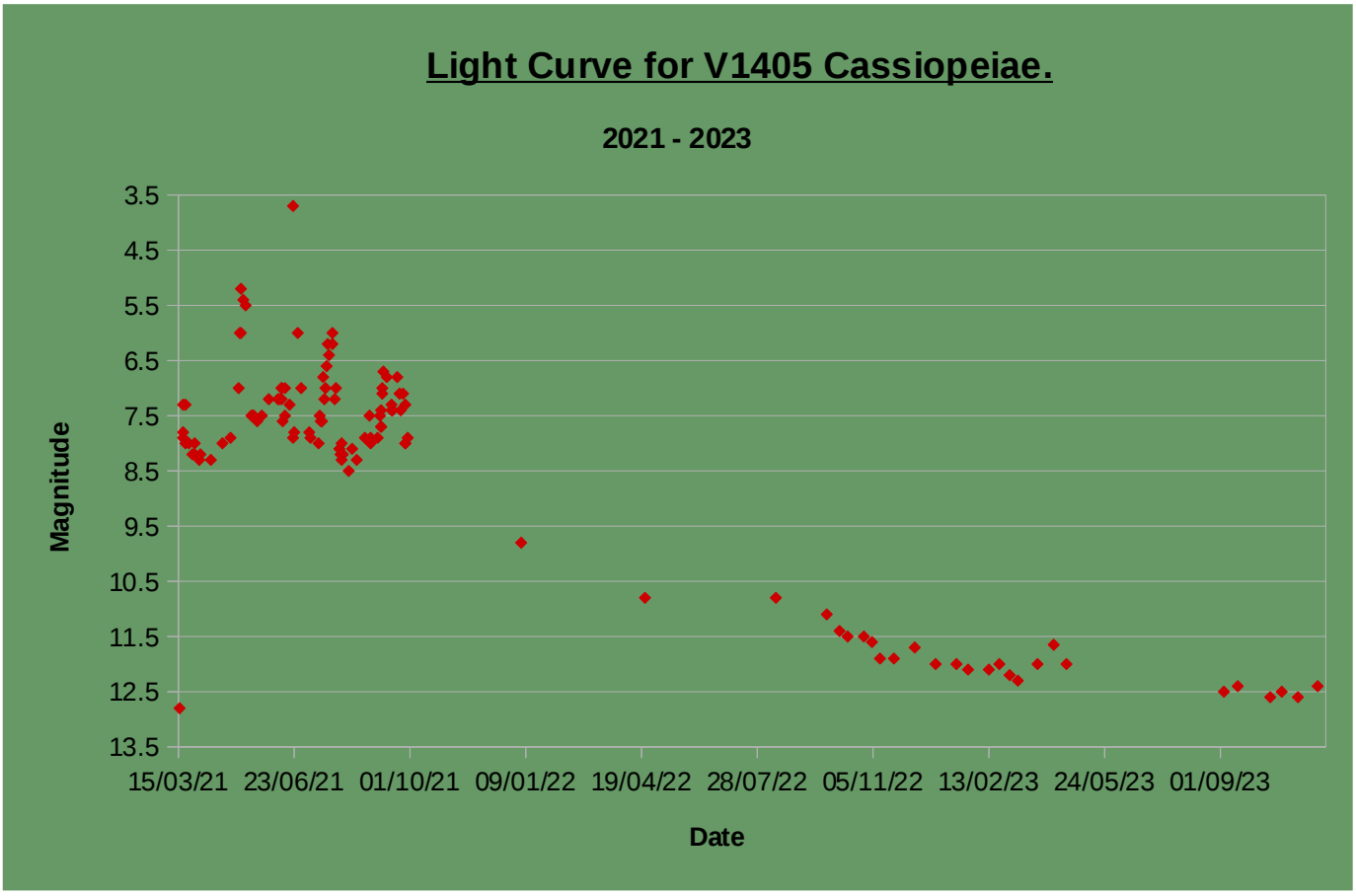
The Society of Popular Astronomy's Variable Star Section Annual Report - 2023.

Over the cause of 2023, eight members submitted observations to the Variable Star Section. Those members were: Bob Steele, Don Matthews, Doug Allen, Edward Sawyer, Jonathan Shanklin, Mark Hardaker, Paul Kitchen and Matthew Barrett.

The two most interesting events in 2023, was the unexpected drop in brightness of R Coronae Borealis, and an unusual drop in the brightness of Rho Cassiopeia.

Nova Cassiopeia 2021 – V1405.

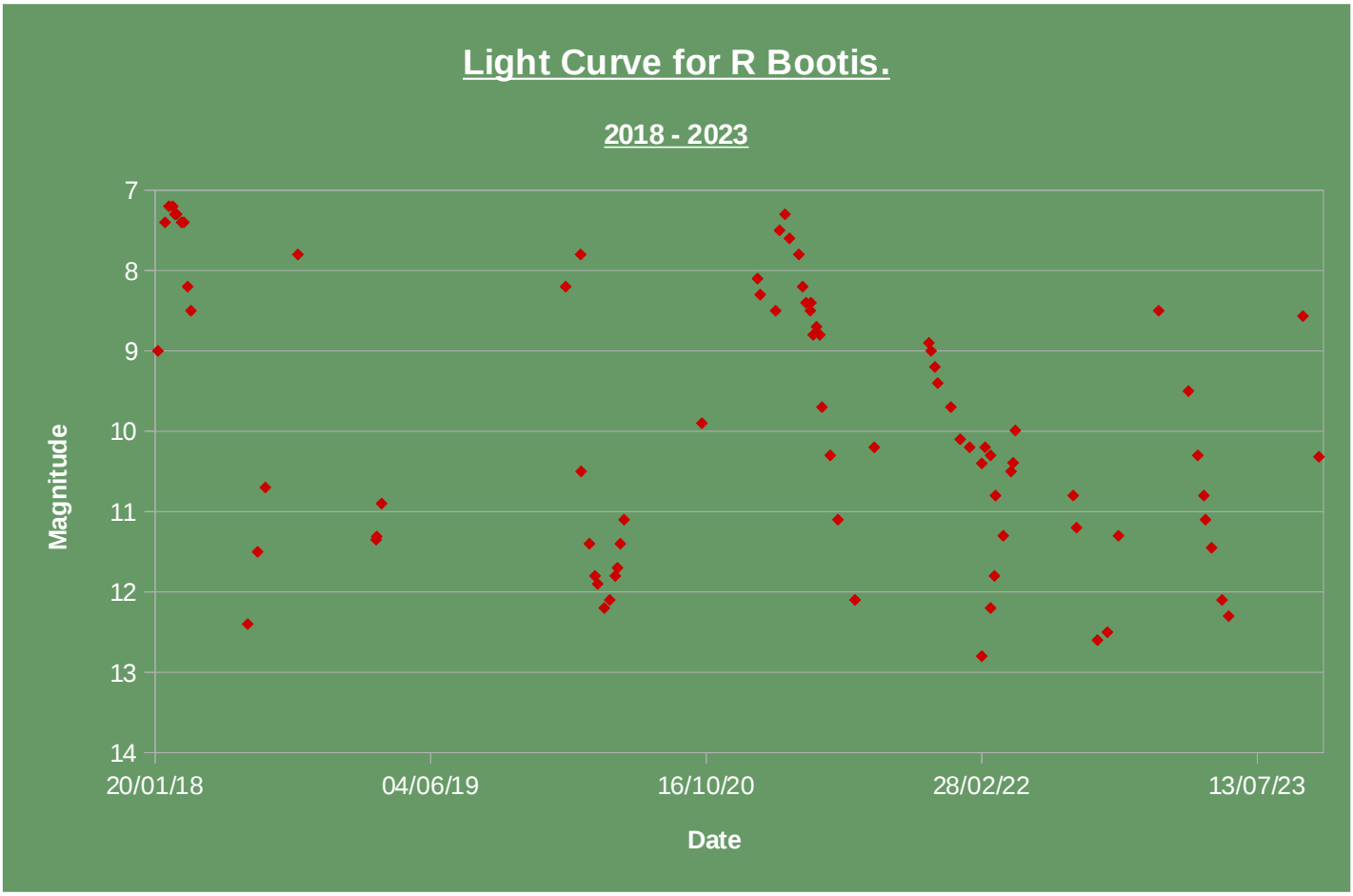


One of the biggest events of 2021 was the discovery of nova Cassiopeia 2021. Nova Cassiopeia, or V1405 Cassiopeia as it has now been designated, was discovered in March 2021 by the Japanese astronomer Yuji Hakamura, and it became the brightness nova seen from the UK since nova V399 Delphini 2013.

Nova V1405 Cassiopeia had fallen below the ninth magnitude by the end of 2021, so was no longer visible to binocular observers, however some of our members were able to continue their observations as the star faded over the course of 2022-2023. Don Matthews in particular was able to keep making observations until the star fell below twelfth magnitude. V1405 Cassiopeia now seems to have returned to its original brightness, before it went into outburst.

R Bootis.

Type	Extreme Range	Typical Range	Period
LPV	6.2 – 13.1	7.2 – 12.3	223d

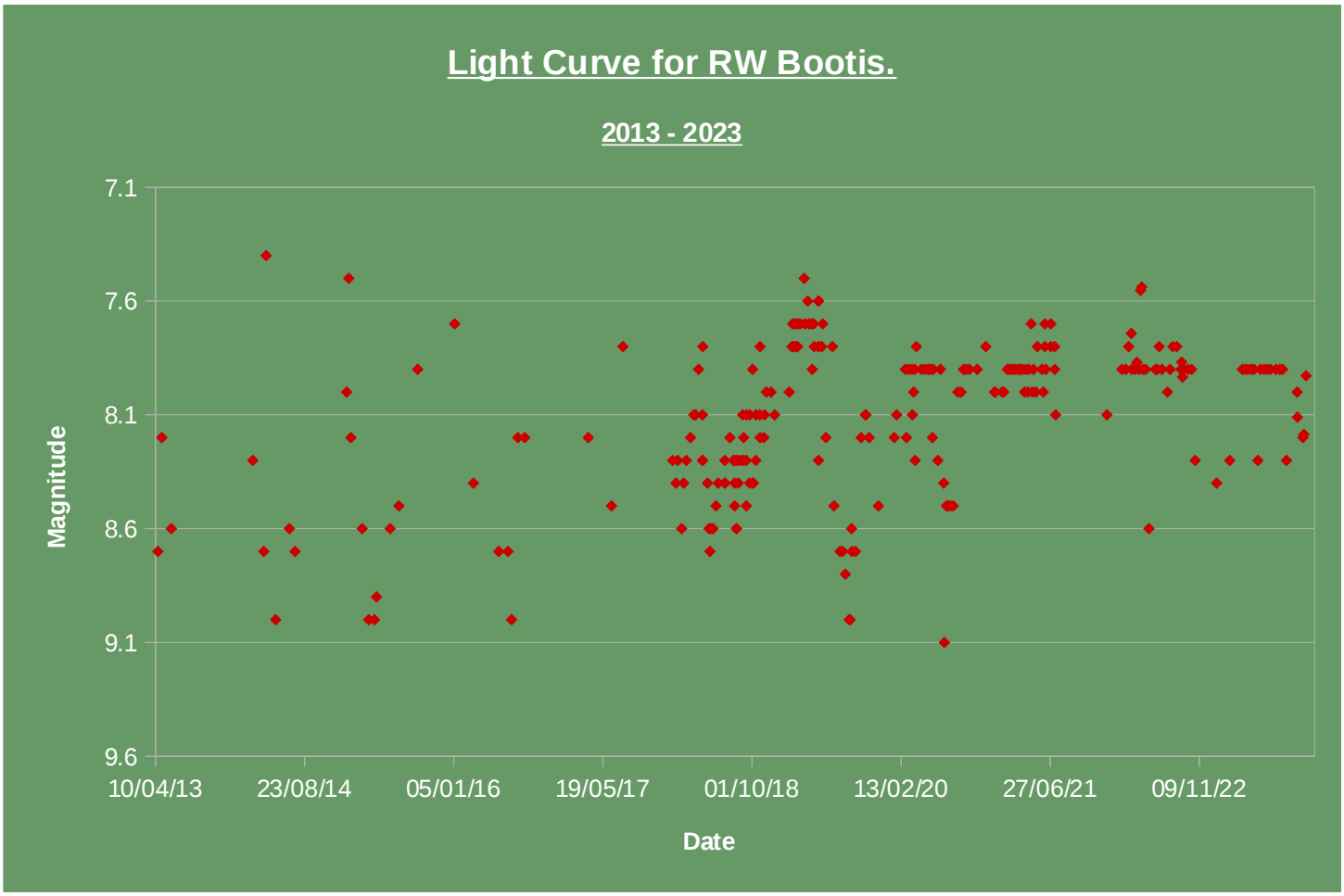


R Leonis is one the brightest long-period variables in the sky and it was the fourth star of its type to be discovered when first seen by J. A. Koch of Danzig in 1782. R Leonis is a red giant with an estimated radius 300 times that of the Sun. It's also notable for its intensely red colour. J. R. Hind described it as being "....fiery in every stage, from maximum to minimum....".

R Bootis was not as well observed in 2023 as it has been in previous years. This may have been due to R Bootis reaching maximum in August, when Boötes is not best placed for observing from the UK. R Bootis seems to have reached a much lower maximum then usually; around magnitude 8.5. However, the actual maximum may have been missed. During 2024, R Booties will reach maximum in April, when it is very placed for observing, so we may have more observations of R Bootis next year.

RW Bootis.

