.536 years. The brightness varied little for about two years, but after 1872 the general decline continued, but at a lower rate of $\sim$0.1 mag yr^{-1}, with η Car fading to magnitude 7.4 by 1886.

3.6 The Lesser Eruption, 1887–95

In 1887 another brightening occurred, the so-called 'Lesser Eruption', when the star reached $m_V \approx 6.2$. It was characterized by a plateau of relatively constant brightness, and η Car remained brighter than $m_V \approx 6.5$ until early 1895, when the star dimmed rather abruptly to $m_V \approx 7.5$. The 1887–95 brightening seems to be intimately associated with the ejection of the Little Homunculus (Ishibashi et al. 2003) and the Weigelt blobs (Smith et al. 2004a; cf. Dorland, Currie & Hajian 2004), suggesting a modest amount of mass loss. Interestingly, the beginning of the Lesser Eruption is within two months of a spectroscopic event predicted from the ephemeris of Corcoran (2004). According to Thome (1889), η Car began to brighten around 1887.5, or phase 0.04, and he detected a possible change in colour slightly earlier (in March 1887 or phase 0.0). This provides further evidence for rare eruptive events (when they do occur) being triggered by the close passage of the two stars during periastron.

It is apparent that there was a marked change in colour index (CI) during the Lesser Eruption (see § 4 and Figure 7). The colour index $m_{pg} - m_V \approx 1.3$

during the eruption is consistent with an F-supergiant photosphere reddened by $E(B-V) = 1.0$, which is similar to that recently observed for the central star (Davidson et al. 1995). The CI changed to $m_{pg} - m_V \approx 0.6$ at the end of the eruption, likely due to emission knots in the unresolved core becoming a significant contributor to the integrated brightness. Support for the redder colour during the lesser eruption comes from Thome (1889)[29]. Since $m_V \approx 6.3$ at this time, the derived colour index, $m_{pg} - m_V \approx 1.0$ agrees with that estimated from the astrographic plates. The observed colour change during the Lesser Eruption is consistent with the observed changes in the integrated spectrum, from F0–2 I during the eruption, to a predominantly emission-line spectrum with weak continuum afterwards (Walborn & Liller 1977). To a first approximation, the integrated color index has been fairly constant since 1895, despite the increase in brightness of the Homunculus.

3.7 The 20th century

Between 1900 and about 1920, η Car was relatively constant at $m_V \approx 7.6$, and though there are very few visual observations between 1920 and 1950 (cf. de Vaucouleurs & Eggen 1952), it is generally accepted that η Car increased in brightness circa 1940 (though this conclusion is based on data from photographic plates). The visual observations over this time interval included a handful of rough estimates from van den Bos and Finsen, plus a set of observations in the 1940s by Luft from the AAVSO database (J. Mattei, pers. comm., 2004). From information kindly provided by the AAVSO, it is known that Luft took the magnitudes for his comparison stars from the *Catalogo La Plata B* (Aguilar & Dawson 1929). Unfortunately the magnitudes in this positional catalogue were never intended for variable star work, and are a mixture of original estimates loosely based on the scale of the *Uranometria Argentina* (Gould 1879), plus some magnitudes directly copied from the Revised Harvard Photometry for some of the brighter stars. The heterogeneity of the magnitudes, in combination with the lack of information on the exact comparison stars used by Luft, precludes deriving accurate magnitudes for Luft on the V scale. The instrumentation used by Luft is also unknown, so it is unclear if any correction needs to be made as a result of the Homunculus being resolved (see § 2.2). Even after a nominal correction, the magnitudes derived from Luft should probably be considered as lower limits to the true brightness.

At present, the full outline of the Homunculus is easily seen visually through a small telescope in good seeing. Curiously, the lobes of the Homunculus were

[29]He noted that a "negative, obtained 1889 June 26, shows a trail for η equal to that of an 8th magnitude star, being fainter than [HD 93250, m_{pg}= 7.3], though at the time η was more than a magnitude brighter."

not seen earlier than ∼1930, even though Innes discovered two nebulous knots within ∼1″ of the core in 1914/15 with a 9-inch refractor (Innes 1914, 1915), confirmed soon after by Voûte (1925). Innes also stated he observed η Car with an 18-inch refractor around 1900, without noticing any companions. In addition, See (1897) measured one of the wide companions to η Car with the Lowell 24-inch refractor and Dawson (1918) gave micrometer measures for four companion stars in 1913 (separations from 14–61″) using the La Plata 17-inch refractor. Neither observer detected any close knots or nebulous appearance to η Car. It is quite possible that the knots seen by Innes only became visible around 1914, suggesting they may have been produced in the Lesser Eruption of 1887–95. There is anecdotal evidence that η Car was seen to be non-stellar as early as 1871 (see Appendix 1),[30] but the full outline of the proto-Homunculus was *not* seen at these early dates. While van den Bos (1928) comments on a red halo seen immediately around the close 'pair' during the 1920s, the full outline of the Homunculus nebula was not seen until later, tentatively in the 1930s (van den Bos 1937), and definitely in the mid 1940s by Gaviola (1946, 1950), and soon after by Thackeray (1949).

Corroborative evidence comes from the fact that the brightest knots forming the head and feet of the Homunculus denoted h, c and d (Gaviola 1950) were not seen and measured until ∼ 1930, even though they were already at relatively large distances from the core. Curiously, the most prominent knot seen visually through a modest telescope at present is the $E1$ knot (Smith & Gehrz 1998) which was not seen by any of the old-time visual observers. This knot was first measured by Gaviola (1946) on a plate taken in 1945, which suggests that it too became conspicuous around 1940. The ground-based proper motion initially suggested an ejection date around 1890 (Smith & Gehrz 1998) associating it with the Lesser Eruption, but this conflicts with a more recent analysis based on Hubble Space Telescope images alone, which gives an ejection date in the Great Eruption around 1845 (Morse et al. 2001).

The secular increase in magnitude for η Car from 1952 to 1997 was at a rate of 0.020 mag yr^{-1} (based solely on PE/CCD photometry). This rate is essentially that predicted by assuming a nebula of constant surface brightness undergoing homologous expansion since its formation in the 1840s (cf. van Genderen et al. 1994). The nearly stellar-appearing core (van den Bos 1928; Gaviola 1950; Thackeray 1953) is assumed to have been at a relatively constant magnitude of $m_V \approx 7.6$, which includes the contribution from the central star and the Weigelt blobs (Weigelt & Ebersberger 1986). If we make the very

[30]See, for example, the observations by Russell (1871, May 5), Burton (1874, Nov) and Tebbutt (1875, Jul 28) in Appendix 1. The observers' descriptions suggest η Car was incipiently resolved through modest-sized telescopes at those dates, similar to the current 'soft' appearance of the (now larger) Homunculus as seen through 8× binoculars.

simplistic assumption that the surface brightness of the Homunculus is similar to that seen over the interval 1952–97, then its full extent should have easily been seen by Innes, if not by Russell, Tebbutt, and Burton, yet the opposite is true. Assuming homologous expansion, the dimensions of the Homunculus would have been $\sim 8.5 \times 5.5''$ in 1915, and $\sim 5 \times 3''$ in 1875, so these early 'non-observations' are indicative that the lobes of the Homunculus were not being illuminated by the central object at this time. To place these observations in context, the small ($4''$) reflection nebula surrounding VY CMa (Perrine 1923, Smith et al. 2001), with near identical surface brightness to the current Homunculus, is readily visible through a telescope of only 20 cm aperture.

The lobes of the Homunculus becoming visible around 1940, or slightly earlier, explains the putative brightening (de Vaucouleurs & Eggen 1952; O'Connell 1956) that took place at this time. There is no need for an eruption of the star (e.g. Dorland et al. 2004), since the increased visibility of the lobes would raise the integrated brightness of the object by a significant amount[31]. Interestingly, it appears that all of the earliest *photographic* spectra (prior to ∼1940) seem to be in a low-excitation state (Feast et al. 2001), though the nature of a causative link between this and the clearing of dust around the central binary is currently unclear[32]. So the brightening of the lobes of the Homunculus may be related to the first appearance of high-state spectra in the 1940s. Perhaps the dust torus surrounding the central binary become more transparent to ionizing radiation at this time, though it should be noted that the higher-excitation HeI λ5876 line was prominent spectroscopically back in 1869–70 (Le Sueur 1870a,b; Le Sueur 1874a,b; Walborn & Liller, 1977). Alternatively, the lobes only became visible after an interaction between the ejecta from the Great Eruption and a previously ejected non-isotropic stellar wind, but this is a less likely mechanism. Further work is needed.

The first photoelectric measurements of the star (ostensibly on the V system), were by Hogg and Eggen in 1952 when η Car was at $m_V = 6.45$ (de Vaucouleurs & Eggen 1952), and since the 1960s, the star has been regularly measured and the light curve is much more precise. The 5.5-year periodicity is apparent in the V-band light curve presented here (first demonstrated by Damineli 1996, though hinted at in the data of Feinstein & Marraco 1974), and is also obvious in the recent IR data of Whitelock et al. (2004).

By 1997, η Car's integrated magnitude had reached $V = 5.5$, but there was an unanticipated brightening of the integrated brightness after the 1998 periastron event (Davidson et al. 1999; Sterken et al. 1999; van Genderen &

[31]In fact Thackeray (1953) suggested that the Homunculus, or halo as he termed it, may have brightened in the years immediately preceding 1945.

[32]Hoffleit (1933) noted possible variability in some spectral lines during the Lesser Eruption which, as it turns out, is close to phase 0.0 in the 5.54-year orbit.

Sterken 2004), and an even greater proportional increase in the brightness of the central object. From $V \approx 8.4$ in 1991 (Davidson et al. 1995), which is in broad agreement with the old visual magnitude estimates for the *core* of the Homunculus (Innes 1914, 1915), the central star has brightened markedly since 1998, reaching $V \approx 7.5$ in 2000, and $V \approx 6.8$ at present (Smith et al. 2000, Martin & Koppelman 2004, Davidson et al. 2004). The cause of the brightening is not yet clear, but may be due either to an intrinsic brightening of the star, reduced obscuration, or both. The integrated brightness of the Homunculus is currently at V =4.9–5.0. As this brightening also followed a spectroscopic event, there may be parallel with the Lesser Eruption of the 1890s, though no obvious spectral changes in the primary star are currently evident.

4 The photographic record

Placing the old photographic magnitudes of η Car on to a common scale is problematic, as the photographic passband depends on the nature of the telescope lens, emulsion, observing site (and varying airmass to which the UV is particularly sensitive), and the reduction method (see Hearnshaw 1996 for a summary). The early plates were mostly taken with a variety of objective lenses that, in general, have a different response to the international photographic system, which is defined using a silvered mirror. Problems with digitizing the old photographic plates are also non-trivial, owing to η Car residing in a crowded and nebulous field.

A first look at 25 astrographic plates produced photographic magnitudes covering the Lesser Eruption (Figure 7). The plates are from the vault at the Macquarie University Library, and were taken with the 33 cm Sydney Observatory Astrograph used for the *Carte du Ciel* project. The magnitudes were carefully estimated from the plates by eye (using the Argelander step method) using a binocular viewer at a power of 20×, and comparison stars were carefully chosen to be free of crowding, strong nebulosity or significant variability. An approximate error of $\pm 0\overset{\mathrm{m}}{.}15$ for the individual eye estimates is adopted here. A detailed account will be published elsewhere.

Previous studies based on Harvard plates show that the star was constant at $\mathrm{m}_{pg} = 7.6$ from 1889 to late 1894 (the Lesser Eruption) before fading in 1895, with little further change until 1930 (Cannon 1920, Bok 1932, Hoffleit 1933). The light curve was extended to 1952 by O'Connell (1956), based on small-scale plates taken at the Riverview College Observatory in Sydney, and covers the putative 1940s brightening. A preliminary light curve based on this data was included in de Vaucouleurs & Eggen (1952). However, it appears that

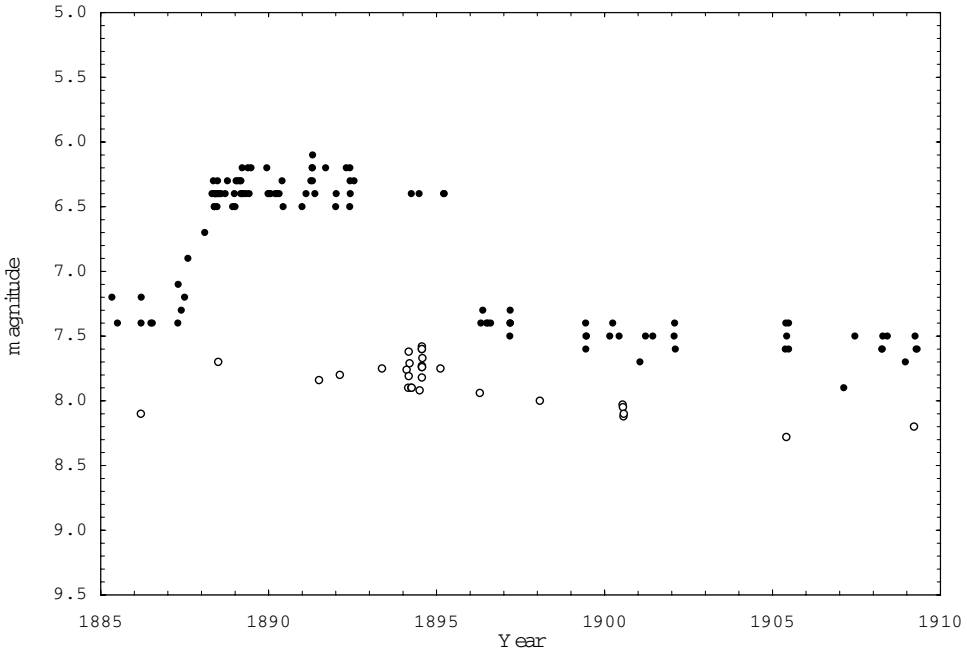

Figure 7: Visual (•) and photographic (○) light curves covering the Lesser Eruption (1887–95). A marked colour change is apparent during the eruption. The photographic magnitudes will be published elsewhere.

a change in instrumentation occurred around 1940 (see O'Leary & O'Connell 1936; O'Connell 1956), and the possible influence on the derived photographic magnitudes needs to be quantified. Confirmation will come after re-examining the Riverview photographic plates, which should allow the shape of the light curve and the exact timing of the brightening to be better defined.

In the future, it is imperative to digitize photographic plates from the various archives to obtain a more complete light curve, from before the Lesser Eruption right through to 1950. Relevant archives, besides those located in Sydney, include the extensive archive at Harvard Observatory, as well as plates from the Union and Cape Observatories (South Africa) and Cordoba Observatory in Argentina. It may also be possible to detect brightness changes corresponding to spectroscopic events at these early epochs given enough data points. Some of the earliest photographs of the η Car region were taken by Gould at Cordoba between 1872 and 1882, and are still extant (see Gould 1897, Hazen 1991). Digitizing these plates should provide important information on the colour of the star prior to the Great Eruption.

5 Conclusions

While the existence of slow-moving knots exterior to the Homunculus suggests that the star had prior episodes of extreme mass-loss, the evidence for large-scale brightness fluctuations from the photometric record prior to the Great Eruption is rather weak. The observation of Keyser leads to an inferred magnitude of $m_V \approx 3.5 \pm 0.5$ for η Car in 1595–96, while new magnitude estimates for 1677, 1687, and 1752 are $m_V \approx 3.3 \pm 0.3$, 3.4 ± 0.4, and 2.3 ± 0.3 respectively. A slow rise from $m_V \approx 3.5$ at the start of the 17th century to $m_V \approx 2.3$ in 1750 and $m_V \approx 1.5$ around 1830 is a reasonable conclusion based on the available photometric data.

It seems probable that the ejecta surrounding η Car represent at least one outburst event earlier than the Great Eruption. However, the photometric record provides no evidence for any long-duration eruption occurring between 1500 and 1800, though it must be emphasized that absence of evidence is not evidence of absence. Morse et al. (2001) conclude that the ejection of some of the partial shell of outer debris preceded the Great Eruption by at least several decades or more but there is no supporting photometric evidence for an eruptive event around 1770. Walborn et al. (1978) propose that the '*E*' condensations were possibly formed around AD 1400, though the lower proper motions reported by Walborn & Blanco (1988) suggest these ejecta are much older. Alternatively, there have been large decelerations in the motion of these knots, though it is difficult to foresee a mechanism that would permit this. The possible outer bipolar shell noted by Bohigas et al. (2000) may also turn out to be evidence of an ancient outburst.

The Great Eruption lasted from 1837 to at least 1856, in agreement with previous work, and η Car probably reached $V \approx -1.0$ in April 1843, but was also this bright in December 1844. There is some evidence that dust condensation began as early as 1845, based on the slow apparent decline after this date. After 1858, η Car began rapidly fading due to increasing absorption by the newly formed dust shell (and probably coincident with an intrinsic fading of the star), though it is difficult to temporally deconvolve the contributions of the two processes. The rate of decline was remarkably constant at 0.4 mag yr^{-1}, before a small plateau or brightening around 1869–70, which may coincide with a spectrum event.