Type	Extreme Range	Typical Range	Period
SR	6.4 – 9.2	7.9 - 8.7	209d

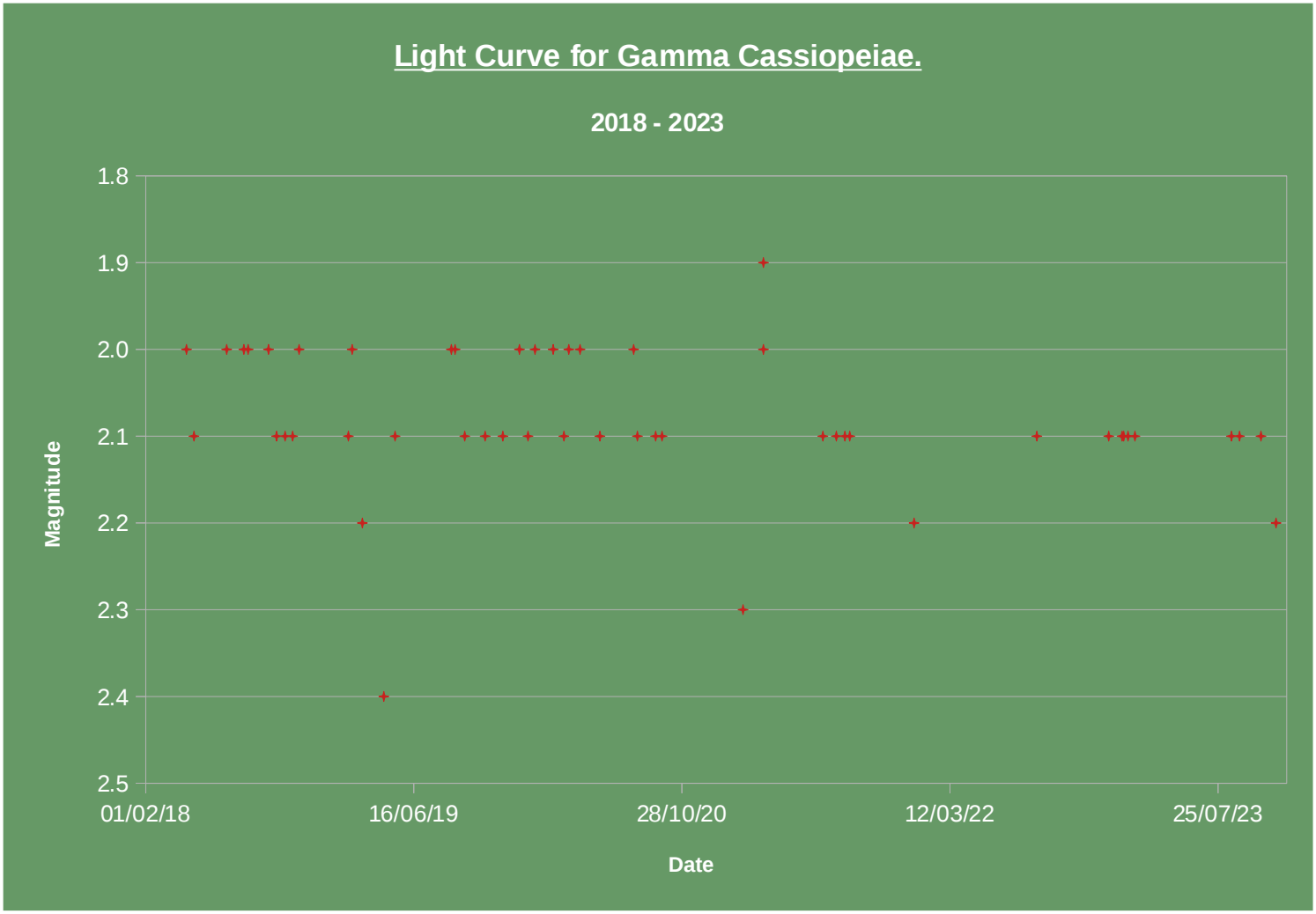


A popular semi-regular star within Boötes is RW Bootis. RW Bootis has an extreme range of 6.4 – 9.2, but a more typical range is 7.9 – 8.7. It is classified as a semi-regular star, with a period of seven months. However, recent observations suggest the period may be lengthening to something closer to 10-11 months. Certainly, observations made by the SPA Variable Star Section, support this. If you look at the light curve, you can see, despite the large amount of scatter, a suggestion that the period is much longer then seven months. For example, RW Bootis reached minimum brightness in August 2019, but didn't see another minima until about a year later.

RW Bootis was rather unobserved during 2023, so the light curve shows a lot of scatter. As RW Bootis is a semi-regular star, it does not have a well defined amplitude or range. It also doesn't help that RW Bootis has quite a small amplitude, which means that we would need a large number of observations to create a very accurate light curve. However, it does seem that the amplitude has decreased slightly, and seems to vary between about 8.5 and 7.5.

Gamma Cassiopeia.

Type	Extreme Range	Typical Range	Period
Eruptive Variable	1.6 – 3.0	2.0 – 2.2	None

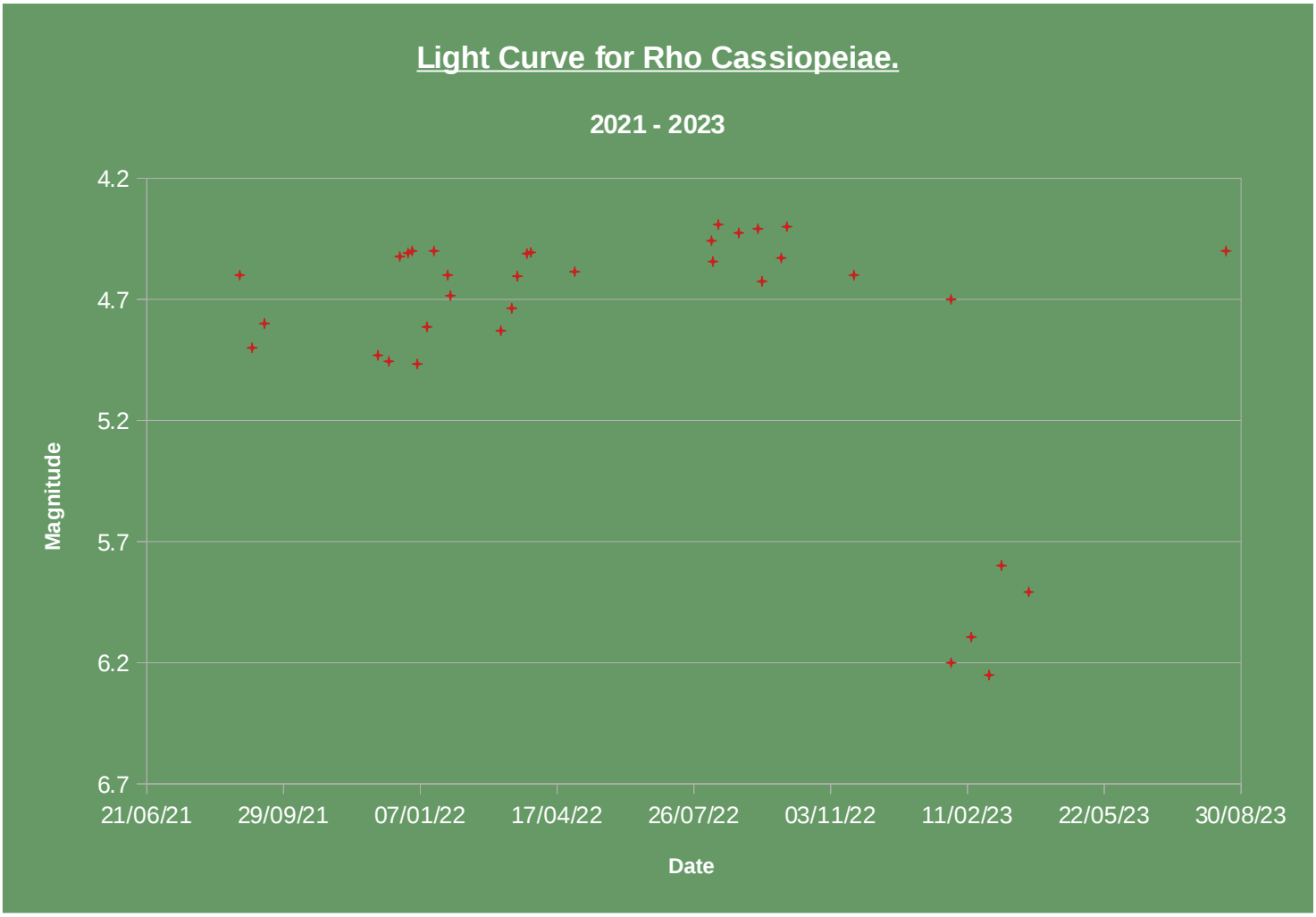


Gamma Cassiopeia is a B0 sub-giant, with bright hydrogen lines, which were first observed by Father Secchi in 1866. Before 1910, it had a magnitude of 2.25, which slowly rose to 1.75 by 1936. Then, in April of 1937, it showed a rapid increase to magnitude 1.6, before returning to its original magnitude of 2.25 by the end of that year. It then faded to magnitude 3.0 by 1940, before slowly rising to magnitude 2.5 by 1954. It then rose still further, so by 1975 it was at magnitude 2.2. It has stayed at about this magnitude up to the present day. Over the past few years, gamma Cassiopeia has only displayed some flickering between magnitude 2.2 and 2.0.

Gamma Cassiopeia hasn't shown any unusual behaviour during 2023. It still continues to hover around magnitude 2.0. However, we never know whether, or when, gamma Cassiopeia will show any unexpected behaviour, so it is always worth keeping an eye upon it.

Rho Cassiopeia.

Type	Extreme Range	Typical Range	Period
Eruptive Variable	4.1 – 6.2	4.2 – 5.0	None



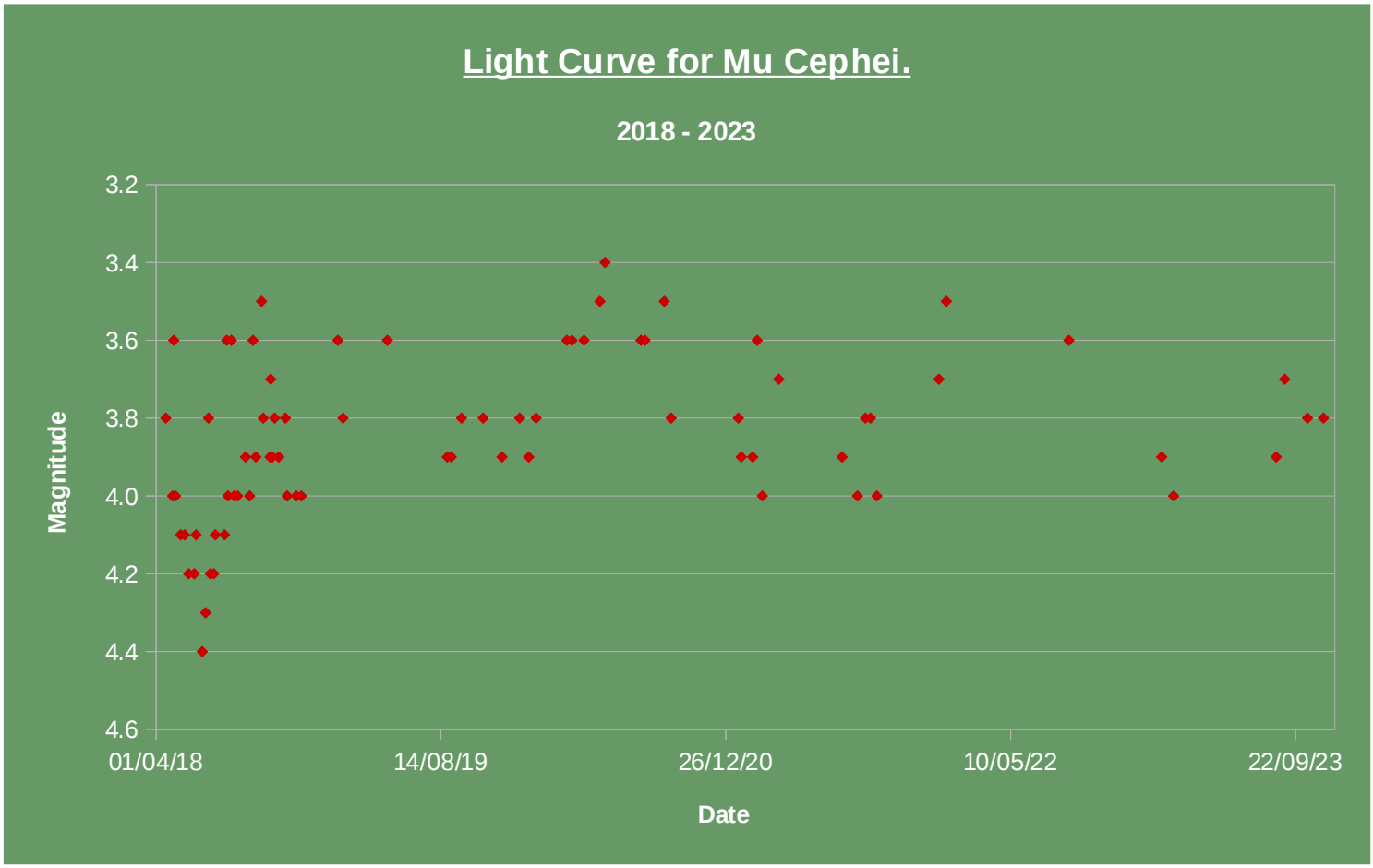
Rho Cassiopeia is an example of an 'S Doradus' type variable - a particular class of eruptive variable. It is a yellow hyper-giant with a mass of about 40 solar masses, and a radius about 400 times that of the Sun. It is also one of the most luminous stars known, being about 300,000 time more luminous then the Sun. Its immense luminosity is showed by the fact that it's visible to the naked eye, despite being about 3,400 light years away.

Rho Cassiopeia usually shines about magnitude 4.5, but it does display occasional, irregular drops in brightness. For example, in 1946, it dropped to magnitude six, and this happened again in 1993. In 2013, it dropped to magnitude five.

During February 2023, Rho Cassiopeia once again showed a dramatic drop in brightness, to around magnitude 6.2. This is a very rare, and extreme drop in brightness for Rho Cassiopeia. It will be interesting to see what behaviour Rho Cassiopeia will display in the future.

Mu Cephei.

Type	Extreme Range	Typical Range	Period
Irr	3.4 – 5.1	3.5 – 4.0	860d

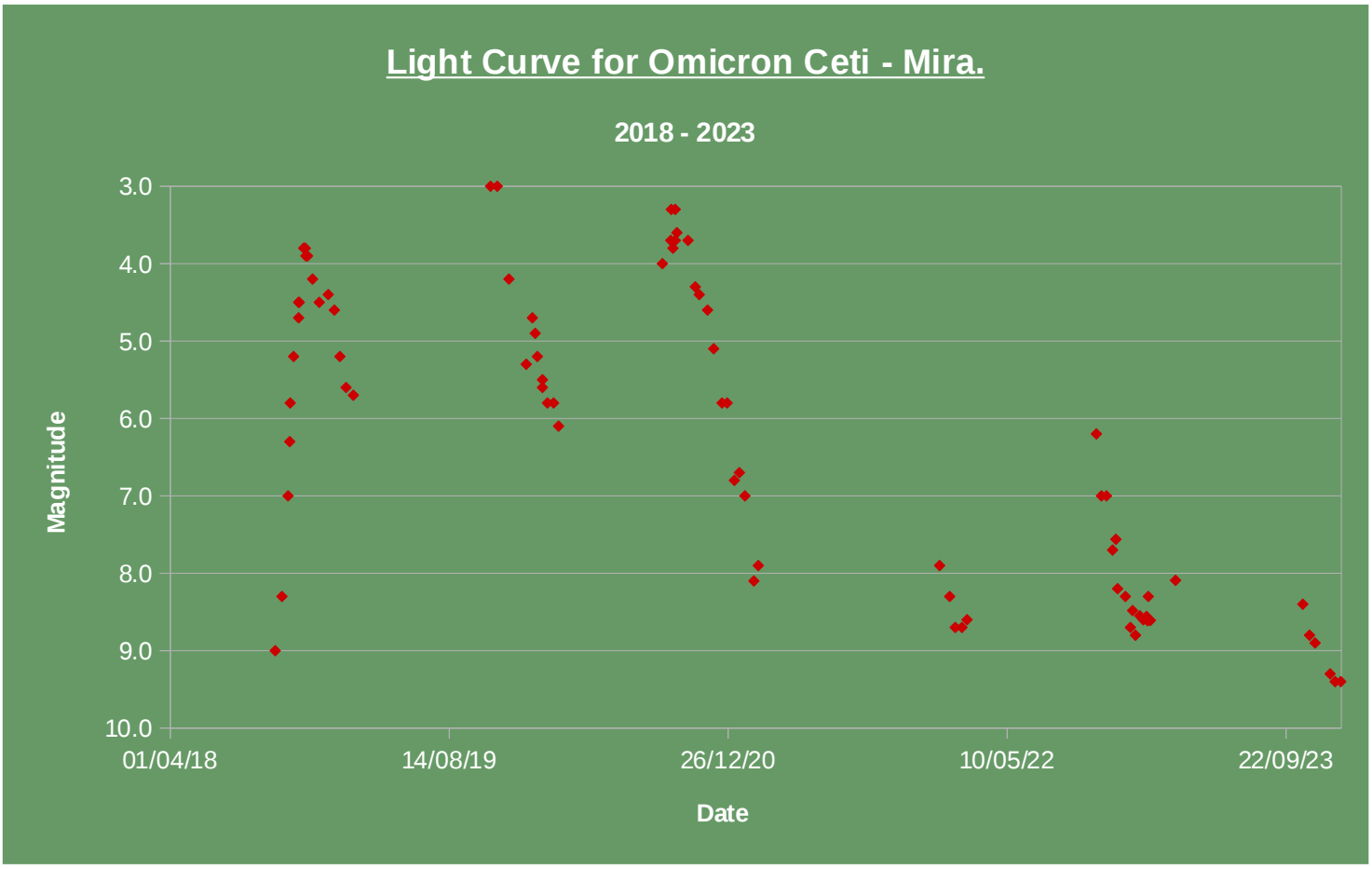


The beautiful golden orange of Mu Cephei compelled Sir William Herschel to name it the 'garnet star'. The variability of Mu Cephei was first detected by J.R. Hind in 1848. Mu Cephei is classified as an irregular variable, with an amplitude of 3.4 – 5.1, and a nominal period of 860 days.

During 2023, Mu Cephei doesn't seem to experienced as much variation as it has in the past. Mu Cephei has displayed no large scale changes in brightness, but continues to vary between magnitudes 3.5 – 4.0.

Omicron Ceti.

Type	Extreme Range	Typical Range	Period
LPV	1.7 – 10.1	3.6 – 9.3	332d

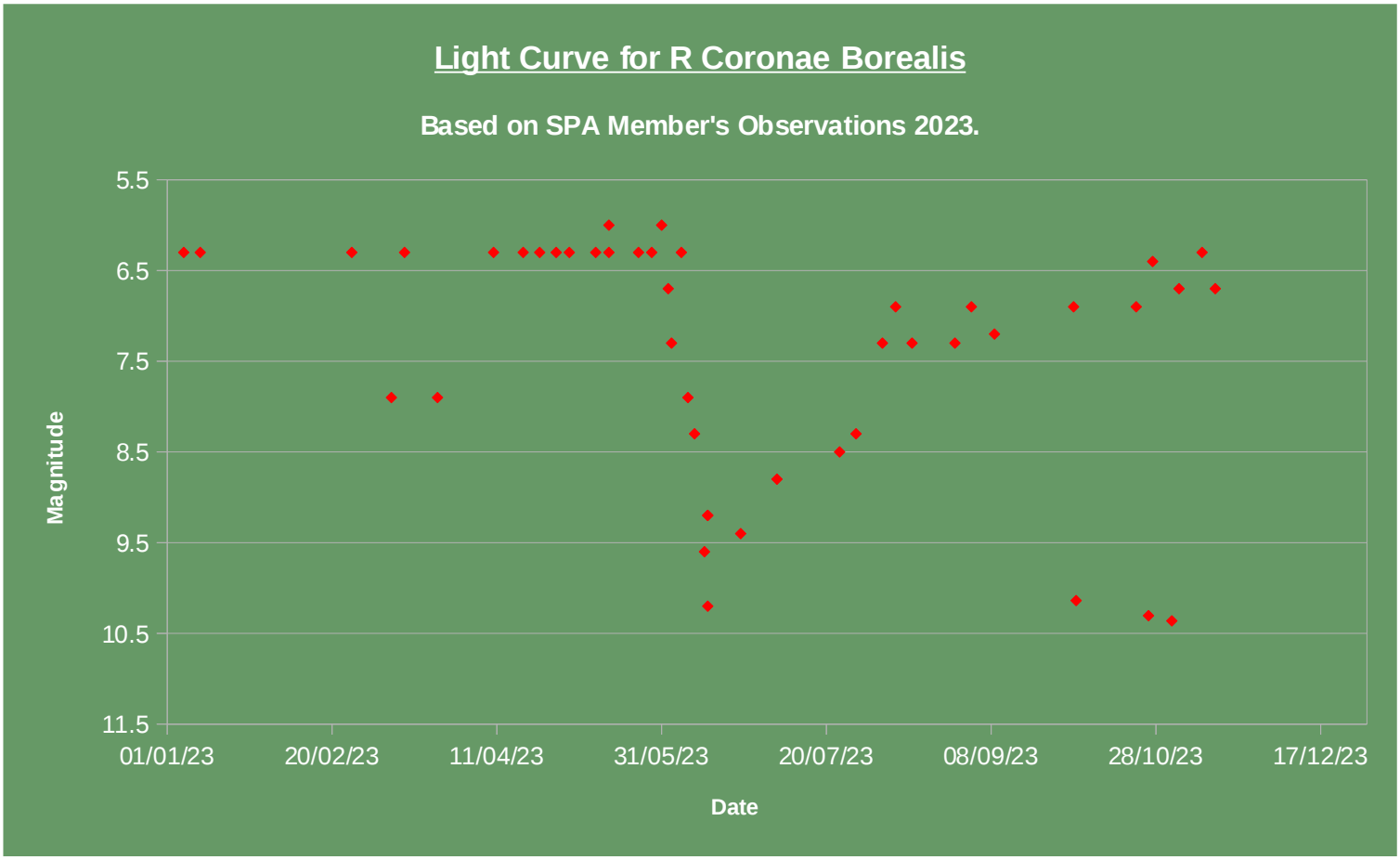


Mira, also known as Omicron Ceti, is both the prototype of all long period variables and one of the most widely observed variable stars in the night sky. Mira was first observed on the 13th of August 1596 by the Dutch astronomer David Fabricius; who mistook it for a nova. The star was next observed in 1603, when the German astronomer Johann Bayer plotted it into his star map, Uranometria, and designated it omicron Ceti. It wasn't until 1638 that the Dutch astronomer Johann Holwarda, determined that it was a variable star with a period of about eleven months. Since 1638, every maxima of omicron Ceti has been observed. As omicron Ceti was the first variable star to be discovered, it was the Polish astronomer, Johannes Hevelius, who suggested the name Mira - meaning 'The Wonderful'.

Unfortunately, during 2023, Mira came to maximum brightness in June, when it is a not well placed for observing from the UK. Once Mira became more easily observed, during the autumn months, it had already started to fade. The same pattern will be true in 2024, as Mira is predicted to reach maximum brightness in May, when it won't be visible. When it does become visible, in the autumn, it will be fading to minimum brightness in December.

R Coronae Borealis.

Type	Extreme Range	Typical Range	Period
R Crb	5.8 – 15.0	6.1 – 6.4	None



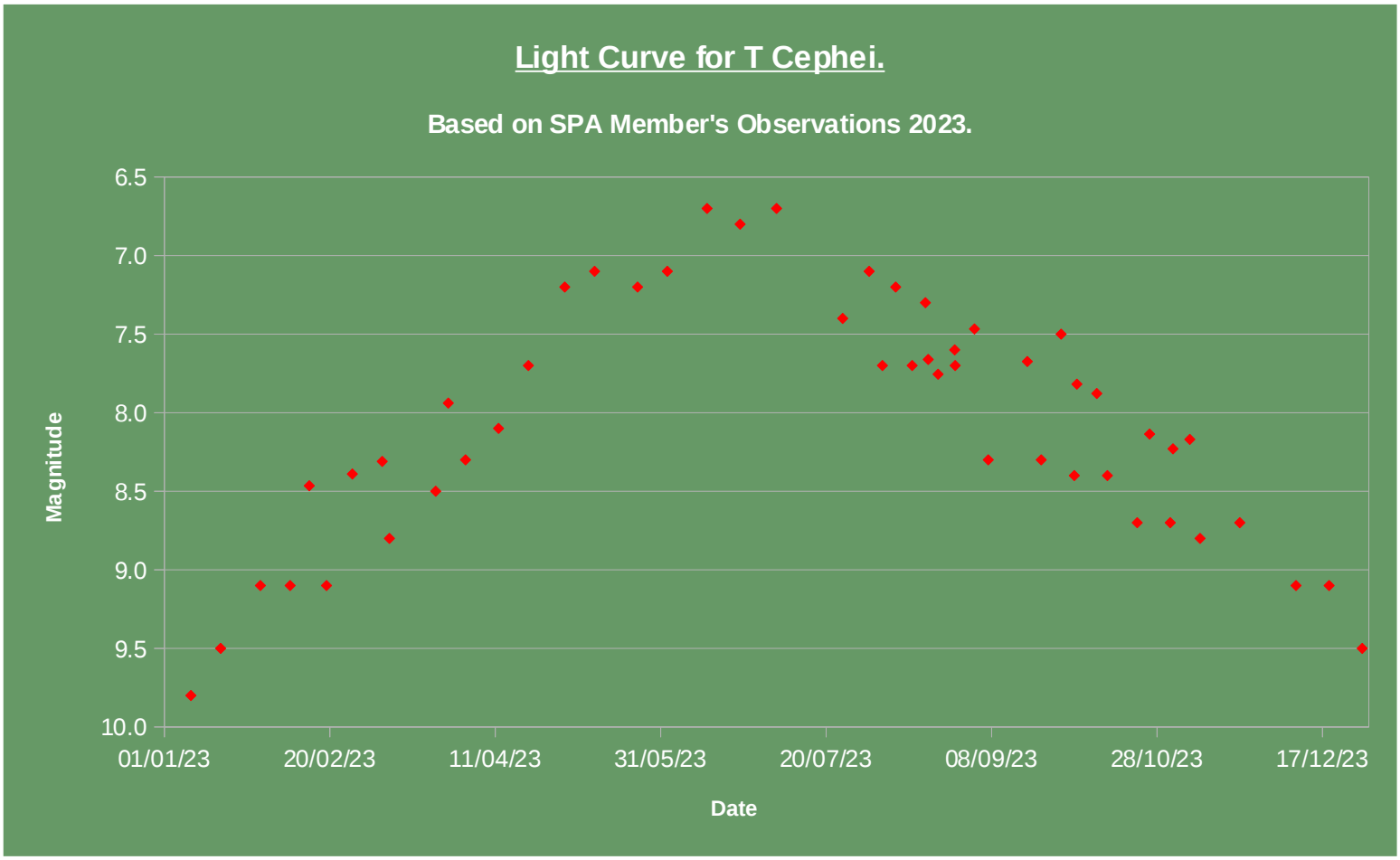
One of the more exciting events that occur during 2023, was the unexpected drop in brightness of R Coronae Borealis.

R CrB is a yellow supergiant, with a spectrum containing weak hydrogen lines and very strong carbon and cyanogen lines. It is thought to have a mass approximately equal to that of the Sun, with a radius of a hundred solar radii and a surface temperature of 7000K. What makes R CrB stars different from most yellow supergiants, is that they are thought to be surrounded by dust clouds, which is produced from material emitted from the star. R CrB is thought to surrounded by a dust cloud with a radii of about 200 au, created by a stream of carbon particles coming from the star. It's the obscuring effect of this carbon-rich dust cloud that causes the rapid drop in brightness of R CrB.

R Coronae Borealis usually hovers around magnitude six, so is easily seen in binoculars. For the last few years, R Coronae Borealis has not shown any unusual behaviour, however, this changed in May of last year, when it suddenly dropped in brightness, to about magnitude ten. What was unusual about this brightness drop, was that is was not as extreme as previous drops in brightness. Normally we would expect R Coronae Borealis to drop to around the 15th magnitude. Another way in which this drop was so unusual, was that it was so short-lived, with R Coronae Borealis recovering too close to its normal brightness over the summer.

T Cephei.