The Lesser Eruption occurred in 1887–95, the onset of which was within two months of a predicted spectroscopic event. According to Thome (1889), η Car began to brighten around 1887.5, or phase 0.04 in the orbit of Damineli (1996) as revised by Corcoran (2004). A preliminary look at the photographic magnitudes suggests a marked change in colour index during the Lesser Eruption of the 1890s. Between 1896 and ∼1930, η Car was relatively constant

at $m_V \approx 7.6$, before a probable brightening around 1940 as the lobes of the Homunculus became brighter. The exact time and quantum of the brightening circa 1940 still needs to be ascertained, but there is no compelling evidence to suggest there was an eruptive event at this time.

Since then η Car has brightened slowly but quite regularly to $V \approx 5.5$ in 1997. Since 1998, the central object has brightened markedly, and there has been a concomitant increase in the integrated brightness of the Homunculus, but the amplitude is less due to reprocessing of the light from the central star — the Homunculus is currently at $V = 4.9$–5.0. As discussed by Davidson et al. (2004), the future behaviour of η Car is unpredictable, and it should be watched with great interest.

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Appendix 1

Table 4: Magnitude Database for η Carinae

Observer	Date	m_V	Description and reference code
Hues	1592±	>2.0 ?	Refer to text
Keyser	1596±	3.5 ::	Refer to text
Houtman	1600±	>4.0 ?	Refer to text
Richer	1673±	>2.0 ?	Refer to text
Halley	1677±	3.3 :	Refer to text
Noël	1687±	3.4 ::	Refer to text
Feuilée	1710	>2.0 ?	Refer to text
La Condamine	1738	>1.0 ?	Refer to text
La Caille	1752	2.3 :	Refer to text
Pingré	1761 Jun	<2.7 ?	Refer to text
Bayly	1773 May	<3.0 ?	Refer to text
Wales	1775 Apr	...	Refer to text
Humboldt	1800±	>1.0 ?	Refer to text
Burchell	1811–15	>2.0 ?	Refer to text
Scully	1822 Feb 20	*6*	Scully also describes ι Car as 7^{th} mag! [In03]
Fallows	1822–23	2.0 ::	Refer to text
Burchell	1825–26	>2.0 ?	Refer to text
Dunlop	1825	...	"The places of the small stars... accompanying the η Robur Caroli, I ascertained by the mural circle in the year 1825, at which time I was preparing to commence a general survey of the southern hemisphere." [D28]
Dunlop	1826	*3*	"η Roboris Caroli, Bode, is a bright star of the 3rd magnitude, surrounded by a multitude of small stars ..." [D28]
Burchell	1827 Feb 1	0.8 :	Refer to text
Burchell	1828 Feb 29	1.5 ::	"...and on the 29th of the same month... made a memorandum that it was then certainly of the second magnitude at least." [H47]
Rümker	1828 Jun (?)	<1.8 ?	Refer to text
Taylor	1831–33	*2*	Refer to text
Dunlop	1832 May 12	*2*	Mural circle observation [DM2]
Dunlop	1832 May 29/31	*2*	Mural circle observations [DM2]
Dunlop	1832 Jun 1	*2*	Mural circle observation [DM2]
Dunlop	1832 Jul 1	*2*	Mural circle observation [DM2]
Dunlop	1832 Jul 5	*2*	Mural circle observation [DM2]
Dunlop	1833 Sep 15	*2*	Mural circle observation [DM2]
Dunlop	1833 Oct 23	*2*	Mural circle observation [DM2]
Herschel, J.	1834 Feb	1.2 :	"When first observed by myself in 1834, it appeared as a very large star of the second magnitude, or a very small one of the first, and so it remained without apparent increase or change up to nearly the end of 1837... [the magnitude] of η would be 1.4, in the whole interval of time from February 1834 to November 1837." [H47]
Herschel, J.	1836 Feb 11	1.1 :	Sequence 4: η Car less than α Crucis, Spica and Antares, greater than β Crucis [H47]
Herschel, J.	1836 Feb 15	1.2	Sequence 5: "On this night, η Argus was placed above but nearly equal to β Crucis." [H47]
Herschel, J.	1836 Feb 18–Mar 6	1.2	Sequence 6: η Car less than Spica and Antares, equal to Regulus, but made brighter than β Crucis [H47]
Herschel, J.	1836 Mar 22	1.1 :	Sequence 7: η Car less than Acrux, Spica and Betelgeuse, but brighter than Regulus, Pollux and β Crucis [H47]
Herschel, J.	1836 Apr 3	1.1	Moon astrometer observation [H47]

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Table 4 – continued from previous page

Observer	Date	m_V	Description and reference code
Herschel, J.	1836 Apr 4	1.2	Moon astrometer observation [H47]
Herschel, J.	1836 Apr 27	1.3	Moon astrometer observation [H47]
Herschel, J.	1836 May 31	1.2	Sequence 13: "No 9, η Argus, not entitled to a place in the first class of stars. – β Crucis is less than η Argus. – α Crucis is but a little greater than Spica."; also η fainter than Spica [H47]
Herschel, J.	1836 Nov 12	1.2 :	Sequence 19: η Car between Aldebaran and Pollux (low) [H47]
Herschel, J.	1836 Nov 26	1.3 :	Sequence 21: η Car between Fomalhaut and α Gruis, ε Canis Majoris [H47]
Herschel, J.	1836 Dec 26	1.2	Moon astrometer observation [H47]
Herschel, J.	1837 Mar 10	1.1 :	Sequence 22: η Car between Spica and β Crucis [H47]
Herschel, J.	1837 Apr 10	<1.5	Sequence 25: η Car brighter than ε Canis Majoris, γ Argus and β Argus [H47]
Herschel, J.	1837 Dec 1 ±	1.2 ::	Inferred magnitude and date, based on accounts in [H47] and [WW]
Herschel, J.	1837 Dec 16–17	0.0 :	Sequence 32: "While yet low it equalled Rigel, and when it had attained some altitude was decidedly greater." [H38a, H38b, H47]
Herschel, J.	1837 Dec 19	−0.2 :	"$3^1/_4$ AM... η Argus is now *hardly inferior* to α Centauri, but it is inferior. Very like in colour. It is much brighter than Rigel. Procyon is left out of all Comparison..." [EDEG]
Herschel, J.	1837 Dec 20	−0.1 :	"$1^1/_2$ AM. η Argus is not so bright as α Centauri but it far exceeds β Orionis now at nearly same Alt. It is much nearer to α Centauri than to β Orionis (Rigel). α Orionis is small and Procyon trifling compared to it. NB α Centauri is low." [EDEG]
Herschel, J.	1837 Dec 22	−0.1 :	"Sat Mg $2^1/_2$ AM. η Argus is far superior to Rigel... and decidedly exceeds α Centauri — but α is lower by far and there is also haze in sky so comparison not fair – yet I *perceived* no haze in or near α. η is evidently going on to rival Canopus." [EDEG]
Herschel, J.	1837 Dec 23	−0.5 ::	"[Sunday] Morning 3 AM. Sat night, among cloud and haze so far as I could come to any conclusion by waiting for gleams & clear intervals η Argus is larger than α Centauri, and begins now to approach Canopus – There is not so much [difference between] Canopus & η as between η and α Cent." Also see entry for 1838, Jan 2. [EDEG]
Herschel, J.	1837 Dec 28	−0.1 :	Sequence 33: "On the 28th December it was far superior to Rigel, and could only be compared with α Centauri which it equalled, having the advantage of altitude, but fell somewhat short of it as the altitudes approaches equality." [H47]
Herschel, J.	1837 Dec 29	0.0 :	Sequence 34: η Argus (40°) equal to α Cen (10°); also brighter than Rigel. Correction for differential extinction applied. [H47]
Herschel, J.	1838 Jan 2	−0.2	"The maximum brightness seems to have been obtained about the 2nd January, 1838, on which night both stars being high and the sky clear and pure, it was judged to be very nearly matched indeed with α Centauri, sometimes the one, sometimes the other being judged brighter, but on the whole α was considered to have some little superiority." [H47]
Herschel, J.	1838 Jan 6	−0.1 :	Sequence 36: η Car between α Centauri and Rigel [H47]
Herschel, J.	1838 Jan 7	−0.1	Sequence 37: η Car between α Centauri and Arcturus, Rigel [H47]

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Table 4 – continued from previous page

Observer	Date	m_V	Description and reference code
Herschel, J.	1838 Jan 13	−0.1	Sequence 39: η Car between α Centauri and Rigel. "Already on the 7^{th}, 13^{th} January, α Centauri was placed unhesitatingly placed above, and Rigel as unhesitatingly below it." [H47]
Herschel, J.	1838 Jan 20	0.2 :	"visibly diminished – now much less than α Centauri, and not *much* greater than Rigel. The change is palpable." [H47]; "η Argus is now very far inferior to α Centauri and not much [greater] than Rigel – i.e. Rapidly declining." [WW]
Herschel, J.	1838 Jan 21	0.3 :	Sequence 40: η between Arcturus (low) and β Centauri. [H47]
Herschel, J.	1838 Jan 22	0.2 ::	"And on the 22nd, Arcturus (the nearest star in light and colour to α Centauri which the heavens afford) when only 10° high surpassed η, the latter being on the meridian; η was still however superior to β Centauri, α Crucis and Spira [sic] and continued so, (and even superior to Rigel) during the whole of February..." [H47]
Maclear, T.	1838 Jan 28	0.1 :	"... I came away convinced that η Argus is still larger than Rigel. It is necessary to extinguish Canopus & Sirius as the eye passes from η to Rigel." [WW]
Herschel, J.	1838 Feb 24	0.1	Sequence 41: η Car between α Centauri and Rigel; Sequence 42: η between Arcturus and Saturn [H47]
Herschel, J.	1838 Feb 25	0.0 :	Sequence 43: η Car between α Centauri and Rigel"... and continued so, (and even superior to Rigel) during the whole of February..." [H47]
Herschel, J.	1838 Mar 28	0.1	Sequence 44: η Car between Arcturus and Rigel [H47]
Herschel, J.	1838 Apr 14	0.6 :	Sequence 45: η Car between Betelgeuse and Aldebaran; "... nor was it until the 14th April, 1838, that it had so far faded as to bear comparison with Aldebaran, though still somewhat brighter than that star." Aldebaran was higher than η Car [H47]
Dunlop	1838 Apr 17	...	Mural circle observation, with η Car described as "Blazing" [DM2]
Dunlop	1840 May 31	...	Mural circle observation; no magnitude given [DM2]
Maclear, T.	1842 Dec 29	0.6	"... it was equal to β Centauri, but inferior to α..." [H47]
Maclear, T.	1843 early Jan	0.3	"... during the first half of January, Procyon and Rigel, were the stars with which it was most comparable" [H47]
Smyth	1843 early Mar	−0.7 :	"But, after having for a few days in the beginning of the above-mentioned month [March 1843] approximated to Canopus, η dwindled down again very rapidly..." Letter dated Jan 1, 1845 [Sm45a, Sm45b]
Maclear, T.	1843 Mar 8	...	"... it was particularly brilliant at midnight" [H47]
Maclear, T.	1843 Mar 11/14	−0.8 :	"... on the 11^{th} and 14^{th}, it was 'much brighter than α Centauri' and Rigel 'and even brighter than Canopus'..." [H47]
Mackay	1843 Mar	−0.7 :	"... in March last, it had become a star of the first magnitude, fully as bright as Canopus, and in colour and size very much like Arcturus. This has been observed by several other persons to whom I pointed it out. Is the star known as a variable star, or is the change now first observed? α Crucis looked quite dim beside it." [Mc43, H47]
Maclear, T.	1843 Mar 19	>0.8 :	"On the 19^{th} it had become 'less brilliant than on last three nights,' and ... considerably less than Rigel and even less than α Crucis, though still much greater than α Hydrae." [H47]

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Table 4 – continued from previous page

Observer	Date	m_V	Description and reference code
Maclear, T.	1843 Mar 24	−0.5 :	"On the 24^{th} it had begun to advance again, as Mr. Maclear states it to have been on that night 'decidedly not so brilliant as Canopus' but still 'brighter than α Centauri'..." [H47]
Maclear, T.	1843 Mar 28	−0.5 :	"... and on the 28^{th} again, 'still less brilliant' [than Canopus]." [H47]
Leps	1843 Apr 1	−0.7 :	"Je vis en effet que ces deux étoiles [η Car & Canopus] avaient à peu près le même éclat..." [Le43]
Maclear, T.	1843 April	−1.0 ::	"... the changes of η Argus are curious, for last April, twelve months it seemed almost equal to Sirius, – I speak as to date without my notes." Letter to Herschel dated Sep 17, 1844. [H47]
Maclear, T.	1844 Sept	−0.6 :	"Now the star is stationary and scarcely so bright as Canopus" Letter dated Sep 17, 1844 [H47]
Smyth	1844 Dec ±	−1.0 :	"... it is now again on the increase. It is, and has been for a month, brighter than Canopus, half way indeed between him and Sirius, and is very red." Letter dated Jan 1, 1845 [S45a,b]
Maclear, T.	1844 Dec ±	<−0.7	"... η Argus has been for some time rather larger than Canopus, and seems again on the decline." Letter dated Jan 3, 1845 [H47]
Smyth	1845 Oct ±	−0.6 :	"When I left the Southern hemisphere, in [October] 1845, this star was brighter than any in the Northern hemisphere, and was the third brightest in the Southern, being transcended only by Sirius and Canopus, if, indeed, the latter was superior. It was then, without doubt, brighter than when Sir John Herschel left the cape in 1838..." [S62]
Jacob	1845.88	−0.6 :	"The star now almost vies with Canopus, and is decidedly brighter and redder than Arcturus." [Jc47]
Jacob	1845.90	<−0.1	"The star is now a little fainter, scarcely brighter than Arcturus; but there is a slight haze round the horizon" [Jc47]; "In November 1845 it was decidedly brighter than Arcturus, and after fading a little it became as nearly as bright as Canopus." [Jc49]
Jacob	1847 Jan–Feb	−0.8 :	"In the early part of 1847 it was noted as almost exactly equal to Canopus, perhaps a very little brighter." [Jc49]
Jacob	1848 Mar	−0.4 :	"In March 1848 it is decidedly inferior to Canopus, and scarcely above α Centauri." [Jc49]
Gilliss	1849 Oct	0.0 ::	Inferred magnitude, determined from comments by Gilliss on May 28, 1850. [Gi 55, Gi56]
Spreckley	1850.0 ±	>−0.7	"... my attention was excited by the unexpected splendour of η Argus, which is now a large first magnitude, surpassing every other star in the constellation except Canopus..." [Sp50]
Gilliss	1850 Feb 9	−0.5 :	"Comparing the brightest visible stars, they rank — Sirius, Canopus, η Argus, α Centauri. The yellowish-red light of η Argus is more marked than that of Mars." [Gi 55, Gi56]
Gilliss	1850 Feb 13	−0.2 :	"η Argus apparently less bright than α Centauri." [Gi 55, Gi56]
Gilliss	1850 Mar ±	−0.4 :	"η Argus was undoubtedly brighter than the two stars of α Centauri at the date of our measures in March, but is on the wane, and is now [July 28, 1850] very little superior to them." [Gi51]
Gilliss	1850 Mar 31	−0.3	"η Argus is quite as bright as the two stars of α Centauri, and superior to all except Sirius and Canopus." [Gi 55, Gi56]

Continued on next page

Table 4 – continued from previous page

Observer	Date	m_V	Description and reference code
Gilliss	1850 Apr 15	−0.5 :	"η Argus approaches the brilliancy of Canopus." [Gi 55, Gi56]
Gilliss	1850 Apr 18	−0.3	"After the observations, careful estimation placed η Argus quite equal with, if not superior in brightness to α Centauri. They were equidistant from the meridian." [Gi 55, Gi56]
Gilliss	1850 May 14	−0.5 :	"η Argus and α Centauri being at the same distance from the meridian, the former is considerably the brighter." [Gi 55, Gi56]
Gilliss	1850 May 16	−0.5 :	"η Argus more brilliant than the two stars of α Centauri combined" [Gi 55, Gi56]
Gilliss	1850 May 28	−0.5 :	"η Argus goes on increasing steadily. With the ruddiness of Aldebaran, its magnitude is only less than Canopus. Its change, since the close of October [1849], has been nearly, if not full half a magnitude." [Gi 55, Gi56]
Gilliss	1850 Jun 3	<-0.1	"η Argus and Arcturus have approximately the same colour; and although the latter is rather ruddier, the former is considerably the brighter. When compared they had about the same altitude." [Gi 55, Gi56]
Gilliss	1850 Jul 5	−0.3	"η Argus is still as bright as the two stars of α Centauri." [Gi 55, Gi56]
Gilliss	1850 Jul 25	−0.4 :	"η Argus as bright or brighter than the two of α Centauri." [Gi 55, Gi56]
Gilliss	1850 Jul 28	−0.3	"η Argus is on the wane, and is now very little superior to α Centauri." [Gi 55, Gi56]
Gilliss	1851 May 18	−0.2 :	"η Argus certainly not so bright as α Centauri." [Gi 55, Gi56]
Gilliss	1851 Dec 28	−0.3	"η Argus quite as bright as α Centauri." [Gi 55, Gi56]
Gilliss	1852 Jan 22	−0.2 :	"η Argus no brighter than α Centauri." [Gi 55, Gi56]; "I have thought for the last eight or ten nights that η Argus is diminishing in brightness. It is certainly not brighter than the combined light of α Centauri, as it was again last summer; but the two are not yet favourably situated for comparison, being at unequal heights." [Gi52]
Gilliss	1852 Mar 15	−0.3	"η Argus continued fully as bright as the double star α Centauri as late as 15th of March last. Some nights I would estimate it a shade brighter; but when the two were at equal distances from the meridian, it was often impossible to detect any difference with the eye." [Gi 55, Gi56]
Gilliss	1852 May 10	0.1 :	"Since [Mar 15] it has sensibly diminished. It comes nearer to my recollection of Capella, as seen in the northern hemisphere, than any other star." [Gi 55, Gi56]
Stock	1853.5 ±	0.0 :	"... in 1853, we used to notice the star constantly. It was between α, β Centauri. If these were noted as 1, 2, I should place η Argus at 1.3." [TM15]
Tebbutt	1853 Sep/Oct	*1.0*	"... η Argus was employed by me as a comparison star on the 30th September and 12th October, 1853, in sextant observations of a large comet at that time visible in the morning sky. It was then a reddish star of the first magnitude." [T66, TM1]
Powell	1853.991	0.0 :	"η Argus slightly inferior to α Centauri, but superior to either α Crucis or β Centauri." [P62]
Powell	1854.076	0.2	"Inferior to α but superior to β Centauri. Rays issue from η as from Rigel." [P62]