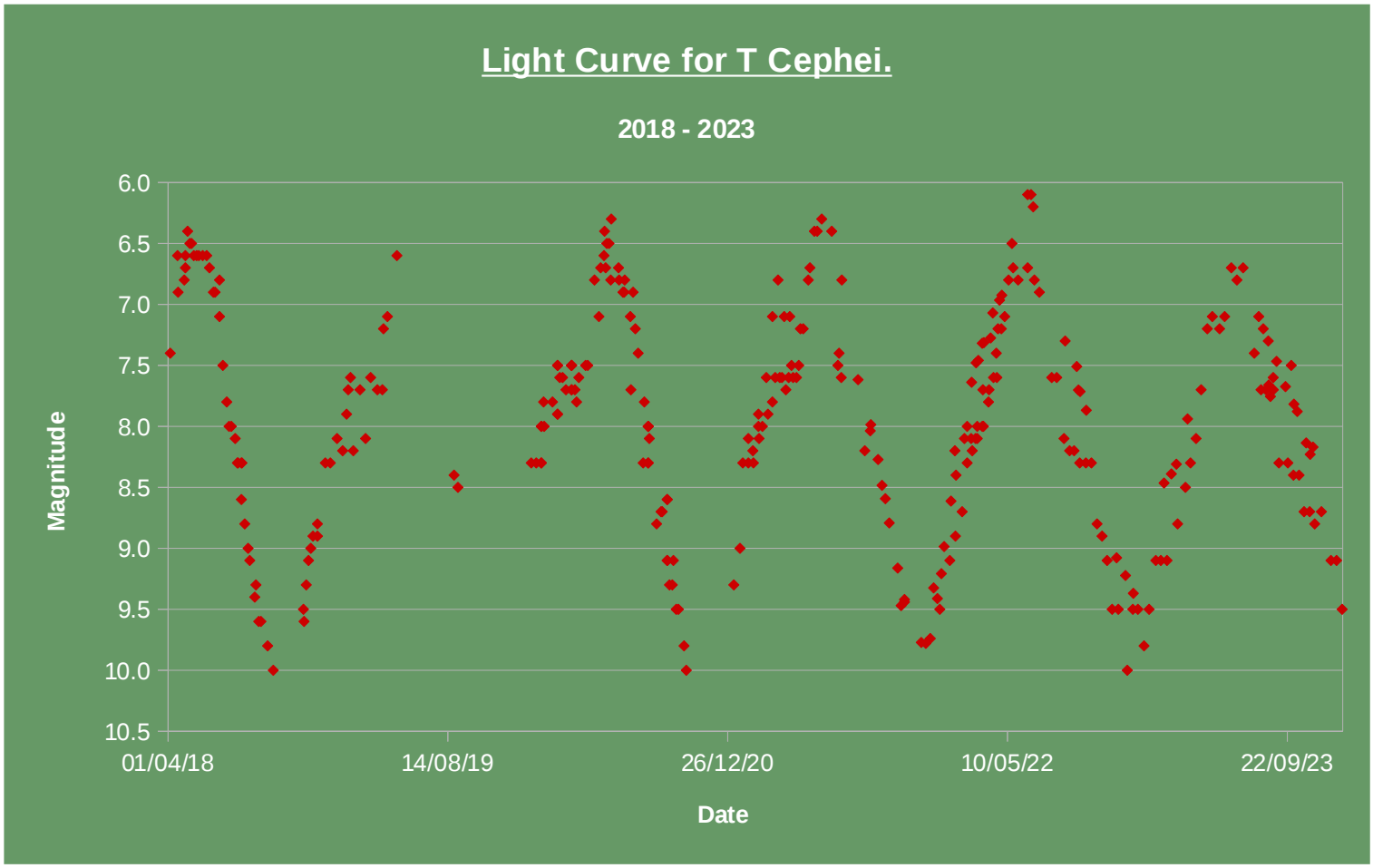
Type	Extreme Range	Typical Range	Period
LPV	5.4 – 11.0	6.0 – 10.5	389d



T Cephei remains one of the most popular stars on the SPA's programme, and as this light curve shows, members were once again able to observe T Cephei over a complete of cycles of variation.

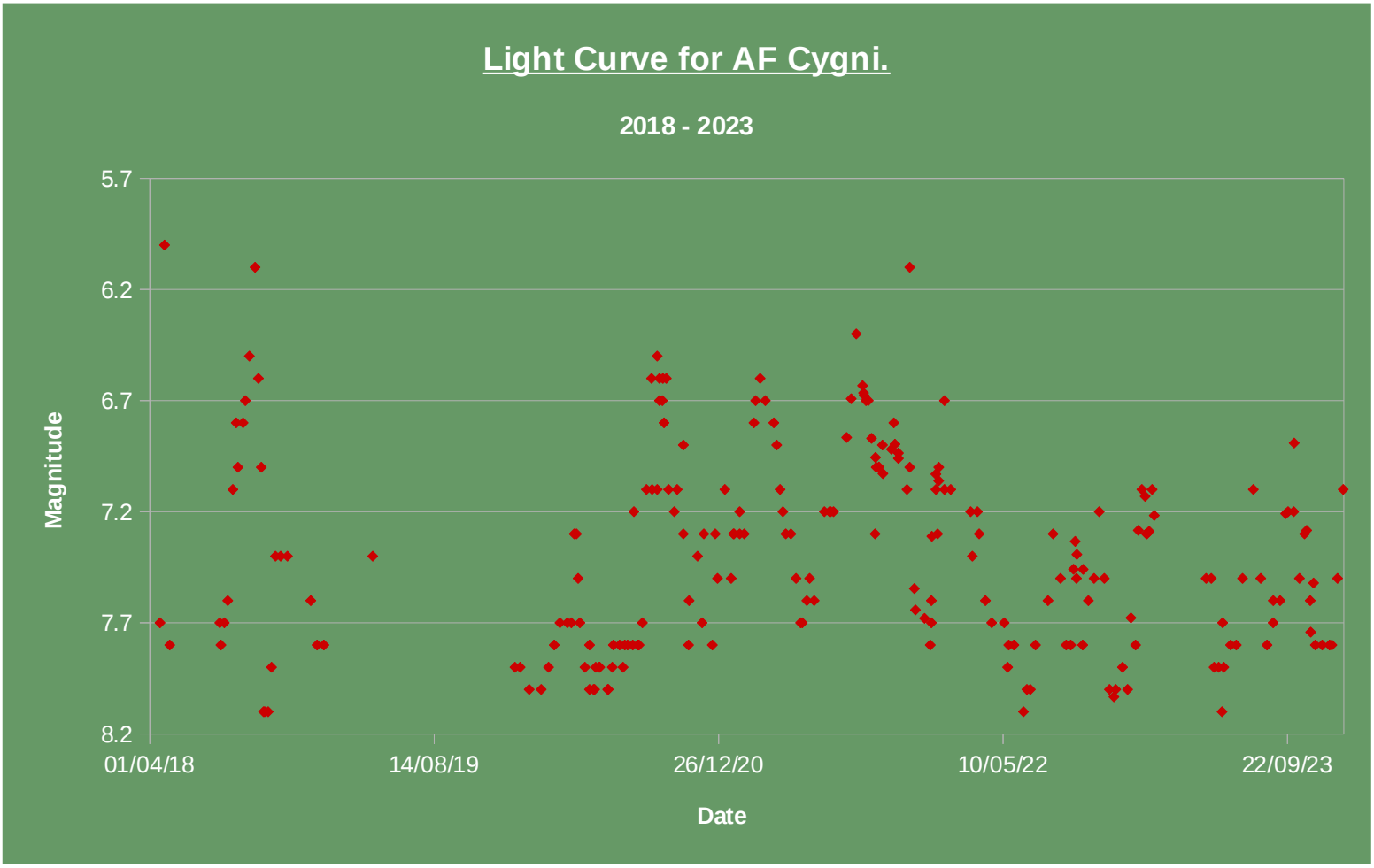
This light also shows a potential problem with visual variable star observing; the problem of personal bias. Some observers will always see some stars as being consistently brighter, compared to other observers. This is a particular problem for red stars, as some people have eyes which are particularly sensitive to red light.

This is why it is important that we have a large number of observations, so the discrepancies between individual observers can be 'ironed-out'. The light curve below, shows how combining larger numbers of observations can produce more accurate results.


Light Curve for T Cephei.
2018 - 2023
Magnitude
6.0
6.5
7.0
7.5
8.0
8.5
9.0
9.5
10.0
10.5
01/04/18
14/08/19
26/12/20
10/05/22
22/09/23
Date

AF Cygni.

Type	Extreme Range	Typical Range	Period
SR	6.4 – 8.4	6.7 – 7.7	92d

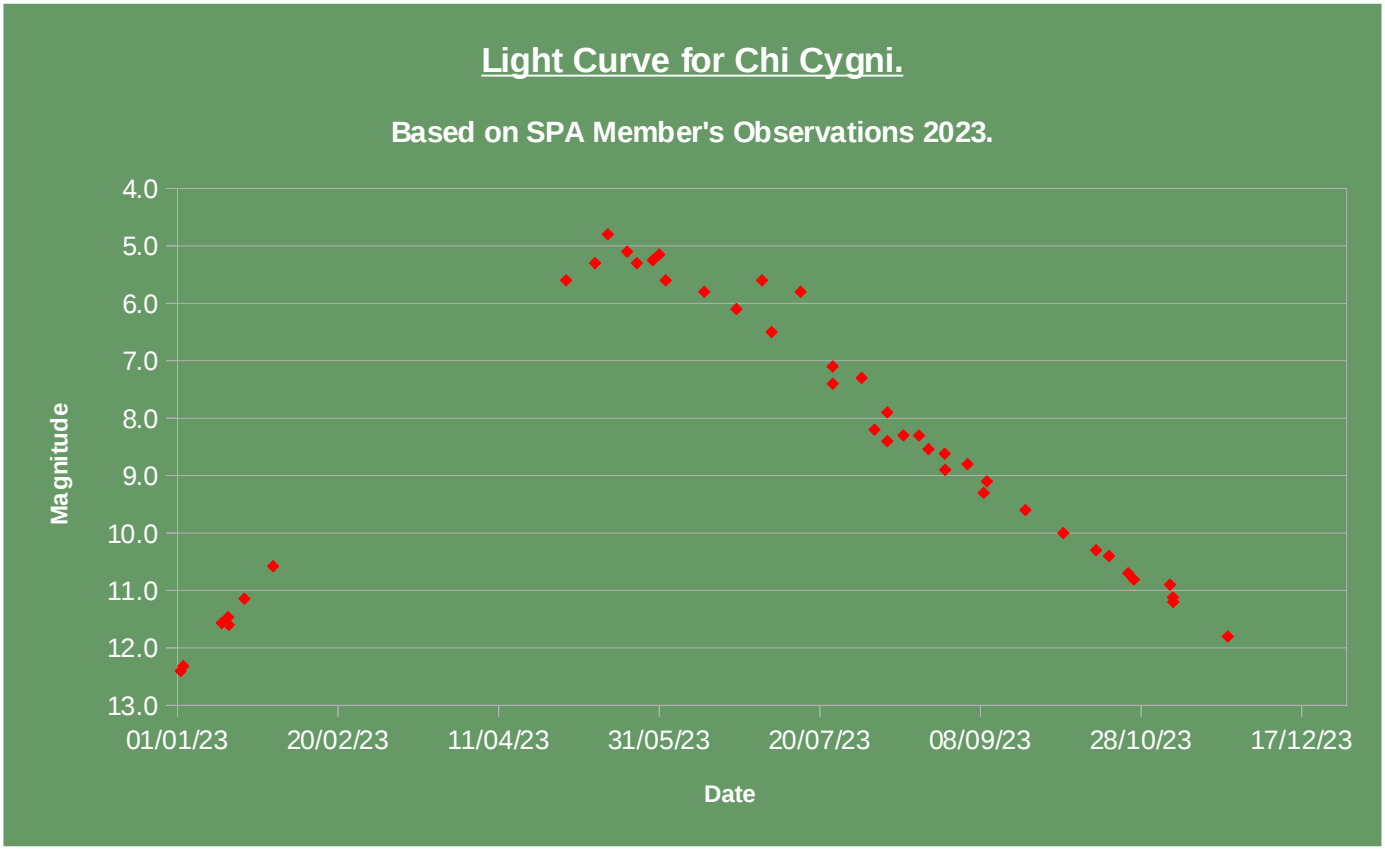


Easily located near Delta Cygni, is the popular semi-regular star, AF Cygni. Like all semi-regular stars, AF Cygni is a red giant in the later stages of its life. It has an amplitude of 6.4 to 8.4 and a period of 92 days. The fact that AF Cygni is easy to find, coupled with fact that it always remains in range of binoculars, makes it an ideal star for beginners. Its relativity short period, means that it is possible to see a change in brightness over the course of only a few weeks.

AF Cygni is becoming an increasingly popular star with the SPA members, and we were able to observe AF Cygni, over a couple of cycles of variation.

Chi Cygni.

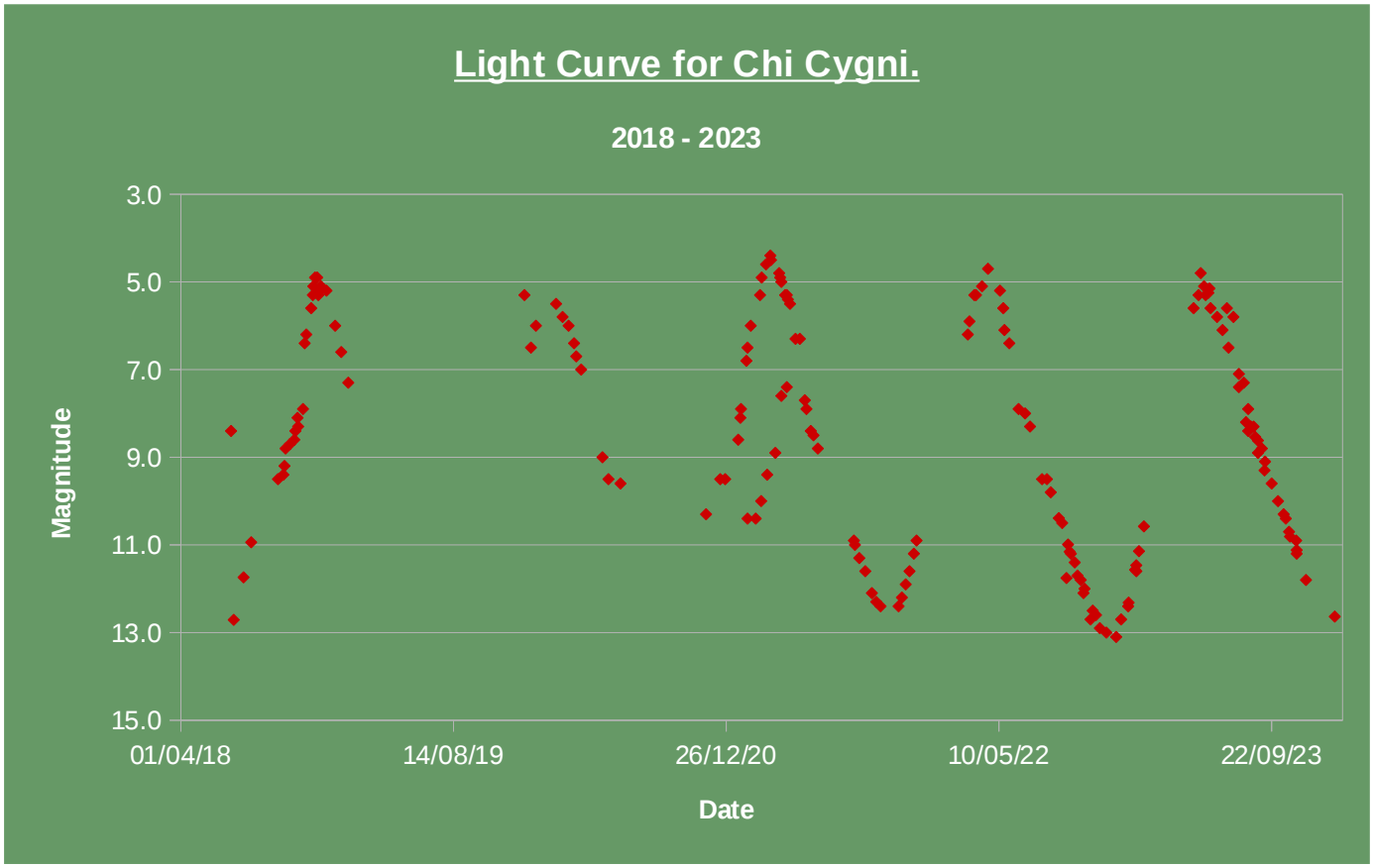
Type	Extreme Range	Typical Range	Period
LPV	3.4 – 14.2	5.1 – 13.4	407d



The variability of Chi Cygni was first determined in 1686 by Gottfried Kirch - making it the second variable star to be discovered. Like Mira, it was first erroneously identified as a non-variable star, and so given the Bayer designation of Chi. It wasn't until the nineteenth century that astronomers started regular observations of Chi Cygni. Since, then Chi Cygni has been kept under almost continuous study by a large number of, mostly amateur, astronomers.

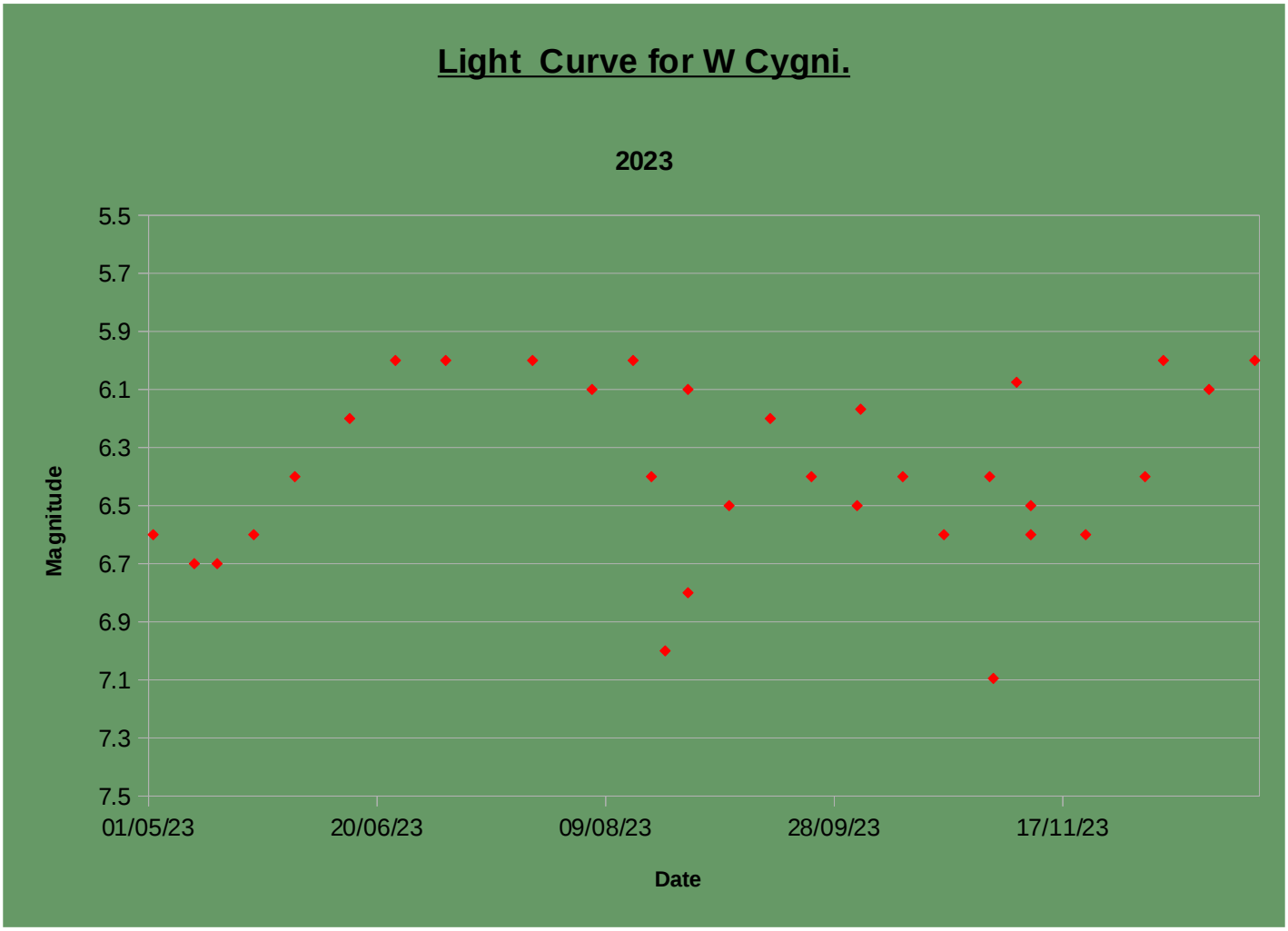
Chi Cygni has a usual brightness range of 5.2 to 13.4, however, Chi Cygni often demonstrates a large variation in its maximum and minimum values. Chi Cygni has a more extreme range of 3.4 to 14.2. At its brightest Chi Cygni may be visible with the naked eye, so that is an apparent extra star in the tail of Cygnus the swan. At is faintness, Chi Cygni is so faint that a large telescope and a detailed star atlas is required just to find it; amongst the thousands of faint stars in the Milky Way.

Chi Cygni was well observed over the course of 2023. The break in this light curve is due to Cygni not being well placed for observing for the UK. However, we can see that Chi Cygni reached a typical maximum brightness of around five.


Light Curve for Chi Cygni.
2018 - 2023
Magnitude
3.0
5.0
7.0
9.0
11.0
13.0
15.0
01/04/18
14/08/19
26/12/20
10/05/22
22/09/23
Date

W Cygni.

Type	Extreme Range	Typical Range	Period
SR	5.1 – 8.9	5.1 – 6.8	132d

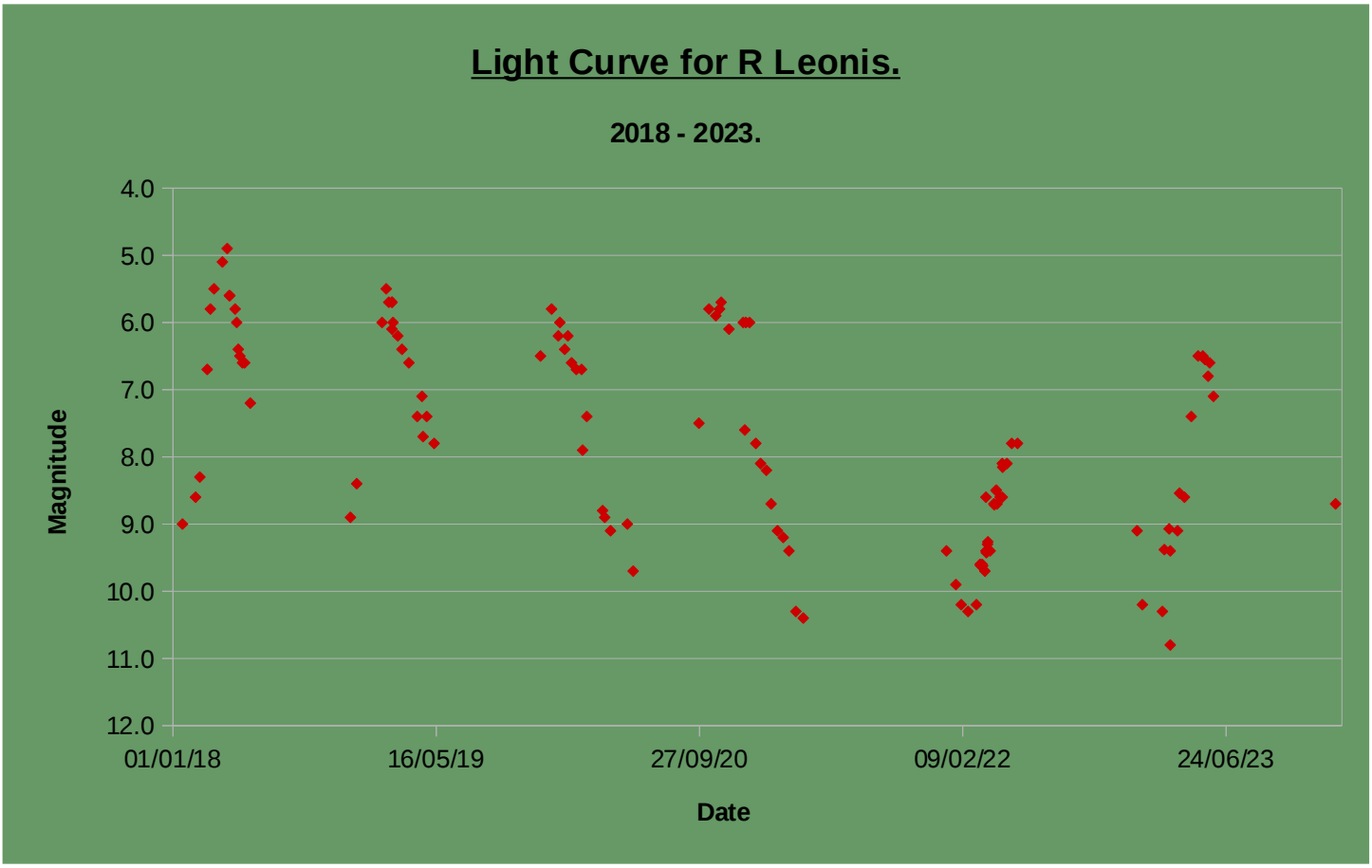


W Cygni has a short enough period, that it can be observed over the course of two cycles of variation. W Cygni has a typical range of 5.1 – 6.8, and interestingly, the range of W Cygni is showing a typical minimum, but it consistently showing a maximum well below the typical maximum. There is also the suggestion of a longer period, of close to six months.

W Cygni is rather unobserved, and it will be interesting to see whether more observations, made over the course of 2024, will allow us to create a more accurate period and range.

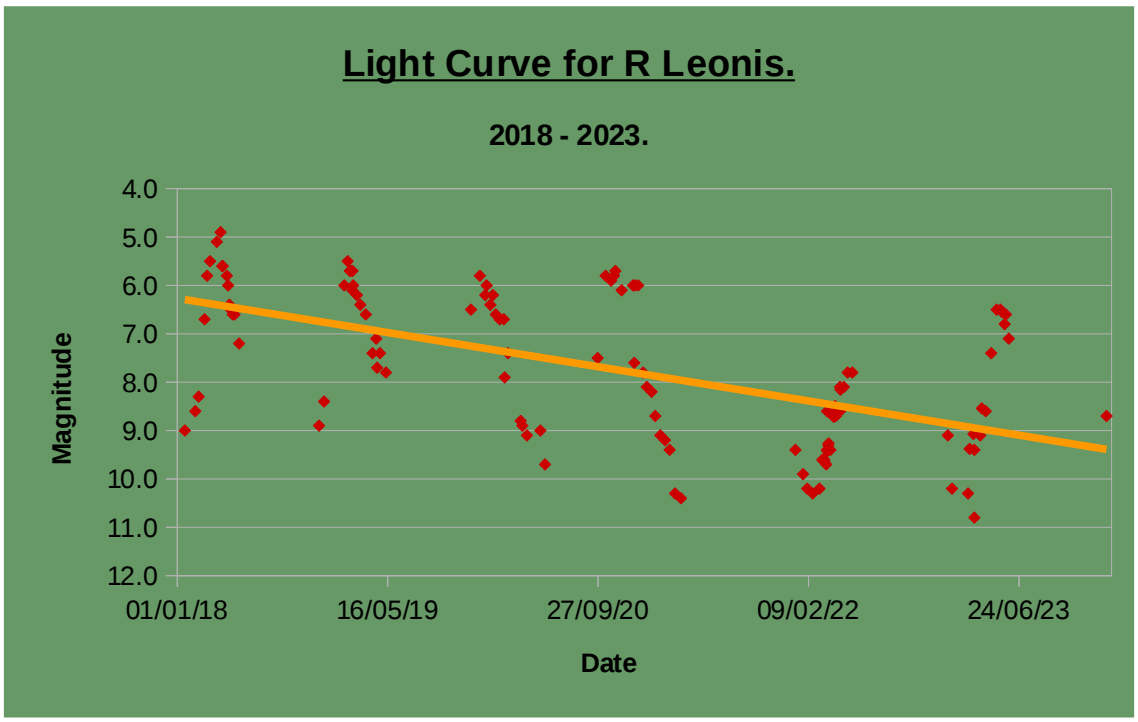
R Leonis.