Continued on next page

Table 4 – continued from previous page

Observer	Date	m_V	Description and reference code
Tebbutt	1854 Jul 5	0.5	"Of α Centauri, β Centauri, α Crucis, and η Argus, the first was by far the brightest, β Centauri and η Argus were very nearly equal in brilliancy. It was very difficult to judge of the comparative brilliancy of these two, but I think the latter was somewhat the brighter. η Argus was somewhat brighter than α Crucis." [TM1; T66]
Powell	1855.967	0.6	"Not brighter than Procyon, and not quite so bright as Capella; scarcely brighter than α Crucis, about equal to β Centauri. Colour reddish or yellowish white; star scintillates." [P62]
Powell	1856.012	0.6	"Scarcely brighter than β Centauri, a trifle brighter than α Crucis ; scintillates more than either, and is reddish. Perhaps equals β Centauri, but, being reddish, strikes the eye more." [P62]
Abbott	1856.2 ±	(−0.3)	"In the early part of this year [1856] I compared η Argus with the united light of the two components of α Centauri, which it nearly equalled." [A61]; "Equal [to] α Centauri." [A63a, A63b]
Moesta	1856 Jan–Aug	0.5	"... η Argus und Arcturus keinen bemerkbaren Unterschied in ihrer Farbe zeigen, welche letztere ich im Vergleich zu der eigenthümlich rothen Farbe des Mars gelb oder röthlich gelb nennen würde... η Argus immer um dieselbe Stufe grösser als β Centauri, um welche β Centauri grösser ist als α Crucis. Jedenfalls scheint die Grösse von η Argus in der erwähnten Periode keinen wahrnehmbaren Schwankungen unterworfen gewesen zu sein..." [M56]
Moesta	1858.0 ±	1.3 :	"... In vorigen und vorvorigen Jahre [1857 & 1858] schien dieser Stern in seiner Lichtstärke ziemlich constant und so hell als β Crucis zu bleiben..." [M59a, M59b]
Abbott	1858 Feb 10	1.3 :	"... a gradual diminution has taken place in the brightness of this star; it now only approximates to β Crucis; if any thing, rather inferior." [A61]
Stock	1858 Feb ±	1.1 :	"Three months ago [before June 4] it was less than α Crucis. Call α Crucis 1, η Argus was 1.3." [St58]
Abbott	1858 Mar 6	1.6 :	"... η Argus is comparable only to γ Crucis, the latter being of somewhat deeper colour and more sharply defined; the former dull and hazy." [A61]
Abbott	1858 Apr 2	1.6	"... to all appearance η Argus and γ Crucis are near alike both in size and colour." [A61]
Powell	1858.367	1.7 :	"Less than γ Crucis, but very little different... The break in the observations between 1856 and 1858 arises from my having been absent from India during that interval." [P62]
Abbott	1858 May 28	>1.6	"... η Argus gradually declining, γ Crucis being much the brighter of the two." [A61]
Stock	1858 Jun 1	>1.6	"... η Argus is now less bright than γ Crucis. The light has diminished very suddenly. I cannot say when, for it has stayed so long at one point that I had neglected to watch it... Three months ago [before June 4] it was less than α Crucis... A fortnight ago I found it diminished..." [St58]
Powell	1858.44	1.7 :	"Certainly inferior to β Crucis, and, I think, to γ Crucis." [P62]
Powell	1858.479	>1.6	"Less than γ Crucis." [P62]
Powell	1858.485	1.8	"Decidedly less than γ Crucis, but is considerably lower. A little brighter than ε Sagittarii, both stars having about the same altitude." [P62]

Continued on next page

Table 4 – continued from previous page

Observer	Date	m_V	Description and reference code
Abbott	1858 Oct 8	>1.6	"... γ Crucis decidedly very superior in splendour to η Argus." [A61]
Abbott	1859 Mar 27	2.0 :	"ε Argus is now more sharply defined than η Argus, it being the nearest comparison star." [A61]; "much inferior to ε Argus" [A63a]; "much inferior to υ Argus [sic]" [A63b]
Powell	1859.274	>1.6	"Considerably less than γ Crucis." [P62]
Powell	1859.328	2.4 :	"Much less than γ Crucis ; a little less than δ Argus ; a little greater than δ Crucis." [P62]
Moesta	1859 Jun	>1.6	"η Argus hat im Laufe des letzten Jahres sehr auffallend an Glanz abgenommen... Jetzt ist er schien kleiner, als γ Crucis." [M59a, M59b]
Abbott	1859 Jul 6	2.5	"η and κ Argus are now about equal ; the latter is estimated at 3rd. mag. = 3.35 of Herschel." [A61]
Powell	1859.931	2.6	"About equal to δ Centauri ; a little greater than θ Argus" [P62]
Powell	1859.98	2.6	"Equal to δ Centauri; a little greater than θ Argus; certainly less than γ Centauri." [P62]
Powell	1860.165	2.8	"Decidedly less than δ Centauri; about equal to δ Crucis" [P62]
Powell	1860.181	2.7	"Equal to δ Crucis nearly, perhaps a trifle superior. Both stars require attention to catch them in full moonlight." [P62]
Powell	1860.287	2.8	"Equal to δ Crucis; not much greater than θ Argus" [P62]
Powell	1860.326	2.8	"Equal to δ Crucis, the stars having about equal altitudes." [P62]
Tebbutt	1860 May 4	2.8	"η Argus was less than β Canis Majoris and about equal to β Canis Minoris. The standard stars were, however, too near the horizon for a good comparison, and the Moon was very bright. It was also about equal to δ Crucis and θ Argus." [T66]
Tebbutt	1860 May 18	2.9 :	"About equal to β Canis Minoris, but not quite so bright as β Canis Majoris." [T66]
Maclear, T.	1860 Oct	*4.0*	"... I wish the stars could be photographed for since the beginning of last year [1859] η Argus has been varying from the 3rd to the 4th magnitude. Now I think any practical astronomer would plant it in the 4th." [FWW]
Abbott	1860 Nov 2	>2.8	"... δ Crucis is scarcely equal to η Argus; if anything more sharply defined ; the latter looking sickly, as if dying out." [A61]; "inferior to δ Crucis" [A63a]
Powell	1860.972	>2.8	"A little less than δ Crucis." [P62]; "I am strongly impressed with the belief that the nebula about this variable star lost lustre very considerably in 1860; the fading away of η, which was going on at the time, ought to have brought out the nebula, whereas in my judgement the latter undoubtedly 'paled its fire.' I have also to call attention to the fact that the oval or lemniscate vacuity, which is represented by Sir John Herschel as possessing a clear boundary on the south, is now open in that direction." [P64]
Kulczycky	1860–62	*1.0*	"L'étoile si remarquable par ses changements d'éclat irréguliers, η du Navire, après avoir brillé comme une étoile de 1^{re} grandeur pendant les années 1860, 1861 et 1862, de manière à pouvoir être observée enne plein jour, me paraissait cependant diminuer pendant tout cet intervalle." [K65, PV]
Powell	1861.014	>2.8	"Less than δ Crucis ; less than θ Argus." [P62]

Continued on next page

Table 4 – continued from previous page

Observer	Date	m_V	Description and reference code
Abbott	1861 Mar 21	>2.8	"... δ Crucis is certainly very superior to η Argus, being much more readily found in the fading twilight." [A61]; "very inferior to δ Crucis" [A63a]
Powell	1861.249	>2.8	"Less than δ Crucis; less than θ Argus." [P62]
Abbott	1861 Apr 8	3.6 :	"... at this date η Argus has not more light than ε Crucis, the former having a faint milky appearance." [A61]; "equal to ε Crucis" [A63a]; "equal to δ Crucis [sic]" [A63b]
Abbott	1861 Apr 13	>3.6	"ε Crucis seen in the evening twilight 10 minutes before η Argus." [A61]; "inferior to ε Crucis" [A63a]; "inferior to ζ Crucis [sic]" [A63b]
Powell	1861.282	>2.8	"With telescope, less than the principal star in θ Argus." [P62]
Scott	1861 Apr 30	*3*	Positional determination [Sc62]
Scott	1861 May 4	*3.5*	Positional determination [Sc62]
Scott	1861 Jun 11	*2*	Positional determination [Sc62]
Abbott	1861 Jun 19	3.1	"Equal to 868 n Argus [N Velorum]." [A63a, A63b]
Abbott	1861 Jun 30	>3.1	"868 n Argus, seen in twilight before η Argus." [A63a, A63b]
Abbott	1861 Jul/Aug	3.5	"No difference between φ and η Argus" [A63a, A63b]
Abbott	1861 Sep 24	3.2	"By moonlight or twilight, when the nebulosity surrounding η Argus is destroyed, the star is identical both in size and light with λ Centauri" [A63a, A63b]
Abbott	1861 Oct 12	3.2	"Equal to λ Centauri." [A63a, A63b]
Heelis	1861 Dec 7	2.8 :	"Equal to δ Crucis" [He62]
Heelis	1861 Dec 9	*3.5*	[He62]
Abbott	1861 Dec 21	3.3 :	"Equal to either λ Centauri, or 943 P *Argo Navis*." [A63a, A63b]
Heelis	1861 Dec 24	*3.5*	[He62]
Abbott	1862 Jan 17/18	3.3 :	"With the Moon at full, and at the same altitude as η Argus, the star was still equal (by the naked eye) to 943 Lac [p Car], and λ Centauri, but with a low magnifying power η Argus was quite ruddy, as were all the stars in the vicinity." [A63a, A63b]
Tebbutt	1862 Jan 23	3.7 :	"... it was certainly not so bright as [θ Carinae]. It was about equal to [u Carinae]." [TM2]
Tebbutt	1862 Jan 26	3.7	"Not quite so bright as β Canis Minoris or θ Argus; perhaps slightly less than σ Orionis, and exactly equal to BAC 3740." [T66]
Abbott	1862 Feb 12	3.3 :	"No difference from the two former [λ Cen & p Car]" [A63a, A63b]
Heelis	1862 Mar 21	2.8 :	"Equal to δ but less than γ Crucis" [He62]
Ellery/White	1862 May	*3.0*	"This star was estimated of the 3rd magnitude in May, 1862..." [E69]
Jacob	1862 May 21	3.5 :	"η Argus is almost lost in the nebula — quite so to the naked eye. In [a] binocular, it looks a little brighter than ε Crucis, but far below δ." [Jc62]
Abbott	1862 Jun 14	3.4 :	"Not so large as 943 P. [p Car], and larger than q [Car], close stars." [A63a, A63b]
Heelis	1862 Jun 18	>2.8	"Less than δ Crucis" [He62]
Heelis	1862 Jun 22	*3.0*	[He62]
Tebbutt	1862 Jun 23	3.4 :	"About equal to ε Crucis and BAC 3526 [q Car] and 3619 [p Car], and considerably less than δ Crucis or θ Argus" [T66]
Heelis	1862 Jun 29	*<3.0*	[He62]
Abbott	1862 Jul 2	4.0 ::	"The star marked 943 Lac, in Argo Navis, is no longer a star of the 4th magnitude. In comparing η Argus with that star, together with q Lac., 11 Argus, t^1 Argus, and 926 t., all stars of the 5th magnitude, no difference could be seen"; "Equal to ε Crucis" [A63a, A63b]

Continued on next page

Table 4 – continued from previous page

Observer	Date	m_V	Description and reference code
Tebbutt	1862 Jul 3	3.9 :	ε Cru = γ Mus = p Car = q Car = δ TrA = λ Mus > ε TrA = u Car = η Car > ζ Cru = η Cru. First of a detailed series of star magnitude comparisons. "Where a star is found in two consecutive [lists], it is understood that its magnitude stands between the magnitude of the two [lists]." [TM16, TM18]
Tebbutt	1862 Jul 4	3.9	ε Cru = ε TrA = δ TrA = δ Mus > η Car = ρ Cen = σ Cen = τ Cen = γ Mus = u Car > ζ Cru = η Cru [TM16, TM18]
Tebbutt	1862 Jul 7	3.6	ε Cru = λ Mus = δ Mus = p Car = q Car = l Car = N Vel = ι Lup > γ Mus = a Car = φ Vel = η Car = u Car [TM16, TM18]
Tebbutt	1862 Jul 10	3.9	ε Cru = p Car = q Car = l Car = N Vel = δ Mus = BAC 3984 [λ Mus] = α Aps > u Car = η Car = x Car = γ Mus = ε TrA =δ TrA = α Aps = ρ Cen = σ Cen = τ Cen [TM16, TM18]
Tebbutt	1862 Jul 11	4.0	ε Cru = δ Mus = λ Mus > u Car = x Car = h Car = η Car = δ TrA =ε Mus = λ Mus = α Aps = γ Aps = ρ Cen = σ Cen = τ Cen > ζ Cru = γ Mus = η Cru = θ^1 Cru = η Car = ε TrA =δ TrA = β Aps = δ Aps = ι Lup [TM18]
Heelis	1862 Jul 11	>2.8	"Less than δ Crucis" [He62]
Tebbutt	1862 Jul 15	4.0	"Greater than BAC 3688 [w Car] and less than BAC 3740 [u Car]. The same result was obtained with a small telescope." [T66] ε Cru = p Car = q Car = λ Mus > ε Mus = u Car = x Car = η Car > ζ Cru = η Cru = η Car > BAC 3688 [TM16]
Tebbutt	1862 Jul 16	4.0	ε Cru = δ Mus = λ Mus = ρ Cen = σ Cen = τ Cen = p Car = q Car = I Car = γ Mus = δ TrA > ε Mus = ρ Cen = σ Cen = τ Cen = u Car = x Car = η Car = δ TrA = ε TrA > ζ Cru = η Cru = θ^1 Cru = η Car > BAC 3688 = K Car = κ TrA [TM16]
Tebbutt	1862 Jul 17	>3.7	"... I made η Argus less than u Carinae and greater than BAC 3688..." [T66] "All three stars were emplaced in the field of the telescope and could therefore be accurately compared." [TM18]
Jacob	1862 Jul 17	3.7 :	"η Argus is now scarcely so bright as ε Crucis." [Jc62]
Tebbutt	1862 Jul 18	4.0	ε Mus = λ Mus = u Car = η Argus = l Car = γ Mus = ε TrA = δ TrA > ζ Cru = η Cru = η Car > BAC 3688 [TM16, TM18]
Heelis	1862 Jul 20	*3.0*	[He62]
Heelis	1862 Jul 21	>2.8	"Less than δ Crucis" [He62]
Tebbutt	1862 Jul 22	4.0	"η Argus was of a magnitude intermediate between BAC 3740 and 3688, and very little brighter than ζ and η Crucis." [T66]
Heelis	1862 Jul 24	*2.5*	[He62]
Tebbutt	1862 Jul 24	4.0 :	ε TrA = u Car = x Car = ε Mus = l Car = η Argus = s Car > ζ Cru = ε Mus = l Car = h Car = η Car = η Cru = s Car > BAC 3688 = m Car [TM16]. "Slightly less than BAC 3740 and 3818, and exactly equal to BAC 3594." [T66, TM18]
Tebbutt	1862 Jul 25	4.0 :	"Less than BAC 3740 and 3818, equal to BAC 3594, and greater than BAC 3655 and 3688." [T66]; "if u Carinae and x Carinae = 5.0, therefore η Argus = 5.2" [TM18]
Tebbutt	1862 Jul 26	4.0 :	"u Carinae = x Carinae = 1.0, η Argus = s Carinae = 0.8, BAC 3688 = 0.4, t^2 Carinae or BAC 3655 = 0.3, t^1 Carinae or BAC 3642 = 0.1." [TM18]
Heelis	1862 Jul 27	*3.0*	[He62]
Tebbutt	1862 Aug 22	3.8	"η Argus = s Carinae" [TM18]

Continued on next page

Table 4 – continued from previous page

Observer	Date	m_V	Description and reference code
Tebbutt	1862 Aug 27	>3.7	"... η Argus was decidedly less than u Carinae." [T66]
Tebbutt	1862 Aug 28	3.8	"Greater than BAC 3688; equal to BAC 3594; and less than BAC 3740." [T66]
Abbott	1862 Aug/Sep	3.6 :	"Equal to ε Crucis." [A63a, A63b]
Abbott	1862 Nov 14	*5.0*	"For the last five months η Argus has not exceeded the 5^{th} magnitude. Below the Pole or by moonlight, it is scarcely visible as a star to the naked eye." [A63a, A63b]
Abbott	1863 Mar 30	(4.9)	"Equal to z and 977 Lac." [A63a]; "equal to ξ [sic] and 977 Lac." [A63b]
Tebbutt	1863 Apr 15	4.0	"Greater than BAC 3655 and 3688, and less than ε Crucis and BAC 3740 and 3818. It was decidedly a shade less brilliant than BAC 3594." [T66]
Tebbutt	1863 Apr 16	4.3 :	"Somewhat less than ω^1 and ω^2 Scorpii and BAC 3594" [T66]
Abbott	1863 Apr 23	(5.5)	"Star in the zenith ; by the naked eye scarcely recognised, as a star. With a low power it was equal to 951, 954, and 977, Lac." [A63a, A63b]. Abbott's estimate seems incorrect; perhaps comparison stars misidentified.
Maclear, T.	1863 May 17	*4.0*	"After you left the Cape I fancied that the magnitude varied at irregular intervals, but upon the average – diminishing: during the last twelve years the rather rapid diminution has glided down so far, that it is now necessary to think for an instant which is η Argus or which is not. Unquestionably the magnitude is less now than that of δ Crucis which is regarded as the third or barely that. The light of the assemblage in the neighbourhood interferes with precise estimate; however, as viewed through an opera glass & without reference to δ Crucis my estimate would be the 4^{th}..." [FWW]
Abbott	1863 May 23	*6*	"A drawing made of the object, η Argus quite distinct within the dark space which is open at both ends." [A63a, A63b]
Tebbutt	1863 May 24	4.2	"Less than ε Crucis and BAC 3740 and 3818; greater than BAC 3688; and about equal to ω^1 and ω^2 Scorpii. It was decidedly a shade less brilliant than BAC 3594, which was very nearly equal to BAC 3818." [T66]
Ellery/White	1863 Oct 14	*5.0*	RA determination [E66]; "This star was estimated of ... the 5th [magnitude] in October 1863." [E69]
Kulczycky	1863 Nov 20	...	"La dimunition est devenue plus sensible en 1863, au point que le 20 novembre de cette année je n'ai pu l'observer à 6^h 46^m du matin" [K65, PV]
Tupman	1864 ±	...	"During 1863, it was just visible to the naked eye, getting dimmer very slowly throughout the year; and during the first six months of 1864 it was invisible to all but the finest eyes." (Ch64)
Tebbutt	1864 Mar 23	4.6	"Equal to BAC 3655 and 3688, both by the naked eye and the telescope. Full Moon." [T66]
Tebbutt	1864 Apr 23	4.8 :	"A shade less than BAC 3655 and 3688 ; it was certainly not greater. It was brighter than BAC 3642, which could only be seen by oblique vision." [T66]; also ε Cru = u Car > s Car = x Car > w Car = t^2 Car > η Car > BAC 3642 [TM3]
Kulczycky	1864 Apr–Jun	*2.5*	"Pendant l'anee 1864, en avril, mai, juin... elle se détachait bien au milieu de sa nébulosité et paraissait de 2^e ou de 3^egrandeur." [K65, PV]

Continued on next page

Table 4 – continued from previous page

Observer	Date	m_V	Description and reference code
Tebbutt	1864 May 6	4.8 :	"I carefully compared Eta Argus with BAC 3642, 3655, 3688 & 5501. It was brighter than [BAC] 3642, very slightly inferior to 3655 and 3688, and about equal to 5501." [TM3]
White	1864 May 6	*4.5*	RA and NPD determinations [E66, LS70]
Tebbutt	1864 May 11	4.8 :	"Eta Argus was slightly inferior to BAC 3655 but brighter than BAC 3642... Eta was about equal to BAC 5501..." [TM3]
White	1864 May 19	*4.5*	RA determination [E66, LS70]
Tebbutt	1864 May 31	4.8 :	"About equal to BAC 5501 [= 22 Sco]... and about equal to or perhaps slightly inferior to BAC 3655 and 3688." [T66]
Tupman	1864 May/Jun	4.6	Tupman gives magnitude = 5.41 (based on J. Herschel's scale) and notes colour as 'orange'. Reduction to V system is based on list of magnitudes published in [Tu73]
Tebbutt	1864 July 28	4.9 :	"Somewhat inferior to BAC 3655 and 3688, and slightly superior to BAC 3642." [T66]
Moesta	1865 Feb	*6.0*	"... Eta Argus noch fortwährend an Helligkeit abnimmt und im jüngst verflossenen Februar bis zu einem Sterne 6ter Grösse herabgesunken war. Der Ort des Sterns ist immer durch den hellen Schimmer der vielen kleinen Sterne, welche Eta Argus umgeben, leicht erkennlich... Ich habe seit 1857 diesen Stern wiederholt mit benachbarten Sternen verglichen und werde mir erlauben, Ihnen diese Vergleichungen gelegentlich mitzutheilen." [M65]
Tebbutt	1865 Feb 22	>4.7	[T66, TM3, TM18]
Tebbutt	1865 Feb 23	>4.7	[T66, TM3, TM18]
Tebbutt	1865 Feb 24	>4.7	"The last three nights being clear at 9 pm, I compared Eta Argus with the two small stars BAC 3655 & 3688: it was certainly inferior to both of them; the stars were at a great altitude." [T66, TM3, TM18]
Tebbutt	1865 Mar 14	>4.7	"η Argus was distinctly visible to the naked eye, notwithstanding the Moon. It was certainly not quite so bright as BAC 3655 or 3688." [T66, TM3]
Abbott	1865 Mar 25	*5.5*	"Being in Melbourne on the night of the 25th March, 1865, which was a very fine one, and happening to look towards η Argus, I fancied that the star appeared as a distinct point in the Nebula [with the unaided eye]. I immediately proceeded to the Observatory, Mr. Ellery with his accustomed kindness, allowing me to take possession of the Equatorial... with the comparative eye-piece, considered the star to be 5.5." [A68]
Kulczycky	1865 Apr 3	...	"Mais en 1865, le 3 avril, j'ai trouvé avec étonnement que cette étoile ne se distinguait plus dans nébeleuse." [K65, PV]
Kulczycky	1865 Apr 9	4.6	"Le ciel, nuageux, ne m'a permis de la revoir que dans le 9 avril. Ce jour je l'ai examinée au moyen de la lunette de passages et d'une lunette à pied grossissant 56 fois. Je l'ai comparée aux étoiles voisines; p et q du Navire de 4^e et de 5^e grandeur étaient beaucoup plus brillantes, et η du Navire me paraissait exactement égale au [BAC] 3688, estimée $5^e 1/2$ grandeur dans le Catalogue mais qui me paraît bien de 6^e." [K65, PV]
Kulczycky	1865 Apr 24	4.5 :	"Depuis cette époque [Apr 9] l'étoile me paraît changer très-peu; je crois cependant qu'elle subit quelques fluctuations peu sensibles dans son éclat. Ainsi, le 24 avril, elle me paraissait plus brillante que le [BAC] 3688." [K65, PV]

Continued on next page

Table 4 – continued from previous page

Observer	Date	m_V	Description and reference code
Tebbutt	1866 Feb 16	>4.7	"Sky brilliantly clear. η Argus was considerably less than BAC 3655 or 3688." [T68]
Tebbutt	1866 Mar 22	>4.7	"Less than BAC 3655 or 3688." [T68]
Maclear, G.	1866 May	*4.3*	Compared with ι Argus, α Hydrae and Regulus on May 14, 21, 22 [In03]
Tebbutt	1866 Jun 29	>4.7	"Much less than BAC 3655 or 3688." [T68]
Tebbutt	1866 Jul 2	>4.7	"Eta Argus scarcely distinguishable by the naked eye at 6.15 pm, and was much less than BAC 3655 or 3688." [TM18]
Tebbutt	1866 Jul 4	5.7 :	"η Argus was much less than BAC 3655 or 3688, and even less than BAC 3642. It could be distinguished only by oblique vision; BAC 3680 and 3673 could not be distinguished at all with the naked eye." [naked eye observation; m = 5.2, but then corrected for bright background by Δm = 0.5. Refer to text] [T68]
Tebbutt	1866 Dec 3	>4.7	"Scarcely distinguishable, and was very much less than BAC 3655 or 3688." [T68]
Tebbutt	1866 Dec 8	5.6 ::	"η Argus was much less than BAC 3655 or 3688. It was seen as a distinct stellar point in the nebula by oblique vision. It might be considered about equal, or perhaps superior, to BAC 3642, the latter being seen by oblique vision." [m = 5.1, but then corrected for bright background, Δm = 0.5; see text] [T68]
Tebbutt	1866 Dec 11	5.6 :	"By means of a small telescope [Lynch 4 cm], η Argus was estimated to be brighter than BAC 3673, and perhaps slightly inferior to BAC 3642 or 3680." [T68]
Tebbutt	1866 Dec 12	5.9 :	"[Using Jones 8cm refractor] BAC 3642 and 3680 were next in the order of brightness, and appeared to be about equal; BAC 3648 next; then η Argus, which was about equal to BAC 3657. BAC 3673 was less than η Argus. The magnitude of η Argus by a very careful examination was intermediate between those of BAC 3648 and 3673, and about equidistant between BAC 3673 and 3680." [T68]
Behrmann	1866–67	≤5.5 :	η Car is included in Behrmann's catalogue and noted as variable, but the magnitude(s) are not given. However stars to V ≈ 5.5 are noted in this part of the southern Milky Way. [Be74]
Tebbutt	1867 Jan 12	5.6 :	"η Argus and 3680 were nearly equal; but 3680 decidedly the brighter..." [T68]
Tebbutt	1867 Jan 26	>5.4	"η Argus was greater than BAC 3673 and less than BAC 3680." [T68]
Tebbutt	1867 Mar 2	5.6 :	"η Argus ranging between BAC 3680 and BAC 3673, but approximately to BAC 3680" and "BAC 3655, the orange coloured star, was the brightest and Eta Argus was between BAC 3680 and 3673, but nearer to BAC 3680." [T68, TM3]
Sinfield	1867 Mar 28	*5.5*	Manuscript observation [In03]
Maclear, G.	1867 Mar 30	*5.8*	Manuscript observation [In03]
Maclear, G.	1867 Apr 6/7	*5.5*	Manuscript observation [In03]
Sinfield	1867 Apr 10	*5.5*	Manuscript observation [In03]
Tebbutt	1867 Apr 17	5.6 :	"η Argus was considerably brighter than B.A.C 3673 and slightly inferior to BAC 3680." [T68]
Tebbutt	1867 May 4	>5.4	"η Argus less than BAC 3680, and greater than BAC 3673." [T68]
Tebbutt	1867 Jul 27	5.6 :	"The magnitude of η Argus was nearer that of 3680 than that of 3673." [T68]
Tebbutt	1867 Dec 28	6.1 :	"The inferiority of η Argus to BAC 3680 was marked; but it was not much superior to BAC 3673." [T68]

Continued on next page

Table 4 – continued from previous page

Observer	Date	m_V	Description and reference code
Tebbutt	1867 Dec 31	6.0 :	"η Argus was certainly less than BAC 3680, and somewhat greater than BAC 3673." [T68]
Abbott	1868 Feb	*6.0*	"... for many times since that period [1865] the star has not reached more than the 6th magnitude, and may be so estimated at present." [A68]
Tebbutt	1868 Feb 26	5.7 :	"η Argus ranged between BAC 3680 and BAC 3673, but approximated to BAC 3680" [T68, TM3]
Tebbutt	1868 Feb 27	>5.4	"η Argus was greater than 3673, and less than 3680." [T68]
Tebbutt	1868 Apr 13	6.1 :	"... 3680 considerably brighter than η Argus, and η Argus slightly superior to 3673. The superiority of BAC 3680 to η Argus was very marked." [T68]
Tebbutt	1868 Apr 22	5.9 :	"The inferiority of Eta to 3680, and its superiority to 3673, were marked." [T68]
Tebbutt	1868 Apr 23	...	"... I examined Eta Argus with the view to ascertain if it were distinguishable by the naked eye. With great difficulty by oblique vision I could occasionally detect a stellar point in the nebula. How remarkable now is the contrast between Eta Argus and Theta Argus..." [TM3, TM18]
Tebbutt	1868 Apr 29	>5.4	"... η Argus was intermediate between BAC 3680 and 3673..." [TM3]
Tebbutt	1868 May 9	6.1 :	"Eta Argus was compared in the transit telescope tonight without illumination, with BAC 3680 and 3673. It appeared to be of an intermediate magnitude, but approximated to 3673, the smaller star." [TM3]
Tebbutt	1868 May 16	6.2	"The following comparisons of stars in the field of the Jones telescope with the low power were made about 8pm. The stars are given in descending sequences... JH 1203 > JH 523 or Eta Argus > JH 2 = JH 387 = JH 522 = JH 1183 > JH 403 + JH 404 > JH 1 = JH 630 > JH 452... The last three sequences belong to a group much less than the first three." [TM3]
Tebbutt	1868 May 19	6.3 :	"Of the compared stars, BAC 3655 was the brightest, next to BAC 3655 stood BAC 3680 ... Next stood JH 1203, then Eta Argus which appeared exactly equal to JH 387 and JH 522, and last in order BAC 3673 which appeared to equal JH 1183. The descending magnitudes of these stars follow so closely on each other that it would be impossible to insert intermediate magnitudes... No difference could be distinguished between JH 387 and JH 522, but JH 1203 was certainly greater than JH 1183." [TM3]
Tebbutt	1868 May 22	6.0	"BAC 3655 the orange star was by far the brightest of the compared stars. BAC 3680 was next in order, then η Argus which appeared to equal 1203 of Herschel's Catalogue. Extremely close upon these follow 387, 522, and 1183 of Herschel's Catalogue, which were exactly equal. Extremely close after these three stars follows BAC 3673 ... [No. 1] of Herschels Catalogue is considerably less than BAC 3673." [TM3]
Tebbutt	1868 May 26	6.0	"BAC 3655 > BAC 3680 > η Argus = JH 1203 > JH 387 = JH 522 = JH 1183 > JH 2 > (JH 403 + JH 404) > JH1 = JH 630 = JH 844 > JH 693 = JH 452 = JH 458 = JH 862 = JH 953 = JH 575.... The stars JH 693 and JH 862 are ruddy stars, but the latter is not so described in Herschel's Catalogue... I fancy η Argus has a slight orange tinge." [TM3]

Continued on next page

Table 4 – continued from previous page

Observer	Date	m_V	Description and reference code
Tebbutt	1868 Jun 12	6.3 :	"The following descending sequence of magnitudes was observed with the Jones telescope, and eyepiece No. 1: JH 1203 > η Argus = JH 387 = JH 522 > JH 2 = JH 1183 > JH 1. JH 1203 was superior to η Argus, the superiority was very slight. The comparisons were made at 6.30 pm. BAC 3680 was superior to JH 1203." [TM3]
Tebbutt	1868 Jul 21	6.1 :	"By the first comparison I made η Argus greater than JH 2 and JH 522 which were equal, and JH 1 the least of all. By the second comparison I made JH 387 greater than JH 1; JH 2, JH 1203, JH 522 and 1183 equal to one another but greater than JH 387, and η Argus the greatest of all. η Argus appeared to be very slightly superior to JH 2 ... and greatly superior to JH 1. Its inferiority to BAC 3680 was quite marked. BAC 3655 was superior to BAC 3680." [TM3]
Tebbutt	1868 Jul 31	6.0 :	"... I compared Eta Argus with neighbouring stars as follows: BAC 3655 the orange star was brighter than BAC 3680, and BAC 3680 then Eta Argus. JH 2, JH 522, JH 1183, and JH 1203 appeared to be about equal and Eta Argus certainly somewhat brighter than any of the four. JH 387 appeared to rank next in order of brightness, and JH 1 last of all." [TM3]
Tebbutt	1868 Aug 24	6.0 :	"At 7.35 I compared of η Argus with the following stars BAC 3680 & 3673 and JH 1, 387, 522, 1183, and 1203... BAC 3680 was brighter than η Argus, and η Argus than BAC 3673, JH 522 and JH 1203 were about equal, and stood next to η Argus. BAC 3673 = JH 1183, and were less than JH 522 and JH 1203, JH 387 was next to BAC 3673 and JH 1183 ..." [TM3]
Herschel, Lt.J.	1868 Nov 22/24	*7.5*	"... η itself I estimate (ignorantly) at 7 to 8 mag." [H69]
Tebbutt	1868 Dec 17	6.3	"... BAC 3680 was the brightest; JH 1203 appeared very slightly brighter than Eta Argus; Eta Argus, JH 1183, 387, & 522 appeared to be equal. JH 2 next, and JH 1 last... The stars Eta Argus, JH 387, 522, 1183 & 1203 differed so slightly from one another that it was difficult to assign the position of each in the order of relative brightness." [TM3]
Stock	1869 Jan	...	"... I now carefully look at it each clear night. I think that it is getting brighter." [TM15]
Tebbutt	1869 Feb 8	6.0 :	"The magnitudes are arranged in descending order, BAC 3655 > BAC 3680 > Eta Argus = JH 1203 > JH 522 = JH 1183 > JH 387 > JH 2 > JH 1 = JH 403 = JH 844 > JH 630. JH 387 appeared to be very slightly brighter than JH 2 ... JH 1203 was decidedly brighter than JH 1183, and JH 522 than JH 387." [TM2]
Tebbutt	1869 Feb 18	6.0 :	"The descending sequence was as follows: JH 1203 = Eta Argus > JH 387 = JH 522 > JH 1183 > JH 2 > JH(403+404) > JH 1 = JH 630. It was difficult to distinguish between the relative magnitudes of Eta Argus, JH 1203, JH 387, JH 522, and JH 1183. I thought JH 1203 was perceptibly brighter than JH 1183. Eta Argus was brighter than BAC 3673 or JH 2, and less than BAC 3680. BAC 3655 was brighter than BAC 3680. JH 637 is a ruddy star. The comparisons were made at 8.15 pm." [TM3]