Type	Extreme Range	Typical Range	Period
LPV	4.8 – 11.0	5.4 – 10.5	310d



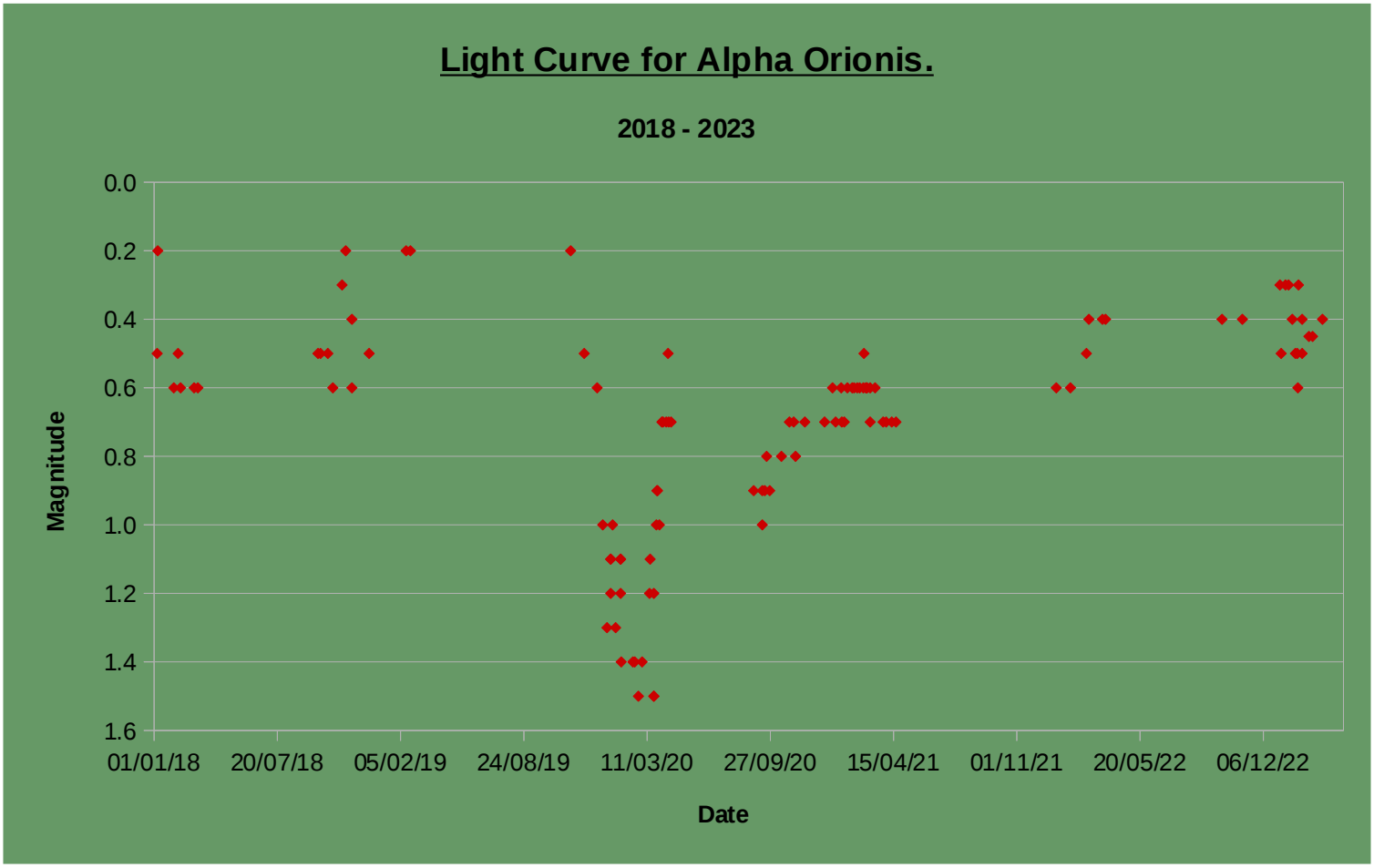
R Leonis is one the brightest long-period variables in the sky and it was the fourth star of its type to be discovered; when first seen by J. A. Koch of Danzig in 1782. R Leonis is a red giant with an estimated radius 300 times that of the Sun. It's also notable for its intensely red colour. J. R. Hind described it as being "....fiery in every stage, from maximum to minimum....". Its maximum range is between magnitude +4.4 and magnitude +11.3, so when at its brightest, R Leonis may be seen with the naked eye.

R Leonis remains a very popular variable star with the members. Interestingly, the trend over the past five years has seen both the minimum, and maximum decreasing over time. The range does not seem to be decreasing, but the trend line does show a gradual decline in the average brightness.


Light Curve for R Leonis.
2018 - 2023.
Magnitude
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
01/01/18
16/05/19
27/09/20
09/02/22
24/06/23
Date

Alpha Orionis.

Type	Extreme Range	Typical Range	Period
SR	0.4 – 1.3	04 – 0.8	1600d

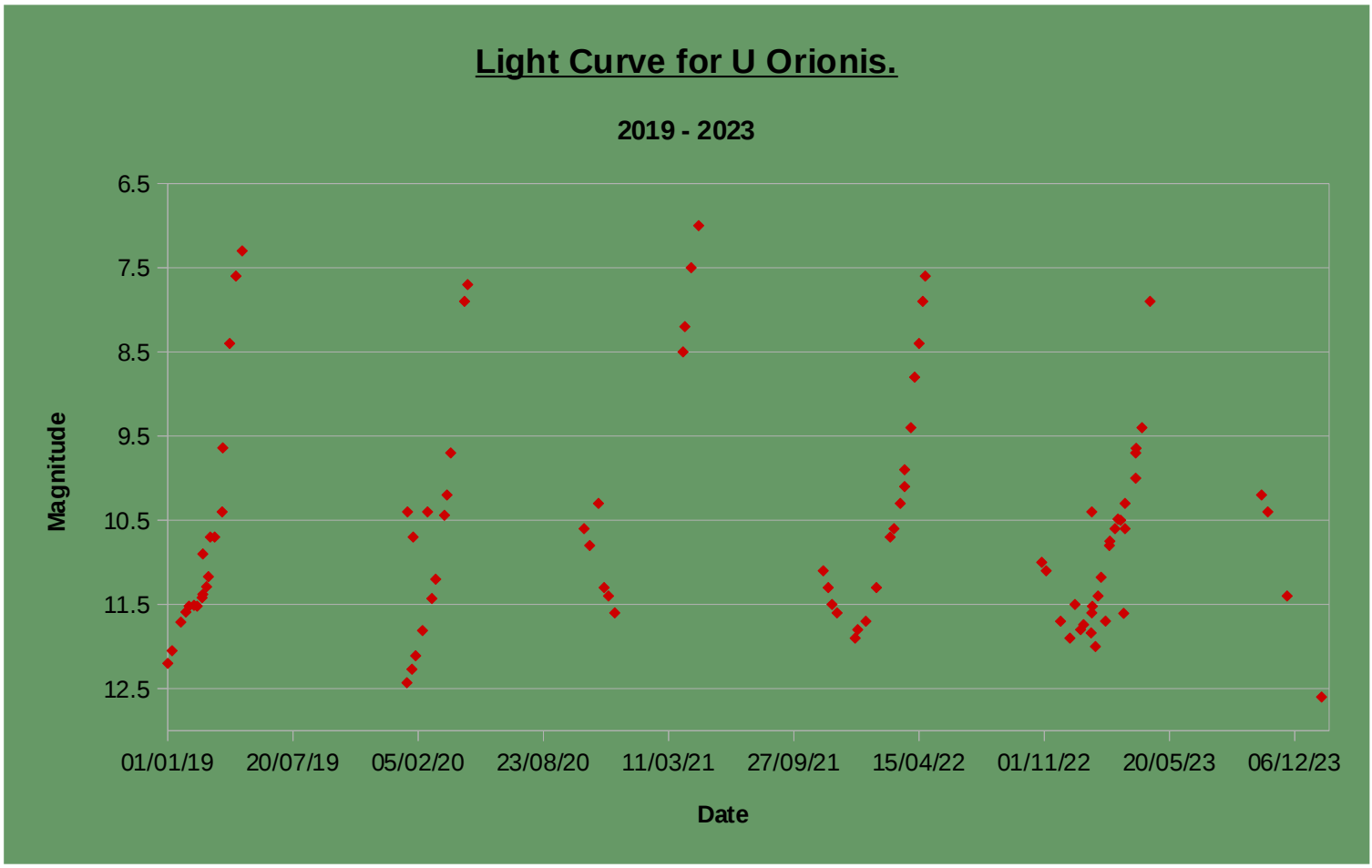


After its dramatic dimming during 2020, Alpha Orionis has once again reached its usual magnitude, of around 0.4. Alpha Orionis has not displayed any unusual behaviour since.

However, it always pays to keep a close eye upon Alpha Orionis, as we never know how it will behaviour in the future.

U Orionis.

Type	Extreme Range	Typical Range	Period
LPV	5.3 – 12.6	6.3 – 12.0	372d



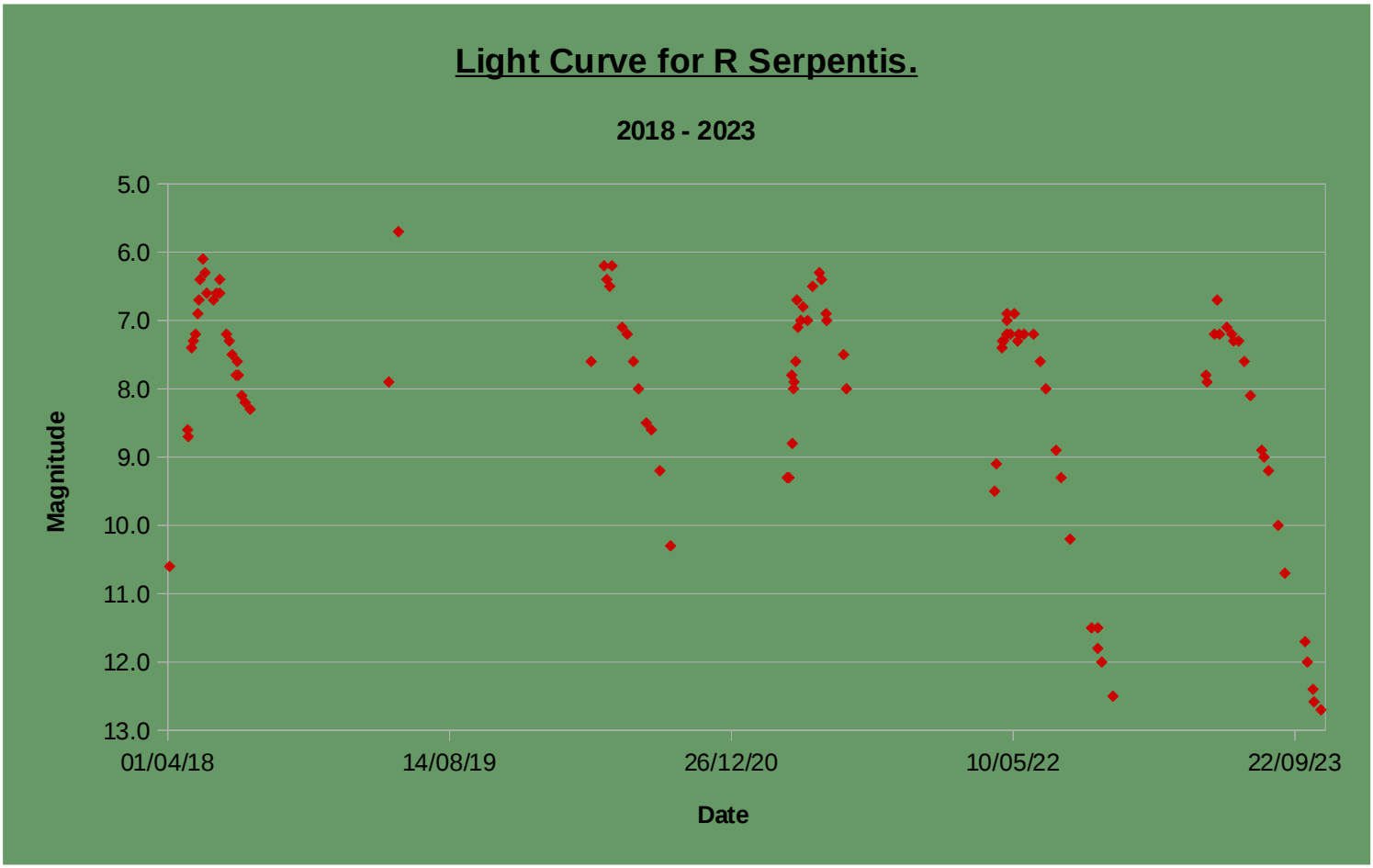
First discovered in 1885 by the Irish astronomer John Gore, who was one of the founding members of the British Astronomical Society, it was originally mistaken for a nova. However, spectra taken at the Harvard observatory in the USA showed it to be a long-period, Mira-like, variable.

Like all long-period variables, it is a red giant whose internal pulsations cause it to change in brightness. U Orionis has a surface temperature of about 2700K and a radius 370 times that of the Sun. So, if this star was placed in our Solar System, it would fill the orbit of Mars. Like all long-period variables, its spectra is characterised by bright lines of hydrogen and dark bands of titanium oxide. The outer layers of the star contain molecules undergoing a cycle of formation and destruction which contribute to the star's unpredictable changes in brightness.

As we move forward, U Orionis will reach maximum brightness during the summer, so it will lost in the Sun's glare. However, we can still observe U Orionis as it increases to maximum brightness.