Continued on next page

Table 4 – continued from previous page

Observer	Date	m_V	Description and reference code
Tebbutt	1869 Feb 23	6.0 :	"... I made the following comparison of stars. They are arranged in descending order of their magnitudes. Time 7.45 pm. BAC 3655 > BAC 3680 > Eta Argus = JH1203 > JH387 = JH522 = JH1183 > JH2 > JH1." [TM3]
Tebbutt	1869 Mar 10	6.0	"Tonight was nearly cloudless and I compared Eta Argus with neighbouring stars... as follows: JH 1203 equalled Eta Argus, JH 387 and JH522 were next and equal to each other, JH 1183 and JH 2 were next and equal... BAC 3655 was brighter than BAC 3680 and both brighter than Eta Argus: Eta Argus was nearer the magnitude of JH 2 than that of BAC 3680." [TM3]
Tebbutt	1869 Apr 19	<6.4	"BAC 3655 was the brightest, 3680 next, Eta Argus next, and 3673 least of all." [TM3]
Tebbutt	1869 May 19	6.2	"I compared η Argus tonight with BAC 3655, 3673, and 3680 as they crossed the path of the transit telescope, with the diagonal eyepiece, and without illumination. They were all seen in the field together. BAC 3655 was by far the brightest, BAC 3680 next, and η Argus but very little superior to BAC 3673. I also compared η Argus in the Jones telescope immediately afterwards, with eyepiece No. I. BAC 3655, the orange star, was by far the brightest, BAC 3680 next The inferiority of η Argus to BAC 3680 was marked, but its superiority to BAC 3673 was not so marked. η Argus appeared to be about the same magnitude as the four stars numbered 387, 522, 1183, and 1203 of Herschel's Catalogue of the Nebula." [TM3]
Tebbutt	1869 May 26	6.3	"I compared η Argus... with BAC 3642, 3673, 3655, and 3680 as they crossed the field of the telescope of the transit instrument, with the diagonal eyepiece. BAC 3655 was the brightest, 3642 next, 3680 next, and η Argus and 3673 about equal. I then compared η Argus with 3655, 3673, and 3680 by means of the Jones telescope... 3655 was the brightest, 3680 next, and η Argus was considerably less than 3680 and slightly greater than 3673." [TM3]
Ellery	1869 Jun 21	*7.0*	"At... Melbourne (21st June last), Mr. Ellery considered the star η to be of the 7th magnitude...." [A70, A71a]
Le Sueur	1869 Jun 21	*6.5*	"... Mr. Le Sueur thought it to be $6\frac{1}{2}$." [A70, A71a]
Tebbutt	1869 Jun 25	6.0 :	"BAC 3655 was by far the brightest, Eta Argus was considerably less than BAC 3680, and somewhat brighter than 3673. Eta Argus was also a shade brighter than the four stars 387, 522, 1183, and 1203. No. 1 was the least of all. The moon was in the full, and although the nebula could be seen with the naked eye, Eta Argus could not be distinguished from it." [TM3]
Tebbutt	1869 Jul 12	...	"I found that although the nebula could be seen, the star could not be distinguished [with the naked eye] even by oblique vision." [TM18]
Tebbutt	1869 Jul 23	6.2 :	"BAC 3655, the reddish or deep orange star, was by far the brightest, BAC 3680 the next; Eta Argus was remarkably less than BAC 3680, but not much superior to BAC 3673... JH 2, JH 387, JH 522, JH 1183, and JH 1203 were about equal to one another. JH 1 was the least of all." [TM3]

Continued on next page

Table 4 – continued from previous page

Observer	Date	m_V	Description and reference code
Tebbutt	1869 Aug 10	6.3 :	"A careful comparison showed that BAC 3680 was considerably brighter than Eta Argus, and that the latter was very slightly superior to BAC 3673... which was considerably brighter than JH 1, and Eta Argus was equal to the four stars JH 387, JH 522, JH 1183, and JH 1203... I fancied that η Argus was of a light straw colour. It is invisible to the naked eye... [BAC 3642] as well as BAC 3655 is light orange... BAC 3526 is reddish, and BAC 3703 deep orange." [TM3]
Tebbutt	1869 Sep 6	6.2 :	"BAC 3680 was much the brightest, Eta Argus considerably less than BAC 3680 and but very slightly superior to BAC 3673. Eta Argus was about equal to the four stars JH 387, JH 522, JH 1183, and JH 1203, and much brighter than JH 1... All the stars were low." [TM3]
Tebbutt	1869 Sep 21	6.2 :	"BAC 3655 was by far the brightest, and BAC 3680 next Eta Argus was less than BAC 3680 and but slightly superior to BAC 3673. Eta Argus was about equal to JH 387, JH 522, JH 1183, and JH 1203." [TM3]
Tebbutt	1869 Dec 6	6.2 :	"Eta Argus still appeared to be of a magnitude between that of BAC 3680 and BAC 3673, but nearer that of the latter star. It was about equal to 387, 522, 1183, and 1203 of Herschel's Catalogue. 1203 was certainly superior to 1183, and JH 522 I think slightly superior to 387." [TM3]
Tebbutt	1869 Dec 25	6.2 :	"BAC 3655, the orange star was by far the brightest, BAC 3680 the next, Eta Argus was inferior to BAC3680 and but slightly superior to BAC 3673. It was about equal to the four stars Nos. 387, 522, 1183 and 1203 of Herschel's Catalogue. 1203 appeared to be brighter than 1183. The stars were at a considerable altitude and the moon absent." [TM3]
Ellery	1870 Jan	*6.5*	"Mr. Ellery estimated it last year as a $6\frac{1}{2}$+, and now thinks it is somewhat brighter" [LS70]
Tebbutt	1870 Jan 8	6.3 :	"Eta Argus was about equal to JH 387, JH 522 , JH 1183, and JH 1203. It was inferior to BAC 3680, and perhaps slightly superior to BAC 3673." [TM4]
Tebbutt	1870 Jan 13	6.0	"... JH 1203 and η Argus about equal, and somewhat brighter than JH 387, JH 522, JH 1183 and JH2 which were about equal. . . The magnitude of Eta was between that of BAC 3680 and JH 2." [TM4]
Tebbutt	1870 Jan 22	6.1	"BAC 3655, the orange star, was the brightest, BAC 3680 next, next followed Eta Argus, JH 522, and JH 1203, next JH2 or BAC 3673, JH 387, and JH 1183 and last of all JH 1." [TM4]
Tebbutt	1870 Jan 28	6.0 :	"Eta Argus equalled JH 1203. JH 522 was equal to JH 1183, and both less than Eta Argus and JH 1203. JH 387 and JH 2 were equal and less than JH 522 and JH 1183." [TM4]
Abbott	1870 Jan 28	*7.0*	"On my return to Hobart Town, I continued to observe it, and from careful comparisons made with the stars given in the drawing, and recorded in the Cape Catalogue, it cannot be more than the seventh magnitude... With the nine seventh magnitude stars in the field, they are by careful comparison exactly the magnitude of η which is left amongst them not marked." [A71a]

Continued on next page

Table 4 – continued from previous page

Observer	Date	m_V	Description and reference code
Tebbutt	1870 Feb 8	6.0	"The superiority of Eta Argus to BAC 3673 and its inferiority to BAC 3680 were marked."; also Eta = JH 1203. [TM4]
Tebbutt	1870 Feb 25	6.2 :	Between JH 1203, and JH 522 = JH 1183 [TM4]
Tebbutt	1870 Mar 25	6.2	"... JH 1203 next, then Eta Argus. Next followed JH 387, JH 522, and JH 1183 which were equal. BAC 3673 or JH 1 was somewhat less than these..." [TM4]
Tebbutt	1870 Mar 26	6.2	"... Eta Argus was slightly inferior to JH 1203 and slightly superior to JH 387, JH 522, and JH 1183 which were about equal to one another. JH 1 was very slightly inferior to the last mentioned three stars..." [TM4]
Tebbutt	1870 Apr 12	...	"The nebula about Eta Argus was distinct to the naked eye tonight, although the moon was very bright..." [TM18]
Tebbutt	1870 May 7	6.0 :	"It was about equal to JH 1203, and slightly superior to JH 387, 522, and 1183." [TM4]
Tebbutt	1870 Jun 3	6.3 :	"The superiority of [BAC] 3680 to Eta Argus was very marked, but the latter was very slightly, if any, superior to 3673." [TM4]
Tebbutt	1870 Jun 6	6.1 :	"... next followed Eta Argus and 1203 which were about equal... I omitted to state that Eta Argus last evening, was very much inferior to BAC 3680 and but slightly superior to BAC 3673." [TM4]
Tebbutt	1870 Jun 8	6.2	"... JH 1203 next, which appeared to be very slightly brighter than Eta Argus, next followed Eta Argus and JH 522 which appeared about equal, next followed very closely JH 387 and JH 1183. Eta Argus was very slightly superior to BAC 3673." [TM4]
Tebbutt	1870 Jun 16	6.1 :	"Eta Argus was about equal to JH 1203 and JH 522 and slightly superior to JH 387 and JH 1183... Eta has decidedly diminished in brilliancy since 1867." [TM4]
Tebbutt	1870 Jul 4	6.2	"Eta Argus was slightly inferior to JH 1203, and slightly superior to JH 522 and BAC 3673 which two were about equal. . ." [TM4]
Tebbutt	1870 Aug 20	6.0 :	"Eta Argus was very slightly superior to BAC 3673, JH 522, and JH 1203..." [TM4]
Tebbutt	1870 Aug 25	5.9 :	"I thought Eta Argus very slightly exceeded JH 522 and 1203. JH 387 and 1183 were somewhat less... Eta Argus I thought had a slight reddish tint." [TM4]
Tebbutt	1870 Sep 26	6.0 :	"... Eta Argus, which was very slightly superior to BAC 3673 or JH2. Eta Argus appeared to be about equal to JH 522, somewhat superior to JH 387 and JH 1203 which were equal [sic]. JH 1183 was inferior to JH 387 and 1203. These comparisons are very unsatisfactory... The stars were indistinct." [TM4]
Tebbutt	1870 Sep 27	6.0 :	"... The stars were, however, badly defined and the comparisons therefore unsatisfactory. BAC 3680 was much brighter than Eta Argus and the latter was perhaps slightly superior to BAC 3673. Eta Argus was perhaps slightly superior to JH387 and JH 1203 which were about equal. JH 522 appeared slightly inferior to these two stars and superior to JH 1183." [TM3]
Gould	1870 Nov 26	(5.4)	"No very great change has taken place in this remarkable star since my first observation, 1870, Nov. 26, although its light has certainly diminished since that time, when it was about equal to No. 222." [G79, p. 255]

Continued on next page

Table 4 – continued from previous page

Observer	Date	m_V	Description and reference code
Gould	1870 Nov 28 ±	6.2 :	"A day or two later [from Nov 26] it appeared intermediate in brightness between Nos. 240 and 239. Repeated observations gave for several months the same result corresponding to a magnitude 6.8 of our present scale." [G79, p. 255]
Tebbutt	1870 Nov 28	6.0 :	"... next followed BAC 3680, next Eta Argus and JH 1203 which were about equal, next JH 522, and lastly JH 387, 1183 and JH 1 [sic], the last three being about equal." [TM4]
Tebbutt	1870 Dec 6	6.2 :	"... BAC 3680 next, JH 1203 next, then followed in descending order Eta Argus, JH 1183, JH 522, JH 387, and JH 1. JH522 = BAC 3673 or JH2." [TM4]
Tebbutt	1870 Dec 29	5.9 :	"Eta Argus appeared to be very slightly superior to JH 1203 and somewhat superior to JH 2 or BAC 3673..." [TM4]
Tebbutt	1871 Jan 14	6.1 :	"Eta Argus was I think somewhat less than JH 1203, considerably brighter than BAC 3673, and much less than BAC 3680." [TM4]
Tebbutt	1871 Jan 25	6.2 :	"Eta Argus was considerably less than BAC 3680 and but little brighter than BAC 3673." [TM4]
Tebbutt	1871 Feb 13	6.0 :	"The following were as nearly as could be judged the descending order of magnitudes. BAC 3655 > BAC 3642 > BAC 3680 > Eta Argus = JH 1203 > JH 522 > BAC 3673 or JH 2 = JH 387 = JH 1183 > JH 1.... Eta Argus was much inferior to BAC 3680 and but little superior to BAC 3673." [TM4]
Abbott	1871 Feb	*7.0*	[A71b]
Russell	1871 Feb 17	6.3	"At 10 30 p.m. a fog in the upper atmosphere came on, which increased, and enabled me to get a very satisfactory estimate of the brightness of η. It is between the two following stars, Nos. 71 and 72, but nearer to 71 than 72" [R71a,b]
Russell	1871 Feb 24	6.3 :	"Compared η with other stars, it is between 71 and 72..." [R71a,b]
Gould	1871 Mar	6.1 :	"... and in March, 1871, its magnitude must have been about 6.8" [G79, p. 255]
Tebbutt	1871 Mar 20	6.0	"BAC 3655 ... was the brightest, BAC 3680 next, next followed Eta Argus and JH 1203 which were equal, next JH 522, and JH 1183 which were also equal, and lastly JH 387 and BAC 3673... The superiority of Eta Argus to BAC 3673 and its inferiority to BAC 3680 were marked... I could not with the naked eye detect Eta Argus or BAC 3673 in the slightest degree." [TM4]
Tebbutt	1871 Apr 3	6.1	"BAC 3680 was by far the brightest of the compared stars. Eta Argus and JH 1203 were next and about equal. JH 522 was less than these, and somewhat greater than JH 387 and JH 1183. The magnitude of Eta Argus was much inferior to that of BAC 3680 and somewhat superior to that of BAC 3673..." [TM4]
Tebbutt	1871 Apr 22	6.4	"BAC 3655 was by far the brightest, BAC 3680 was much inferior to BAC 3655 and much superior to Eta Argus which appeared to be exactly equal to BAC 3673." [TM4]
Tebbutt	1871 May 3	6.0	"Eta Argus and JH 1203 appeared to be about equal to each other, and greater than JH 522 [QZ Car]. JH 522 was superior to JH 1183 and JH 387. Eta Argus appeared to be equidistant in magnitude between BAC 3680 and 3673, perhaps somewhat nearer the latter." [TM4]

Continued on next page

Table 4 – continued from previous page

Observer	Date	m_V	Description and reference code
Russell	1871 May 5	>6.0	"Definition very fine. Carefully compared η with [R]71 and 72, disc looks as large as 72 but not so bright nor so well defined. Power 150. 230 gives same results. η looks almost like a planet's disc compared with the star." [RM1]
Tebbutt	1871 May 16	6.3	"[Eta] appeared to be nearly as possible equal to BAC 3673 or JH 2, JH 522 and JH 1183, and somewhat superior to JH 387. JH 1203 was certainly superior to Eta Argus..." [TM4]
Tebbutt	1871 May 31	6.1 :	"Eta Argus was greater than JH 522 and JH 1183 which were equal, and less than JH 1203. JH 387 was less than any of the stars just mentioned. Eta Argus appeared... midway between BAC 3680 and BAC 3673 and I thought it redder than usual." [TM4]
Tebbutt	1871 Jun 29	6.0 :	"Eta was very slightly superior to BAC 3673... It appeared to be about equal to JH 1203." [TM4]
Tebbutt	1871 Jul 13	6.5 :	"Eta was decidedly less than JH 522, 1183 and 1203 and I think less than JH 387. It was about equal to BAC 3673. Eta appears to be more dull and red than it used to be." [TM4]
Tebbutt	1871 Jul 28	6.5 :	"Eta Argus was about equal to BAC 3673, slightly inferior to JH 387 and JH 1183 and certainly inferior to JH 522 and JH 1203." [TM4]
Tebbutt	1871 Aug 31	6.2 :	"It was much less than BAC 3680 and very slightly brighter than BAC 3673. Eta was certainly brighter than JH 387 and JH 522 and about equal to JH 1183 and JH 1203." [TM4]
Tebbutt	1871 Oct 11	6.3	"Eta Argus was less than JH 1203, and perhaps slightly superior to JH 1183. It was superior to JH 522 which was again superior to JH 387... perhaps a shade brighter than BAC 3673." [TM4]
Tebbutt	1871 Nov 24	6.3	"Eta Argus was much inferior to BAC 3680 and somewhat superior to BAC 3673. It was about equal to JH 522 and JH 1183, inferior to JH 1203 and superior to JH 387. It was much superior to JH 1... The star appeared to be slightly red." [TM4]
Tebbutt	1871 Dec 13	6.3	"The stars were however low. Eta was equal to JH 522 and JH 1183, less than JH 1203, and greater than JH 387. Eta was nearest in magnitude to BAC 3673 than to BAC 3680." [TM4]
Tebbutt	1871 Dec 29	6.3	"Eta was superior to JH 387, equal to JH 522 and JH 1183 and inferior to JH 1203. It was considerably less than BAC 3680 and rather greater than BAC 3673." [TM4]
Tebbutt	1872 Jan 16	6.4	"The stars were very clear and bright except Eta which appeared to be duller and of a more reddish tint than usual... Eta exactly equal to BAC 3673. JH 1203 was greater than JH 1183 and JH 522 which appeared to be about equal. Eta appeared to be slightly less than these stars and equal to JH 387..." [TM4]
Tebbutt	1872 Feb 20	6.3	"Eta was much less than BAC 3680, less than JH 1203, brighter than JH 387 and about equal to JH 522 and JH 1183. It was slightly superior to BAC 3673." [TM4]
Ragoonatha	1872 Feb 26	*7.0*	Meridian circle observation [Sm92]
Tebbutt	1872 Mar 8	6.5 :	"Eta was certainly less than JH 1203, and slightly less than JH 522 and JH 1183. It appeared to be about equal to JH 387. It was much less than BAC 3680 and greater than BAC 3673." [TM4]

Continued on next page

Table 4 – continued from previous page

Observer	Date	m_V	Description and reference code
Tebbutt	1872 Apr 5	6.5	"Eta was less than JH 1203 and about equal to JH 522 and JH 1183. It was certainly not brighter than BAC 3673 nor do I think it quite equalled that star." [TM4]
Ragoonatha	1872 Apr 10	*6.8*	Meridian circle observation [Sm92]
Tebbutt	1872 May 9	6.4	"It was considerably less than JH 1203, somewhat less than JH 522 and JH 1183 and about equal to JH 387. It was exactly equal to BAC 3673." [TM4]
Tebbutt	1872 May 20	6.4	"It was considerably less than JH 1203, and even slightly less than JH 522 and JH 1183; it was about equal to JH 387. . . about equal to BAC 3673." [TM4]
Tebbutt	1872 Jun 21	6.3	"I considered it inferior to JH 1203, superior to JH 387 and perhaps slightly superior to JH 522 and JH 1183. It was far inferior to BAC 3680 and about equal to BAC 3673." [TM4]
Tebbutt	1872 Jul 23	6.6 :	"By means of both telescopes, especially the larger one, it was well seen that Eta Argus was greatly inferior to BAC 3680, and considerably less than JH 522 and JH 1203. It also appeared to be slightly less than JH 387, JH 1183 and BAC 3673. It was decidedly of a ruddy hue." [TM4]
Tebbutt	1872 Aug 20	6.4	"Eta was far inferior to BAC 3680 and about equal to BAC 3673. It was evidently less than JH 1203 and about equal to JH 522 and JH 1183. . . " [TM4]
Tebbutt	1872 Dec 10	6.2 :	"I estimated JH 1203 to be greater than Eta, Eta greater than either JH 522 or JH 1183 and JH 387 the least of the five. Eta was less than BAC 3680 and greater than BAC 3673." [TM4]
Tebbutt	1873 Feb 4	6.5	"Eta was considerably less than JH 1203, and I think somewhat less than JH 522 and JH 1183. It was I judged about equal to JH 387 and BAC 3673, being greatly less than BAC 3680. Eta appeared of a slight orange tint, but not at all hazy." [TM4]
Tebbutt	1873 Feb 18	6.4 :	"Eta was not as bright as JH 1203, being perhaps a somewhat less than JH 1183 and JH 522 and greater than JH 387." [TM4]
Russell	1873 Mar 5	6.6 :	"Examined η Argus – it is rather less than the two following stars 71 and 72" [RM1]
Tebbutt	1873 Mar 21	6.5	"Eta was about equal to JH 522 but perhaps slightly inferior to JH 1183. It was certainly less than JH 1203, and perhaps slightly inferior to BAC 3673. The difference between the magnitudes of JH 1183 and JH 1203 did not seem so great as on previous occasions. Eta appeared of a slightly orange colour." [TM4]
Russell	1873 Apr 5	6.6 :	"Examined η Argus neb: η is certainly less than either of the two following stars viz. (71 and 72)" [RM1]
Tebbutt	1873 Apr 7	6.5	"BAC 3680 was far superior to JH 1203 and the latter considerably superior to Eta Argus. Eta Argus was I think slightly inferior to JH522 and JH1183. It was about equal to BAC 3673 or perhaps slightly inferior to it." [TM5]
Tebbutt	1873 Apr 22	6.5	"Eta appeared to be about equal to JH 1183 and JH 387, but inferior to JH 522. It was also about equal to BAC 3673." [TM5]
Tebbutt	1873 Apr 23	>6.4	"Eta Argus was fainter than BAC 3673 as it crossed the field of the transit telescope." [TM5]

Continued on next page

Table 4 – continued from previous page

Observer	Date	m_V	Description and reference code
Tebbutt	1873 Apr 24	6.5 :	"I noticed both yesterday and this evening that Eta Argus was fainter than BAC 3673 as it crossed the field of the transit telescope. There appeared to be scarcely any difference between the stars as viewed with the Jones refractor, eyepiece No. 1, at 9:50 per chronometer." [TM5]
Tebbutt	1873 May 1	>6.4	"Eta Argus was fainter than BAC 3673..." [TM5]
Tebbutt	1873 May 26	>6.4	"Eta appeared to be fainter than BAC 3673, and much inferior to BAC 3680. BAC 3655, a reddish star, was far superior to BAC 3680." [TM5]
Tebbutt	1873 Jun 5	6.4	"BAC 3680 was much superior to BAC 3673 and the latter somewhat superior to Eta. Eta appeared to be less than JH 1203, about equal to JH 522 and JH 1183 and slightly superior to JH 387." [TM5]
Tebbutt	1873 Jul 12	6.5	"Eta was perhaps slightly superior to BAC 3673 and slightly inferior to JH 1183... Eta was certainly inferior to JH 1203." [TM5]
Tebbutt	1873 Aug 5	6.6 :	"Eta was certainly not superior to BAC 3673, but I think was slightly inferior to it. It was certainly much inferior to JH 1203, and also inferior to JH 1183. It appeared to be of a slight orange tinge." [TM5]
Tebbutt	1874 Jan 16	6.6	"Eta was much less than JH 1203, and even less than JH 522 or JH 1183... barely equal to JH 387 and BAC 3673." [TM5]
Russell	1874 Feb 4	6.8 :	"Observed η Argus it is evidently smaller than either 71 or 72 two following bright stars by fully $^1/_2$ a magnitude." [RM1]; "On 4th February, 1874, I was surprised to find it $^1/_2$ a magnitude smaller than in 1871, or 7.4 magnitude, and I have since been in the habit of frequently examining it and comparing it with several stars in its own cluster which are not variable." [R88]
Tebbutt	1874 Feb 18	6.4 :	"Eta was of a magnitude between those of JH 387 and JH 522. It was much inferior to JH 1203 and apparently less than JH 1183. It was about equal to BAC 3673." [TM5]
Tebbutt	1874 Mar 19	6.5	"It was much inferior to JH 1203 and I think very slightly inferior to JH 522 and JH 1183. It appeared to be superior to JH 387 and certainly not superior to BAC 3673. BAC 3680 was far superior to JH 1203." [TM5]
Tebbutt	1874 Apr 17	6.5	"Eta was much inferior to JH 1203. It appeared to be also inferior to JH 522 and about equal to JH387 and JH1183. It was perhaps slightly inferior to BAC 3673 and certainly not superior to that star. Eta appeared reddish." [TM5]
Tebbutt	1874 May 13	>6.5	"Eta was considerably fainter than BAC 3673 : the difference between them was very marked, more so, I think, than I had ever noticed it before." [TM5]
Tebbutt	1874 May 15	>6.5	"The inferiority of Eta to BAC 3673 was very marked." [TM5]
Tebbutt	1874 May 21	6.6 :	"By very careful observation, I considered it to be somewhat fainter than BAC 3673... it was not superior to that star." [TM4]
Tebbutt	1874 May 23	6.5 :	"I considered it to be about equal to JH 1183 and BAC 3673 but much inferior to BAC 3680. It appeared reddish and more hazy than it has been for some years past. Its light was duller than that of BAC 3673." [TM5]

Continued on next page

Table 4 – continued from previous page

Observer	Date	m_V	Description and reference code
Tebbutt	1874 Jun 13	6.6	"It was not greater than JH387 and BAC 3673 and perhaps slightly less than these stars. . . Eta Argus appeared to be slightly reddish." [TM5]
Tebbutt	1874 Jul 16	>6.5	"Eta Argus was certainly less than JH 1183, 1203, 387 and 522 and BAC 3673." [TM5]
Burton	1874 Nov	*9*	"The sketch must speak for itself, as I was not fortunate to obtain many notes on the nebula. Those which were obtained are as follows: η was considered to be 9 mag. (Herschel's scale) and orange red... η I thought had not so 'hard' a disk as that of the 8.5m ruby near β Crucis, with which it was compared under the same power, 400 linear, which was used in making all the sketches of the nebulae described." The magnitude of 9 is almost certainly a misprint for 7. [B75]
Tebbutt	1874 Nov 19	6.6 :	"Eta was certainly not superior to BAC 3673 and JH 522 and 1183. I think it was somewhat inferior to those three stars. It was very much inferior to BAC 3680." [TM5]
Tebbutt	1874 Dec 28	6.5	"Eta was much less than BAC 3680 and JH 1203 and certainly less than JH 1183. It was less than JH 522 and about equal to JH 387. It was I think slightly superior to BAC 3673." [TM5]
Tebbutt	1875 Jan 28	6.5	"I judged Eta to be slightly less than JH522 and JH1183, and about equal to JH 387. It was slightly inferior to BAC 3673. It was slightly red, and appeared to show a more steady and subdued light than its companions." [TM5]
Tebbutt	1875 Mar 19	>6.5	"It was of a reddish colour, and decidedly inferior in magnitude to JH 1183, JH 387, JH 522 and B.A.C. 3673." [TM5]
Tebbutt	1875 May 13	7.0 :	"As thus compared, Eta was certainly less in a marked degree than BAC 3673. It appeared to be about equal to the stars marked O in Sir John Herschel's catalogue..." [TM5]
Tebbutt	1875 May 22	>6.4	"I compared Eta Argus with BAC 3673... It was certainly less than that star." [TM5]
Houzeau	1875.5 ±	>6.0	η Car not noted in this naked eye survey, which has a limit of about magnitude 6.0 in this region of the Milky Way [Hz78]
Tebbutt	1875 Jul 5	>6.5	"Eta appeared to be reddish and duller than usual. It was certainly inferior to JH 1183, JH 387 and JH 522 and BAC 3673..." [TM5]
Tebbutt	1875 Aug 17	6.5 :	"Eta was certainly slightly inferior to BAC 3673 and JH 1203. I thought it equal to JH 387 and perhaps inferior to JH 1183 and JH 522. It was slightly superior to JH 403+404, which latter was again superior to JH 630." [TM5]
Tebbutt	1875 Nov 30	7.0 :	"Eta was certainly inferior to BAC 3673 and JH 387, 522, 1183 and 1203, and about equal though perhaps inferior to the star 403+404..." [TM5]
Tebbutt	1875 Dec 18	>6.5	"Eta was considerably inferior to JH 387, 522, 1183 and 1203. It was also inferior to BAC 3673." [TM5]
Tebbutt	1876 Jan 17	>6.5	"... Eta Argus was less than BAC 3673. It was also inferior to JH 387 and 522." [TM5]
Tebbutt	1876 Jan 24	7.0	"... Eta Argus was considerably less than BAC 3673, and somewhat brighter than JH 1. It was also inferior to JH 387 and 1183 and about equal to JH 403+404." [TM5]

Continued on next page

Table 4 – continued from previous page

Observer	Date	m_V	Description and reference code
Russell	1876 Jan 31	6.8 :	"... 'η' is fully certainly $^1/_2$ mag greater than 69 tonight, and much darker red; 69 is full orange red. 62 red. 62 is now quite as bright as 63; 7 inches aperture..." [RM1]
Russell	1876 Feb 17	(7.5)	"... 'η' is very little brighter than No 28. No 62 = 63, $^1/_2$ mag less than 69." [RM1]
Russell	1876 Feb 23	7.0	"Clear & calm. η Argûs midway between 71 and 43. 62 about 0.1 brighter than 63, 0.4 less than 69. 69 – 59 are perhaps 0.1 brighter. 'η' shows no sign of division with 800 power..." [RM1]
Tebbutt	1876 Mar 13	>6.5	"... Eta Argus was considerably less than JH 387, 522, 1183 and 1203 and BAC 3673." [TM5]
Tebbutt	1876 May 11	6.7 :	"Eta was very much inferior to BAC 3680 and slightly inferior to BAC 3673 and JH 387, 522 & 1183. It was considerably less than JH 1203." [TM5]
Tebbutt	1876 Jul 3	>6.5	"I found that Eta Argus was still less than BAC 3673 and JH 387, 522 and 1183. Eta was slightly red and of a duller hue than the comparison stars." [TM5]
Tebbutt	1876 Aug 31	6.6 :	"JH 1203 was considerably brighter than JH 1183, which latter was somewhat superior to Eta. JH 387 and JH 522 were nearly equal, and both slightly superior to Eta. Eta was slightly less than BAC 3673." [TM5]
Tebbutt	1876 Sep 8	>6.5	"... Eta Argus was not so bright as BAC 3673." [TM5]
Tebbutt	1876 Nov 21	>6.5	"I found Eta Argus somewhat inferior to JH 387 & JH 522 and much inferior to BAC3673. The stars were very low." [TM5]
Tebbutt	1876 Dec 28	>6.5	"Eta was not quite as bright as BAC 3673 or JH 1183." [TM5]
Tebbutt	1877 Mar 14	>6.5	"I found that Eta Argus was much less than any of the stars JH 387, 522, 1183, 1203 or BAC 3673. It seems to have diminished considerably since last observations... Eta Argus was slightly red." [TM5]
Tebbutt	1877 Mar 20	6.9 :	"It was much less than JH 387, 522, 1183, 1203 or BAC 3673, and was about equal to or slightly superior to JH 403+404... It was certainly superior to JH 452, 458 or 630." [TM5]
Tebbutt	1877 Apr 6	7.0	"It was certainly superior to either JH 452 (or JH 455+458) and about equal, certainly not superior to JH 403+404. Its inferiority to JH 387, JH 1183, or BAC 3673 was certainly marked. It appeared to be of a dull reddish colour." [TM5]
Tebbutt	1877 May 5	>6.5	"It was of a dull reddish colour and considerably less than BAC 3673 and JH 387 & 522." [TM5]
Tebbutt	1877 Sep 12	>6.5	Original record not located. Magnitude inferred from data in [TM17]
Tebbutt	1877 Dec 11	7.0	"It was considerably less than JH 387, 522, 1183 & 1203, but did not appear to be much less than BAC 3673. It was about equal to the combined light of JH403+404. JH630 was somewhat less than Eta Argus but somewhat greater than JH468..." [TM5]
Tebbutt	1878 Mar 4	7.0	"I found Eta to be much less than JH 1183, JH 387, and JH 522. It was slightly greater than JH 630, and equal to the combined light of JH 403+404." [TM5]

Continued on next page

Table 4 – continued from previous page

Observer	Date	m_V	Description and reference code
Tebbutt	1878 Mar 20	6.8 :	"It was much less than either of the four stars JH 387, 522, 1183, 1203 and was slightly greater than JH 630 and very slightly greater than the components JH 403+404, JH 452, and the components JH 455+458. It was slightly greater than BAC 3673 (?) and was of a faint brickdust colour." [TM5]
Tebbutt	1878 May 11	7.0 :	"JH 1203 was brighter than JH 1183, 387 & 522, and all were superior to Eta... about equal to JH 403+404." [TM5]
Tebbutt	1878 Jun 28	7.0 :	"It was of a slightly ruddy colour, and appeared of a duller hue than the other stars of equal magnitude. It was much less than BAC 3673, JH 1183, 1203, 387 & 522, and was about equal to the united light of JH 403 & JH 404." [TM5]
Tebbutt	1878 Aug 30	7.0 :	"It was very much less than B.A.C. 3673, JH 387, 522, 1183 & 1203 and about equal to the united light of 403 + 404 or O of Herschel's Catalogue, certainly brighter than JH 452." [TM5]
Gould	1878 Oct	7.2	"... the magnitude is between 7.3 and 7.4, being a grade brighter than between B. 4202 [sic], but six or seven grades fainter than L.4448." [G79, p. 255]
Gould	1878 Nov	7.2	"It has continued slowly to decrease, and at the beginning of November, 1878, is about 7.4 [UA scale], being scarcely superior to B.3202." [G79, p. 256]
Tebbutt	1878 Dec 18	7.0 :	"It was greatly inferior to JH 387, 522, 1183 & 1203 and B.A.C. 3673. It was about equal to the combined light of 403, 404 or O of Herschel's Catalogue, and somewhat brighter than 531 of the same catalogue. This star is put down at 11 mag. by Herschel but it is now but slightly inferior to JH 403+404." [TM5]
Tebbutt	1879 Mar 10	7.3 :	"Eta was slightly less than JH 403, the brighter of the components of O, slightly greater than JH 630, much greater than JH 452, 455+458, and very much greater than JH 736, which last star was close to Eta." [TM5]
Tebbutt	1879 May 22	>7.0	"Eta Argus was very much less than JH 387, 522, 1183 & 1203, and even less than the stars JH 403, 404. It was slightly red." [TM5]
Tebbutt	1880 Jan 21	7.4 :	"I found it less than the united light of the components No 403, 404, and greater than two small stars in the position assigned to Nos 452, 455 and 458 in the Catalogue." [TM6]
Tebbutt	1880 Mar 22	7.1 :	"... Eta Argus was greatly inferior to [JH 1183]. It was brighter than No. 693 and of the same dull red colour." [TM6]
Tebbutt	1880 May 3	7.0 :	"... about equal to the combined light of No. 403 and 404..." [TM6]
Tebbutt	1880 May 5	7.0 :	"I compared η Argus as it crossed the dark field of the transit instrument with JH 403+404 and found that it was certainly not less than that star. The two were about equal." [TM6]
Tebbutt	1880 Jun 9	7.2 :	"... η was about equal to the stars numbered 403+404, 844, 862, 630 and 953. It was somewhat brighter than 571 or 575 and much brighter than 983." [TM6]
Tebbutt	1880 Jul 12	7.2	"I estimated η to be about midway between Nos. 403+404 and 630 of Herschel's catalogue..." [TM6]
Tebbutt	1880 Aug 22	7.0 :	"Eta Argus was about equal to 403 + 404 of Herschel's Catalogue." [TM6]