R Serpentis.

Type	Extreme Range	Typical Range	Period
LPV	5.7 – 14.4	6.9 – 13.4	357d

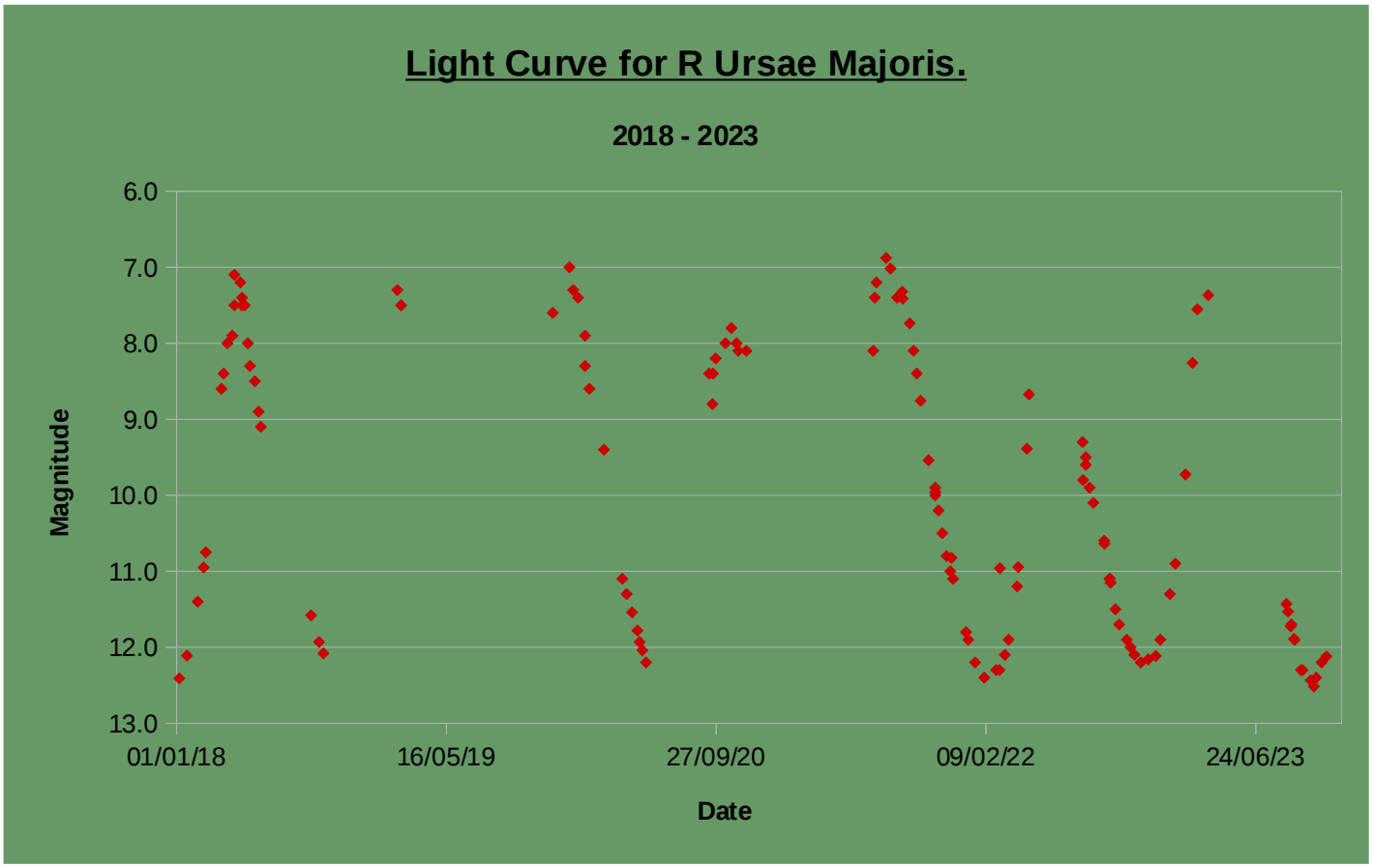


R Serpentis is a Mira-like, long-period variable with an extreme range of 5.7 to 14.4 and a period of 357 days. However, a more usual range is 6.9 to 13.4, so at its brightness it's easily visible in binoculars. R Serpentis was first discovered in 1826 by the German astronomer, Karl Ludwig Harding, who is best remembered as the discoverer of the asteroid Juno. R Serpentis is, like all long-period variables, a red giant - a star late in its evolutionary life. R Serpentis displays typical behaviour, for a long-period variable, and has a very symmetrical light-curve.

Like R Leonis, R Serpentis seems to display a gradual decline in its average brightness. If this is a real affect, it would probably be due to the star's outer layers cooling, and therefore, decreasing in luminosity.

R Ursa Majoris.

Type	Extreme Range	Typical Range	Period
LPV	6.7 – 13.4	7.2 – 13.0	302d

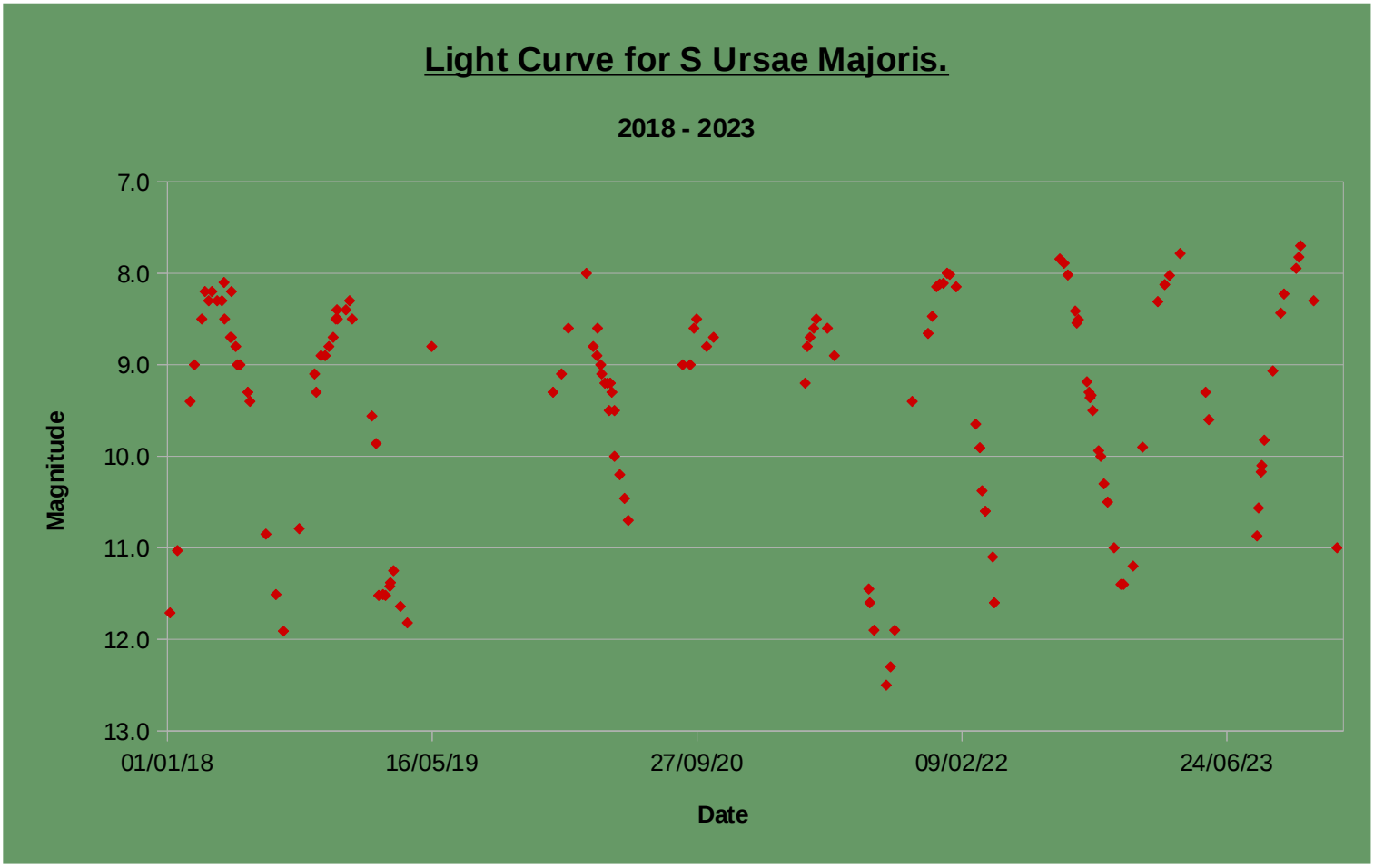


R Ursae Majoris is one of the more popular variable stars on the SPA programme. R Ursae Majoris was the first long-period variable to be discovered in Ursa Major, being first observed in 1853 by N. Pogson. It varies from magnitude 6.5 to magnitude 13.7, so when it's at its faintest, it's only visible with a large telescope. However, it should be visible in binoculars as it rises to maximum.

T Ursae Majoris, S Ursae Majoris are both popular long-period variables on the SPA programme. Again, like R Ursae Majoris, T Ursae Majoris and S Ursae Majoris can only be observed by binoculars when they are close to maximum brightness. A large telescope would be required to observe them both when they are nearer to minimum.

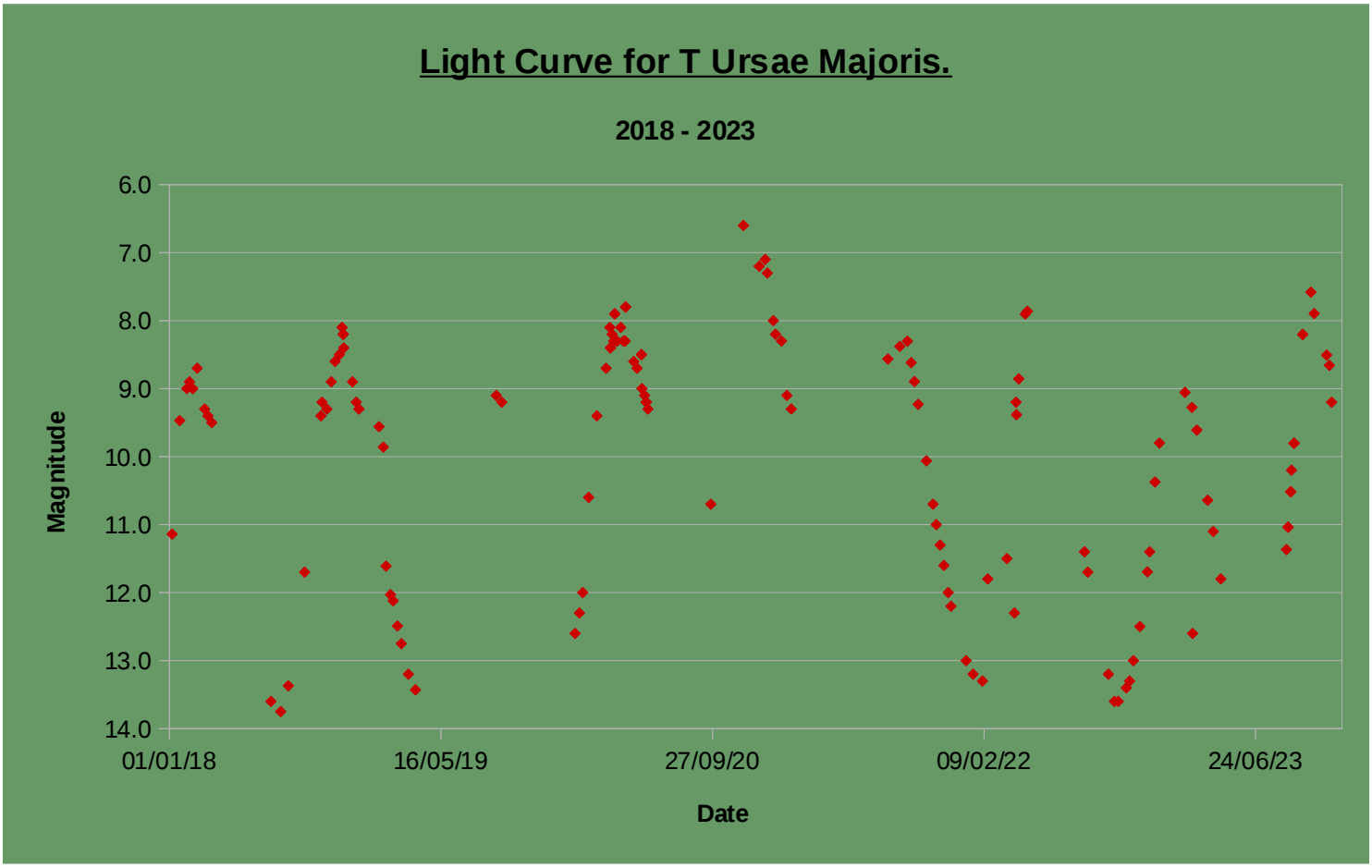
S Ursa Majoris.