Continued on next page

Table 4 – continued from previous page

Observer	Date	m_V	Description and reference code
Tebbutt	1880 Oct 31	7.3	"η Argus was inferior to the united light of 403 and 404... and superior to 630. Its magnitude was nearer that of 630. It was much superior to the two close stars 452, 455 . ." [TM6]
Tebbutt	1880 Dec 1	7.4	"I found η Argus to be as nearly as possible equal to No. 630 and much less than the combined light of Nos 403 & 404..." [TM6]
Cordoba	1881.0 ±	7.3 :	mag. 7.5 on UA scale [Th89a, Th89b]
Tebbutt	1881 Jan 27	7.4	"It was rather less than the combined light of 403, 404 or O... about equal to 630 F, 862 β, not quite so great as 844 λ, and much greater than 452K[1], the combined light of 455, 458 or K[2], and 736 a." [TM6]
Ragoonatha	1881 Apr 6	*7.5*	Meridian circle observation [Sm94]
Ragoonatha	1881 Apr 7	*7.5*	Meridian circle observation [Sm94]
Ragoonatha	1881 Apr 9	*7.5*	Meridian circle observation [Sm94]
Ragoonatha	1881 Apr 13	*7.8*	Meridian circle observation [Sm94]
Tebbutt	1881 Jun 1	7.4 :	"I also looked at η Argus but it did not appear to have changed since I last compared it." [TM6]
Tebbutt	1881 Aug 19	7.4 :	"I found it to be inferior to the combined light of 403+404 and greater than 468 or 452 and 458. There are only two stars to be seen in the place of 452, 458 with the comet eyepiece." [TM6]
Tebbutt	1881 Dec 21	7.4	"It was considerably less than 403 + 404 or O... and equal to 630 or F." [TM6]
Cordoba	1882 Apr/May	7.4 ::	Mean of 12 meridian observations is mag. 7.6 on UA scale [Th96]
Peek	1882 Dec 6	7.2 ::	"... on the morning of December 6th, [HDE 303308] was estimated as being about one magnitude less than η." [Pk86]
Pechüle	1883 Jan 3	...	"η Argus. Jan 3 et plusieures autres fois: je n'y vois aucune étoile rouge." [Pe83]
Russell	1883.5 ±	7.4 :	"... in 1883 the estimates varied from 7.5 to 7.8 [UA scale]..." [R88]
Tebbutt	1883 Dec 18	7.4	"Its magnitude was between that of 403, 404 and 630 on the one hand and 452 and 458 on the other, being less than the former and greater than the latter, but much nearer to the former. It was superior to 468..." [TM7]
Markwick	1883 Dec 28	7.3	"Two or three steps [> HD 93250]; about = [BO Car]." [Mk00]
Russell	1884.5 ±	7.4	"... in 1884 I made it 7.6 [on UA scale] ..." [R88]
Markwick	1884 Feb 5	7.3 :	"Between [BO Car] and [HD 93250] in brightness." [Mk00]
Markwick	1884 Feb 18	7.4	"After careful observation I came to the conclusion that it was about [= HD 93250] in brightness." [Mk00]
Markwick	1884 Jun 19	7.3 :	"Between stars [HD 93403] and [BO Car] in brightness." [Mk00]
Markwick	1884 Jun 20	7.3 :	"As before." [Mk00]
Thome	1885.0	7.4	7.62 on U.A. scale [Th89a, Th89b]
Russell	1885.5 ±	7.4 :	"... in 1885 and 1886 about the same [7.6 on UA scale]..." [R88]
Tebbutt	1885 May 4	7.2	"I regarded it as a mean between No. 403, 404 on the one hand and No. 630 on the other." [TM8]
Williams	1886 Feb	>6.0 :	"The nebula was also examined several times in February last with a $2^3/_3$-in. refractor; and though η was not identified, I do not think there were any stars near so bright as the 6th mag." [W86]
Finlay	1886 Mar	7.4	"O [JH 403] > F [630] $\geq \eta \geq$K' [452] > C [468] and η sl.< β [862]; I also note β very slightly < λ [844]." [Fy86]

Continued on next page

Table 4 – continued from previous page

Observer	Date	m_V	Description and reference code
Tebbutt	1886 Mar 17	7.2	"I estimated it to be equal or perhaps a shade superior to F 630... and equal or perhaps slightly inferior to the combined light of O 403, 404." [T86, TM8]
Russell	1886.5 ±	7.4 :	"... about the same [7.6 on U.A. scale], although in the latter year I several times thought it was getting brighter." [R88]
Thome	1886 Jul	7.4	"... it had reached a point midway between Brisbane 3204 and Gillis 1332 in July of the latter year." [Th89a, Th89b]
Thome	1887 Mar 20	...	"The color, which before minimum was a dull scarlet, is now bright orange; and, in fact, it was the change in color, which had begun to glow again and lighten, rather than any measurable increase in brilliancy in the object, that first attracted my attention." [Th89a]. "My attention was not directed to it again until the night of March 20, 1887, when I at once noticed a change in its appearance, more like a dying ember which had begun to glow again than as an actual change in brilliancy; of which however I felt confident, though not able to prove it conclusively." [Th89b]
Thome	1887.3	7.4	7.6 on U.A. scale [Th89a, Th89b]
Tebbutt	1887 Apr 23	7.1	"... very slightly brighter than F 630 and equal to the combined light of O 403, 404. It was of a pale dull red colour." [TM9, T88]
Thome	1887.4	7.3	7.5 on U.A. scale [Th89a, Th89b]
Thome	1887.5	7.2	7.4 on U.A. scale [Th89a, Th89b]
Thome	1887.6	6.9 :	7.2 on U.A. scale [Th89a, Th89b]
Thome	1888.1	6.7 :	7.1 on U.A. scale [Th89a, Th89b]
Thome	1888 Apr 25	6.4	Estimate made with Zöllner photometer, 6.98 on U.A. scale [Th89a, Th89b]
Thome	1888 May 9	6.3	Estimate made with Zöllner photometer, 6.85 on U.A. scale [Th89a, Th89b]
Tebbutt	1888 May 19	6.5	"... very much superior to Nos 403, 404, 452, 455, 458, 468, 475 [sic] and 630, considerably superior to 844 and 862, little inferior to 387 and considerably less than 522." [TM10]; "increased fully half a magnitude since my last observations in April 1887." [T88a; see also T88b]
Tebbutt	1888 May 21	6.5	"It was very much superior to Nos 403, 404, 630, 844, 862 and 1177 of Sir J. Herschel's catalogue... It was certainly superior to No 1 and very nearly if not quite equal to Nos 2 and 387, being possibly a shade less than these two stars. It was certainly inferior to Nos 522, 1183 and 1203..." [TM10]
Tebbutt	1888 May 23	6.4	"It was considerably less than 1183 and 1203, less than 2 and 522, about equal to 387 and considerably brighter than 1. It was much brighter than 403, 404, 630 and 862..." [TM10]
Thome	1888 May 30	6.4	Estimate made with Zöllner photometer, 6.90 on UA scale [Th89a, Th89b]
Russell	1888 May 31	6.4	"... in 1887 I was away, but the first examination on my return removed all doubt, there was evidently a very decided increase . . I find Eta at the end of May, 1888, was of 6.9 magnitude [UA scale], or almost as great as it was in 1871." Also given as mag. 7.24 [UA scale] using a wedge photometer, though this instrument had a strong colour term. [R88]

Continued on next page

Table 4 – continued from previous page

Observer	Date	m_V	Description and reference code
Tebbutt	1888 Jun 8	6.4 :	"I found it much superior to 403, 404, 630 and 862. It was also much superior to 1 and about equal to 2 and 387, but perhaps slightly inferior to 522. It was much inferior to 1183 and 1203." [TM10]
Tebbutt	1888 Jun 12	6.4 :	"... considerably less than 1183 and 1203, perhaps less than 522, about equal to 2 and 387 and considerably greater than 1." [TM10]
Tebbutt	1888 Jun 19	6.5 :	"It was superior to 1, about equal to 2 and 387, but inferior to 522, 1183 and 1203... Eta Argus and R Carinae were red." [TM10]
Tebbutt	1888 Jun 24	6.3	"η Argus was much superior to 1, perhaps slightly superior to 2 and 387 and very nearly equal to 522. It was inferior to 1183 and 1203." [TM10]
Thome	1888 Jun 26	6.4	Estimate made with Zöllner photometer, 6.87 on UA scale [Th89a, Th89b]
Tebbutt	1888 Jul 5	6.4	"Eta was much brighter than L [JH1], about equal to X [2] and Z [387] and not quite so bright as U [522], W [1183] or Y [1203]..." [TM10]
Tebbutt	1888 Jul 19	6.4 :	"... found no sensible change in its lustre since the last comparisons." [TM10]
Tebbutt	1888 Aug 2	6.4	"It was superior to G (sic), L, and Z, very nearly equal to U, W and X and certainly inferior to Y..." [TM10]
Tebbutt	1888 Sep 15	6.4 :	"The variable was much superior to F630, equal to 387Z and 522U and inferior to 1183W and 1203Y." [TM10]
Thome	1888 Oct 10	6.3	Estimate made with Zöllner photometer, 6.77 on UA scale [Th89a, Th89b]
Clerke	1888 Oct 23	*7.0*	"it is now fully [mag] 7, and the object stands out at a glance from the numerous surrounding stars both by the superior intensity and by the reddish glow of its light. Indications of dark shadings are perceptible in its spectrum, which at present includes no bright lines." [C88]
Tebbutt	1888 Dec 5	6.5 :	"Eta was decidedly reddish, considerably superior to F630, inferior to Z387 and U522, and certainly very slightly inferior to W1183 and Y 1203." [TM10]
Tebbutt	1888 Dec 24	6.4 :	"It was a shade brighter than 387 and a shade inferior to 522, 1183 and 1203..." [TM10]
Tebbutt	1889 Jan 1	6.5 :	"[Eta] was but little less than 387, 522, 1182 [sic] and 1203..." [TM10]
Tebbutt	1889 Jan 12	6.3 :	"Eta was less than 1183 and 1203, but greater than 387 and 522." [TM10]
Tebbutt	1889 Jan 28	6.3	"Eta was of a magnitude about midway between those of 387 and 522 on the one hand and 1183 and 1203 on the other." [TM10]
Tebbutt	1889 Feb 21	6.3 :	"Eta was slightly brighter than X, L and slightly inferior to W, Y..." [TM10]
Tebbutt	1889 Mar 4	6.4 :	"Eta was about equal to 387 and 522... but somewhat inferior to 1183 and 1203. It was decidedly redder than when of the $7^1/_2$ magnitude." [TM10]
Tebbutt	1889 Mar 6	6.3	"... 1203 was certainly superior to 1183 and 522 to 387. It was difficult to compare Eta with these four stars as they could not all be seen in the field at the same time. It was certainly as bright as 522 but I think not so bright as 1203. Its superiority to 630 was very marked." [observed through 8" Grubb refractor] [TM10]
Thome	1889 Mar 19	6.2	Estimate made with Zöllner photometer, 6.69 on UA scale [Th89a, Th89b]

Continued on next page

Table 4 – continued from previous page

Observer	Date	m_V	Description and reference code
Tebbutt	1889 Mar 21	6.4	"Eta Argus was very much superior to F630, about equal to Z387, U522 and W 1183, and inferior to Y1203." [TM10]
Tebbutt	1889 Apr 1	6.4	"Eta Argus was equal to Z387 and U522, nearly if not quite equal to W 1183 and not quite so bright as Y1203." [TM10]
Tebbutt	1889 Apr 30	6.4	"Eta was equal to Z387, U522 and W 1183, and less than Y1203." [TM10]
Thome	1889 May 20	6.2	Estimate made with Zöllner photometer, 6.66 on UA scale [Th89a, Th89b]
Tebbutt	1889 Jun 3	6.4	"Eta was equal to Z387, U522, W 1183 and inferior to Y1203." [TM10]
Thome	1889 Jun 23	6.2	"... is now easily visible to the naked eye, having a magnitude of 6.66, or a shade fainter than Lacaille 4484." [Th89a, Th89b]
Tebbutt	1889 Dec 13	6.2 :	"It was certainly superior to equal to Z387, U522 and about equal to W 1183 and Y1203 which were themselves equal." [TM10]
Tebbutt	1889 Dec 25	6.4	"η Argus was about equal to Z387 and U522 and somewhat inferior to W 1183 and Y1203." [TM10]
Tebbutt	1890 Jan 8	6.4 :	"There was no change in Eta Argus." [TM10]
Tebbutt	1890 Jan 22	6.4 :	"Eta was perhaps scarcely as bright as Z387 or U 522, and certainly inferior to W 1183 and Y 1203." [TM10]
Tebbutt	1890 Mar 15	6.4	"Eta Argus was about equal to 387, 522 , and 1183, and inferior to 1203." [TM10]
Bailey	1890 Apr 2	6.4	Harvard meridian photometer (magnitude is equivalent to V for red stars) [BP95]
Tebbutt	1890 Apr 26	6.4 :	"Eta Argus was about equal to 387 and 522, somewhat less than 1183 and much less than 1203." [TM10]
Bailey	1890 May 26	6.3	Harvard meridian photometer [BP95]
Bailey	1890 Jun 6	6.5	Harvard meridian photometer [BP95]
Tebbutt	1890 Dec 30	6.5	"Eta was scarcely so bright as 387 or 522 and considerably less than 1183 and 1203 of Herschel's catalogue." [TM11]
Tebbutt	1891 Feb 11	6.4 :	"It was about equal to 387 and 522 but certainly less than 1183 and 1203. It was decidedly red." [TM11]
Tebbutt	1891 Apr 6	6.3 :	"Eta (η) Argus was brighter than Z387, about equal to U522, and less than W1183 and Y1203 . ." [TM11]
Bailey	1891 Apr 18	6.2	Harvard meridian photometer [BP95]
Bailey	1891 Apr 21	6.3	Harvard meridian photometer [BP95]
Bailey	1891 Apr 22	6.2	Harvard meridian photometer [BP95]
Bailey	1891 Apr 23	6.1 :	Harvard meridian photometer [BP95]
Tebbutt	1891 May 18	6.4	"It was scarcely as bright as 387 or 522, perhaps slightly brighter than 1183 and not so bright as 1203... It is becoming decidedly redder." [TM11]
Roberts	1891 May–Dec	6.2 :	"This remarkable variable has not varied much during the eight months I have examined it. The surrounding nebula may add to its brightness, but it has uniformly appeared about 6.6 or 6.7 [U.A. scale]. It can be quite easily seen with the naked eye." [Ro92] [NB.: 0.1 mag. added to allow for companion star(s) unresolved in Roberts' low-power glass]
Tebbutt	1891 Dec 30	6.5 :	"... but as compared with 387, 522 , 1183 and 1203 of Herschel's Cape Catalogue it certainly has not increased in lustre since my last observation of it. It was certainly less than any of these stars." [TM11]
Roberts	1892 Jan 5	6.4 :	6.9 on Roberts' scale [NB: 0.1 mag. added to allow for companion stars unresolved in Roberts' low-power glass] [Ro93]
Roberts	1892 Apr 24	6.2 :	6.7 on Roberts' scale [NB: 0.1 mag. added] [Ro93]

Continued on next page

Table 4 – continued from previous page

Observer	Date	m_V	Description and reference code
Tebbutt	1892 May 31	6.5 :	"It was about equal or perhaps a shade inferior to 1183 and certainly not so bright as [JH 387, 522 and 1203]. It does not appear to be quite so bright as it was some months ago, and more ruddy." [TM11]
Roberts	1892 Jun 3	6.2 :	6.7 on Roberts' scale [NB: 0.1 mag. added] [Ro93]
Roberts	1892 Jun 4	6.3 :	6.8 on Roberts' scale; [Ro93]
Roberts	1892 Jun 6	6.4 :	6.9 on Roberts' scale; [Ro93]
Roberts	1892 Jul 17	6.3 :	6.8 on Roberts' scale; [Ro93]
Bailey	1893.5 ±	*6.3*	η Car given as mag. 6.30 in Bailey's Uranometry [Pi08]
Tebbutt	1894 Apr 2	6.4 :	"[Eta] was about equal to Z387 and U522... but not quite as bright as W1183 or Y1203." [TM12]
Tebbutt	1894 Jun 26	6.4 :	"It had not increased in brightness since it was last observed by me." [TM12]
Tebbutt	1895 Mar 19	6.4	"I also examined Eta (η) Argus with the [$3^1/_4$"] and found it to be not quite so bright as 522, 1183 and 1203 which were about equal, but certainly brighter than 387 of Herschel's map. 387 was decidedly inferior to 522." [TM13]
Tebbutt	1895 Mar 25	6.4	"It was certainly not so bright as 1183 or 1203. 522 was brighter than 387, and η Argus was of a magnitude about a mean of 387 and 522." [TM13]
Innes	1896 Apr 26	7.4	mag. 7.6 on UA scale [In97]
Innes	1896 May 17	7.3	mag. 7.5 on UA scale [In97]
Innes	1896 Jun 28	7.4	mag. 7.6 on UA scale and described as "orange yellow" [In97]
Innes	1896 Jul 13	7.4	mag. 7.6 on UA scale [In97]
Tebbutt	1896 Aug 11	7.4 :	"It was very much inferior to 1183, 1203, 387 or 522 of Herschel's catalogue. It was perhaps slightly superior to 468 and 630, and certainly slightly inferior to the combined light of 403 and 404." [TM14]
See	1897 Mar 7	7.4	"The color is distinctly reddish, perhaps a shade deeper than that of the neighbouring star, A.G.C. 14723 [HDE 303308], which Gould calls crimson [sic]. The colour seemed to be substantially identical with that of the larger component of the double star AGC 14686 [HD 93129]" [Se97]
See	1897 Mar 8	7.5	mag. 7.65 on UA scale [Se97]
See	1897 Mar 12	7.3	mag. 7.54 on UA scale [Se97]
See	1897 Mar 13	7.4	mag. 7.63 on UA scale [Se97]
See	1897 Mar 14	7.4	mag. 7.60 on UA scale [Se97]
Tebbutt	1898 Jan 29	>7.4	"I also looked at Eta (η) Argus. It appeared to be somewhat less than when I last saw it." [TM14]
Innes	1899 Jun 10	7.4	mag. 7.6 on UA scale [In99]
Innes	1899 Jun 11	7.6	mag. 7.8 on UA scale, colour = 8 (on ten point Chandler scale) [In99]
Innes	1899 Jun 13	7.5	mag. 7.75 on UA scale [In99]
Innes	1899 Jun 18	7.5	mag. 7.7 on UA scale, colour = 6 [In99]
Roberts	1899 ±	...	"The Lovedale observations indicate that the light of this star has been practically permanent during the last decade. The observations of Finlay , See, Innes and Markwick point to the same conclusion..." [Ro01]
Innes	1900 Feb 26	7.5	mag. 7.7 on UA scale, colour = 6 [In02]
Innes	1900 Mar 31	7.4	mag. 7.65 on UA scale, colour = 6 [In02]
Innes	1900 Jun 8	7.5	mag. 7.7 on UA scale, colour = 7 [In02]
Innes	1901 Jan 21	7.7	mag. 7.9 on UA scale, colour = 7 [In02]
Innes	1901 Mar 22	7.5	mag. 7.75 on UA scale, colour = 6.5 [In02]
Innes	1901 Jun 8	7.5	mag. 7.7 on UA scale, colour = 7 [In02]
Innes	1902 Jan 26	7.5	mag. 7.7 on UA scale, colour = 6.5 [In02]
Innes	1902 Feb 1	7.4	mag. 7.65 on UA scale, colour = 6.5 [In02]
Innes	1902 Feb 8	7.6	mag. 7.8 on UA scale, colour = 6.5 [In02]

Continued on next page

Table 4 – continued from previous page

Observer	Date	m_V	Description and reference code
Innes	1905 May 20	7.6	mag. 7.8 on UA scale [In05]
Innes	1905 May 25	7.4	mag. 7.6 on UA scale [In05]
Innes	1905 Jun 3	7.5	mag. 7.7 on UA scale, colour = 7 [In05]
Innes	1905 Jun 24	7.4	mag. 7.55 on UA scale, colour = 8 [In05]
Innes	1905 Jun 25	7.6	mag. 7.7 on UA scale [In05]
Tebbutt	1907 Feb 16–24	7.9 :	"Careful comparisons on the evenings of February 16, 22, 23, and 24 last, by means of my $3^1/_4$-inch refractor employed on former occasions, showed that the variable was very much less than Nos. 387, 522, 1183, and 1203, slightly less than Nos. 403, 404, 452, and 630, and about equal to Nos. 468 and 571 [sic]. It certainly does not exceed the eighth magnitude. It is reddish, and its light very dull." [L07]
Manning	1907 Jun	7.5 :	"η is quite 0.5 mag below [HD 93129], or 7.5 on the Harvard scale. Probably η has faded since 1889–91." [M07]
Innes	1908 Apr 2	7.6	mag. 7.8 on UA scale, colour = 5 [In08]
Innes	1908 Apr 7	7.6	mag. 7.8 on UA scale [In08]
Innes	1908 Apr 13	7.5	mag. 7.7 on UA scale, colour = 6 [In08]
Innes	1908 Jun 2	7.5	mag. 7.7 on UA scale, colour = 6 [In08]
Manning	1908 Dec	7.7	"Eta Argus has been compared with the same stars as in former years. The mean magnitude from 6 comparisons is 7.92 [Harvard scale], which is practically the same as that obtained in 1907." [M09]
Innes	1909 Mar 31	7.5	mag. 7.75 on UA scale, colour = 5 [In09]
Innes	1909 Apr 11	7.6	mag. 7.8 on UA scale, colour = 6 [In09]
Innes	1909 Apr 22	7.6	mag. 7.8 on UA scale, colour = 6 [In09]
Baldwin	1911 Feb 20	7.5	mag. 7.7 on Hagen's (= UA) scale [AAVSO]
Dawson	1913.27	7.5 :	η Car & HDE 303308 (V= 8.16) given as mag. 7.9 & 8.6 respectively [Da18]
Tebbutt	1913 Apr ±	*7.5*	"Mr Tebbutt put it to the test with his 8-in. equatorial refractor, and found it to be $7^1/_2$ magnitude, quite below the limit of visibility to the naked eye." [BAA]
Innes	1914 May 10	7.6	mag. 7.8 on UA scale, colour = 6. Innes wrote: "At the first glance on the 10th inst., it was plain that η Argus was not a single star, and the use of a higher power showed that it had a faint companion north following (74°, 1", mags. about 8.0 and 10.5). Both Mr. Wood and Mr. Worsell saw the companion readily, and the former remarked that η Argus was fuzzy. This I was able to confirm easily; it is impossible to focus η Argus sharply, whilst neighbouring stars of much the same hue, as well as those both redder and yellower, can be sharply focussed." [In14]
Innes	1914 May 11	7.5	mag. 7.7 on UA scale, colour = 6.5 [In14]
Innes	1914 May 12	7.7	mag. 7.9 on UA scale, colour = 7 [In14]
Innes	1915.33	7.6 :	mag. 7.8 on Harvard scale [In16]; "While remeasuring the close companion on the 20th inst. I had a strong suspicion that there was a still closer companion, but it was impossible to decide because the object might be a flare or due to bad seeing. The star has since been frequently re-examined by myself, Mr. Voûte, and Mr. Wood, and Mr. Voûte and myself have no doubt that there is a closer companion than the one announced last year. My first measures of it give:– 1915.31, 308°.5, 0".85. It is about 2.5 magnitudes fainter than η itself." [In15]
Innes	1916.37	7.6 :	colour = 6; mag. 7.8 on Harvard scale [In17]

Continued on next page

Table 4 – continued from previous page

Observer	Date	m_V	Description and reference code
van den Bos	1932.364	<7.4 :	On this date, sum of component magnitudes = 7.4, which is a lower limit as contribution from nebulosity not estimated. [vdB37]
Finsen	1934.367	<7.5 :	Magnitudes of components A, B & C = 7.5, 9.0, and 9.5 respectively. However, mag. scale used by Finsen is uncertain. [Fi51]
Luft	1943 Jul 24	(7.3)	m = 8.0 [AAVSO; refer to text]
Luft	1946 May 7	(7.1)	m = 7.8 [AAVSO]
Luft	1946 May 8	(6.9)	m = 7.6 [AAVSO]
Luft	1946 May 20	(6.8)	m = 7.5 [AAVSO]
Luft	1946 May 21	(6.8)	m = 7.5 [AAVSO]
Luft	1946 May 22	(6.8)	m = 7.5 [AAVSO]
Luft	1946 May 23	(6.8)	m = 7.5 [AAVSO]
Luft	1946 May 24	(6.9)	m = 7.6 [AAVSO]
Luft	1946 May 28	(6.8)	m = 7.5 [AAVSO]
Luft	1946 May 29	(6.9)	m = 7.6 [AAVSO]
Luft	1946 May 31	(7.0)	m = 7.6 [AAVSO]
Luft	1946 Jun 7	(7.1)	m = 7.7 [AAVSO]
Luft	1946 Jun 13	(7.1)	m = 7.8 [AAVSO]
Luft	1946 Jun 17	(7.1)	m = 7.8 [AAVSO]
Luft	1946 Jun 18	(7.1)	m = 7.8 [AAVSO]
Luft	1946 Jun 22	(7.1)	m = 7.8 [AAVSO]
Luft	1946 Jun 23	(7.2)	m = 7.9 [AAVSO]
Luft	1946 Jun 26	(7.2)	m = 7.9 [AAVSO]
Luft	1946 Jun 28	(7.2)	m = 7.9 [AAVSO]
Luft	1946 Jul 3	(7.2)	m = 7.9 [AAVSO]
Luft	1946 Jul 4	(7.2)	m = 7.9 [AAVSO]
Luft	1946 Jul 15	(7.1)	m = 7.8: [AAVSO]
Luft	1946 Jul 18	(7.2)	m = 7.9: [AAVSO]
de Vaucouleurs	1952 Jan 28	*6.5*	"A casual visual observation made on January 28, 1952, with a 80 mm. binocular (10×) revealed an increase of about one magnitude in the brightness of the star as compared with former estimates." [dVE]
Eggen / Hogg	1952 Feb/Mar	6.45	Eta Car is 6.42 on m_{pv} [= V] scale (n = 9); assumed correction = 0.03 mag for 60 arcsec aperture [dVE]

Appendix 2

Reference codes for Appendix 1

AAVSO: American Association of Variable Star Observers, 2004, J. Mattei, pers. comm.

A61: Abbott, F., 1861, MNRAS, 21, 230

A63a: Abbott, F., 1863a, MNRAS, 24, 2

A63b: Abbott, F., 1863b, Pap. Proc. Roy. Soc. Tasmania, 4 (6), 4

A68: Abbott, F., 1868, MNRAS, 28, 200

A70: Abbott, F., 1870, Pap. Proc. Roy. Soc. Tasmania, 5 (5), 21

A71a: Abbott, F., 1871a, MNRAS, 31, 226

A71b: Abbott, F., 1871b, MNRAS, 31, 230

B75: Burton, C.E., 1875, MNRAS, 36, 69

BAA: British Astronomical Association, 1913, JBAA, 23, 371

Be74: Behrmann, C., 1874, *Atlas des Südlichen Gestirnten Himmels*. Leipzig

BP95: Bailey, S.I. & Pickering, E.C., 1895, Harvard Annals, 34, 146

C88: Clerke, A., 1888, Observatory, 11, 429

Ch64: Chambers, G.F., 1864, Astron. Register, 2, 262

D28: Dunlop, J., 1828, Phil. Trans., 118, 113

Da18: Dawson, B.H., 1918, Publ. La Plata Obs., Serie Astronomica, 4, 1

dVE: de Vaucouleurs, G. & Eggen, O.J., 1952, PASP, 64, 185

E66: Ellery, R.L.J., 1866, *Results of Astronomical Observations made at the Melbourne Observatory in the years 1863, 1864 and 1865*. Blundell & Ford, Melbourne

E69: Ellery, R.L.J., 1869, *Astronomical Observations made at the Williamstown Observatory in the years 1861, 1862, and 1863*. John Ferres, Melbourne

EDEG: Evans, D.S., Deeming, T.J., Evans, B.H. & Goldfarb, S., 1969, *Herschel at the Cape: Diaries & Correspondence of Sir John Herschel 1834–1838*. Balkema, Cape Town

Fi51: Finsen, W.S., 1951, Union Obs. Circ., 112, 104

FWW: Feast, M.W, Whitelock, P.A & Warner, B., 1994, A&A, 285, 199

Fy86: Finlay, W.H., 1886, MNRAS, 46, 340

G79: Gould, B.A., 1879, *Uranometria Argentina*, Res. Obs. Nac. Arg., 1, 1

Gi51: Gilliss, J.M., 1851, MNRAS, 11, 42

Gi52: Gilliss, J.M., 1852, MNRAS, 12, 174

Gi55: Gilliss, J.M., 1855, *The U.S. Naval Astronomical Expedition to the Southern Hemisphere, during the years 1849–50,–51,–52*, Vols. I & II. Washington

Gi56: Gilliss, J.M., 1856, MNRAS, 16, 133

H38a: Herschel, J.F.W., 1838a, MNRAS, 4, 121

H38b: Herschel, J.F.W., 1838b, AN, 15, 311

H39: Herschel, J.F.W., 1839, AN, 16, 187

H43: Herschel, J.F.W., 1843, MNRAS, 6, 9

H47: Herschel, J.F.W., 1847, *Results of Astronomical Observations Made During the Years 1834,5,6,7,8 at the Cape of Good Hope*. Smith, Elder & Co., London

H69: Herschel, J. & Herschel, J.F.W., 1869, MNRAS, 29, 82

He62: Heelis, T., 1862, Proc. Manchester Lit. Phil. Soc., 3, 28

Hz78: Houzeau, J.-C., 1878, *Uranométrie Générale*, Annales de l'Observatoire Royal de Bruxelles (Nov. ser.), 1, 1

In97: Innes, R.T.A., 1897, MNRAS, 57, 155

In99: Innes, R.T.A., 1899, MNRAS, 59, 570

In02: Innes, R.T.A., 1902, MNRAS, 62, 429

In03: Innes, R.T.A., 1903, Ann.Cape Obs., 9, 75B

In05: Innes, R.T.A., 1905, MNRAS, 65, 872

In08: Innes, R.T.A., 1908, MNRAS, 68, 613

In09: Innes, R.T.A., 1909, MNRAS, 69, 632

In14: Innes, R.T.A., 1914, MNRAS, 74, 697

In15: Innes, R.T.A., 1915, Observatory, 38, 333

In16: Innes, R.T.A., 1916, Union Obs. Circ., 33, 253

In17: Innes, R.T.A., 1917, Union Obs. Circ., 37, 286

Jc47: Jacob, W.S., 1847, Mem.RAS, 16, 311

Jc49: Jacob, W.S., 1849, Mem.RAS, 17, 79

Jc62: Jacob, W.S., 1862, MNRAS, 23, 53

K65: Kulczycky, A., 1865, Connaissance des temps (1867), Additions p.42

L86: Lynn, W.T., 1886, Observatory, 9, 101

L07a: Lynn, W.T. 1907a, Observatory, 30, 216

L07b: Lynn, W.T., 1907b, JBAA, 17, 175

L07c: Lynn, W.T., 1907c, JBAA, 17, 284

Le43: Leps, [M], 1843, Comptes Rendus, 17, 262

LS70: Le Sueur, A., 1870b, Proc. Roy. Soc., 18, 245

M56: Moesta, C.W., 1856, AN, 44, 337

M59a: Moesta, C.W., 1859a, AN, 51, 123

M59b: Moesta, C.W., 1859b, MNRAS, 19, 327

M65: Moesta, C.W., 1865, AN, 65, 143

Mc43: Mackay, W.S., 1843, MNRAS 6, 8

Mk00: Markwick, E.E., 1900, MNRAS, 60, 223

Mn07: Manning, S., 1907, English Mechanic, 85, 536

Mn09: Manning, S., 1909, English Mechanic, 89, 12

Pe83: Pechüle, C.F., 1883, *Expédition danoise pour l'observation du Passage de Vénus 1882*. Copenhagen

Pi08: Pickering, E.C., 1908, Harvard Annals, 50, 211

Pk86: Peek, C.E., 1886, *Astronomical Observations 1882–5*. Rousdon Observatory, Devon

PV: Polcaro, V.F. & Viotti, R., 1993, A&A 274, 807

Pw57: Powell, E.B., 1857, Mem. RAS, 25, 55

Pw62: Powell, E.B., 1862, MNRAS, 22, 47

Pw63: Powell, E.B., 1863, Mem. RAS, 32, 75

R71a: Russell, H.C., 1871a, Trans. Roy. Soc. NSW, 5, 15

R71b: Russell, H.C., 1871b, *Observations on the stars and nebula about η Argus*. Govt. Printer, Sydney

R88: Russell, H.C., 1888, J. Proc. Roy. Soc. NSW, 22, 76

Ro92a: Roberts, A.W., 1892a, Mem. BAA, 1, 54

Ro92b: Roberts, A.W., 1892b, JBAA, 3, 422

Ro01: Roberts, A.W., 1901, AJ, 21, 81

S45a: Smyth, C.P., 1845a, MNRAS, 6, 242

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