Type	Extreme Range	Typical Range	Period
LPV	7.2 – 12.7	7.9 - 11.7	226d



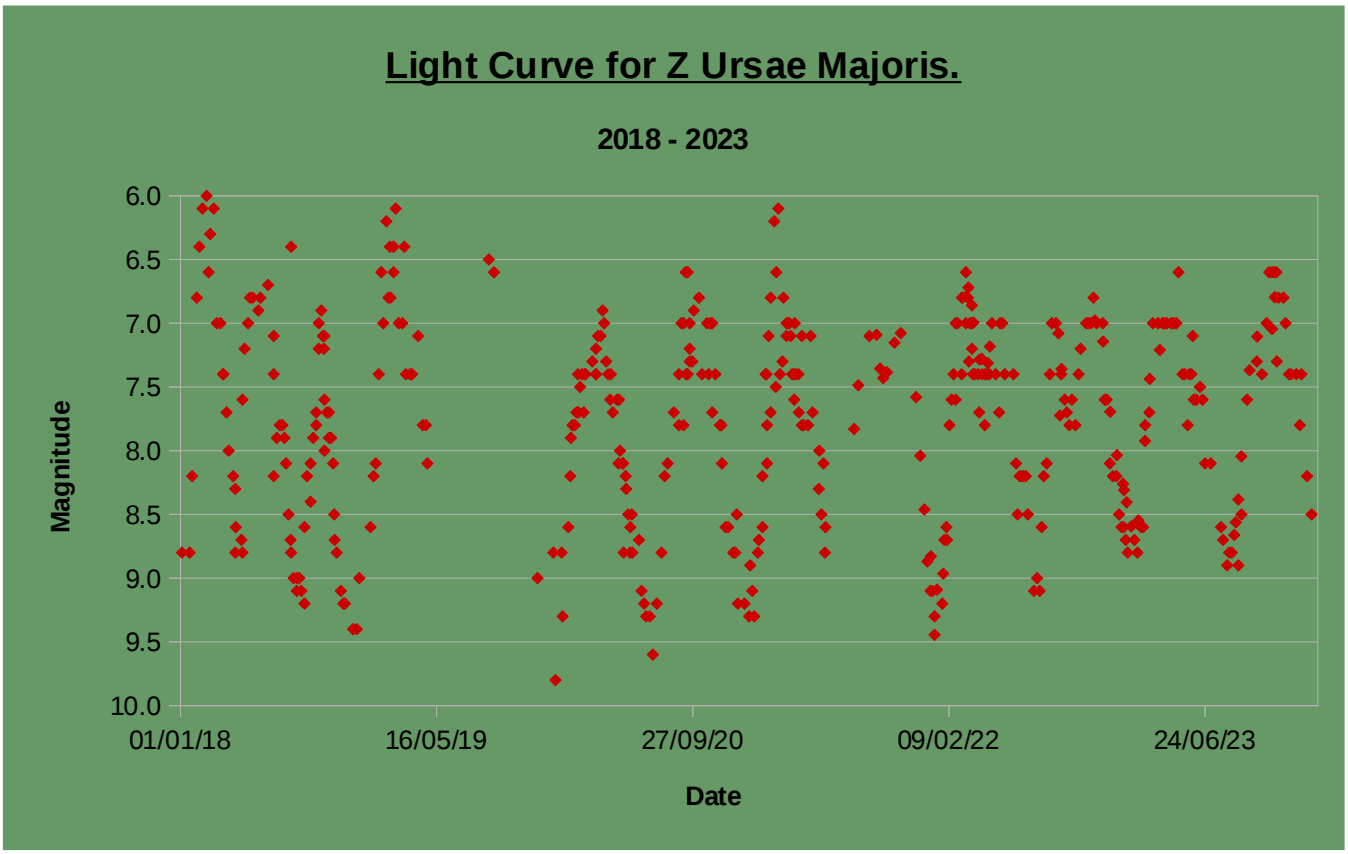
T Ursae Majoris.

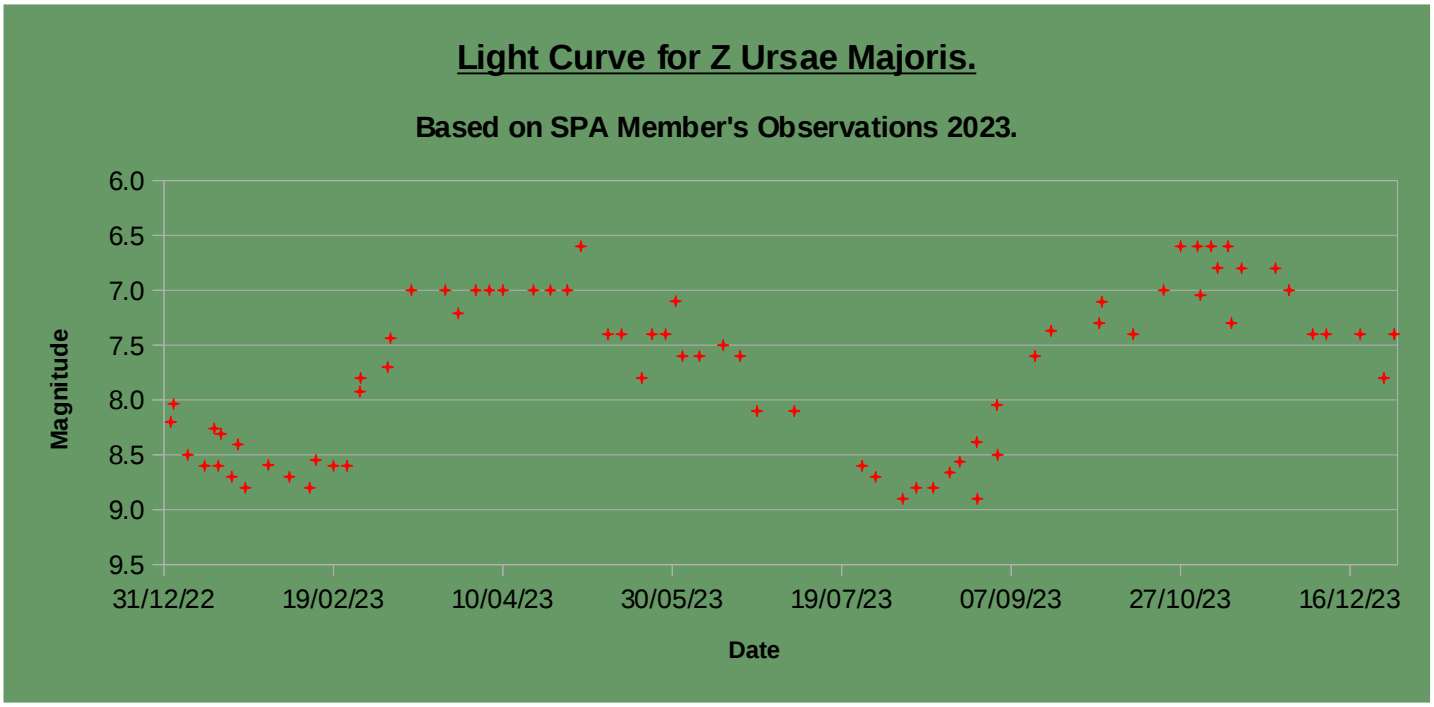
Type	Extreme Range	Typical Range	Period
LPV	6.6 – 13.5	7.7 – 12.9	257d



Z Ursae Majoris.

Type	Extreme Range	Typical Range	Period
SR	6.3 – 9.8	6.9 - 8.7	195d





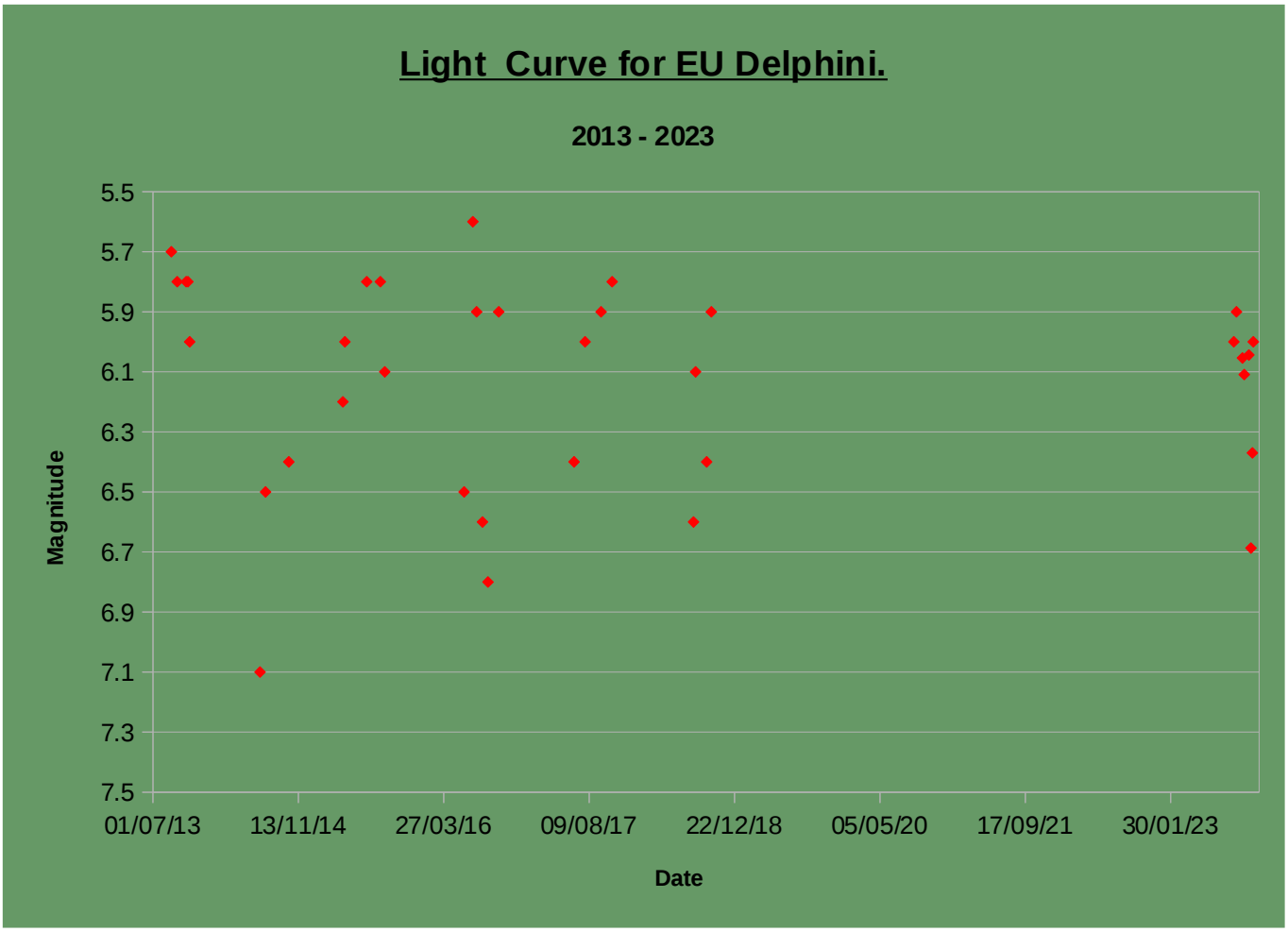
Z Ursae Majoris is a very popular star on the programme, and thanks to its circumpolar position, members were able to observe it over the course of two cycles. Z Ursae Majoris didn’t show any surprises during 2023, keeping as it did within its usual range.

Other Light Curves.

Some observations were made of the following stars; but not enough to make a detailed light curve.

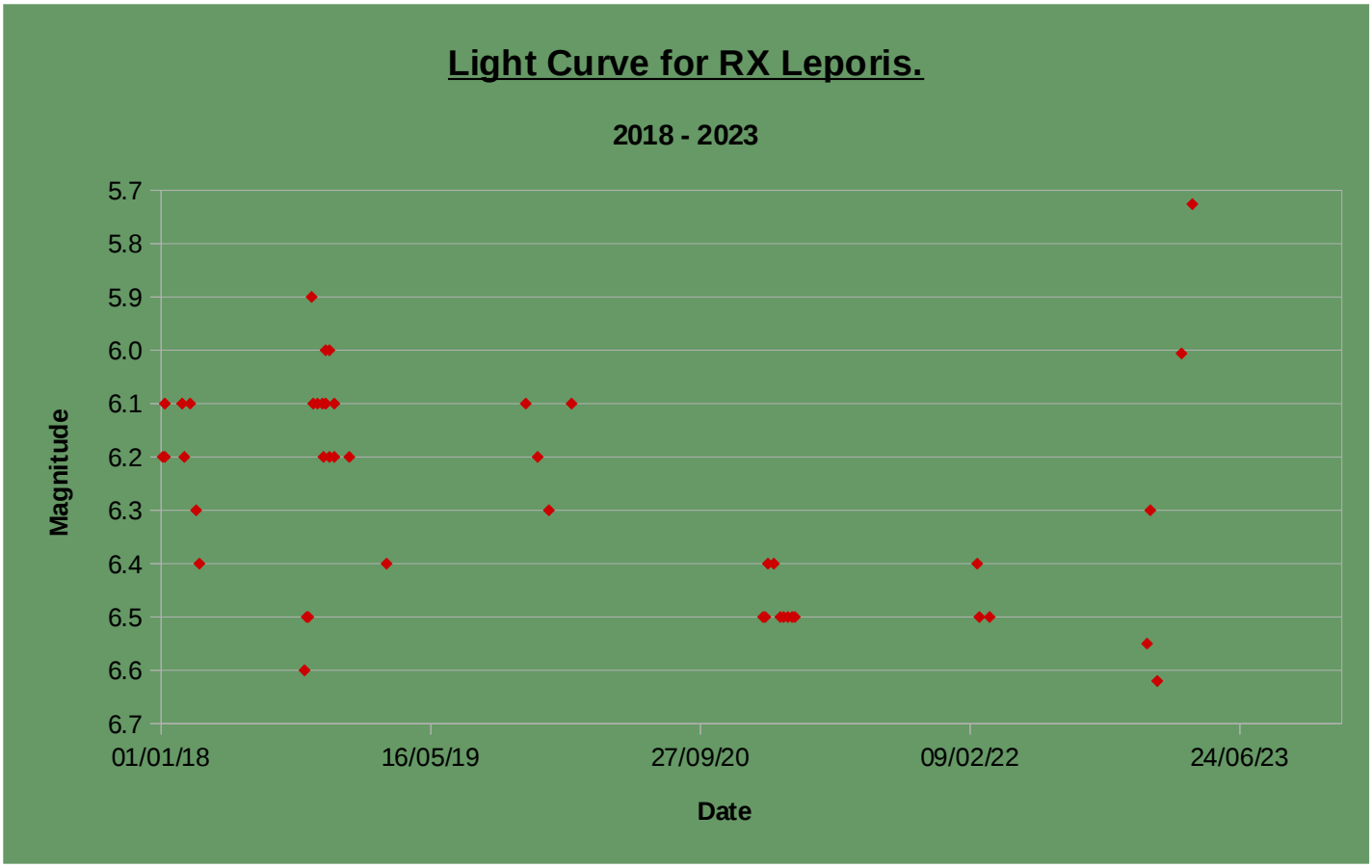
EU Delphini.

Type	Typical Range	Period
SR	5.4 – 6.7	59d



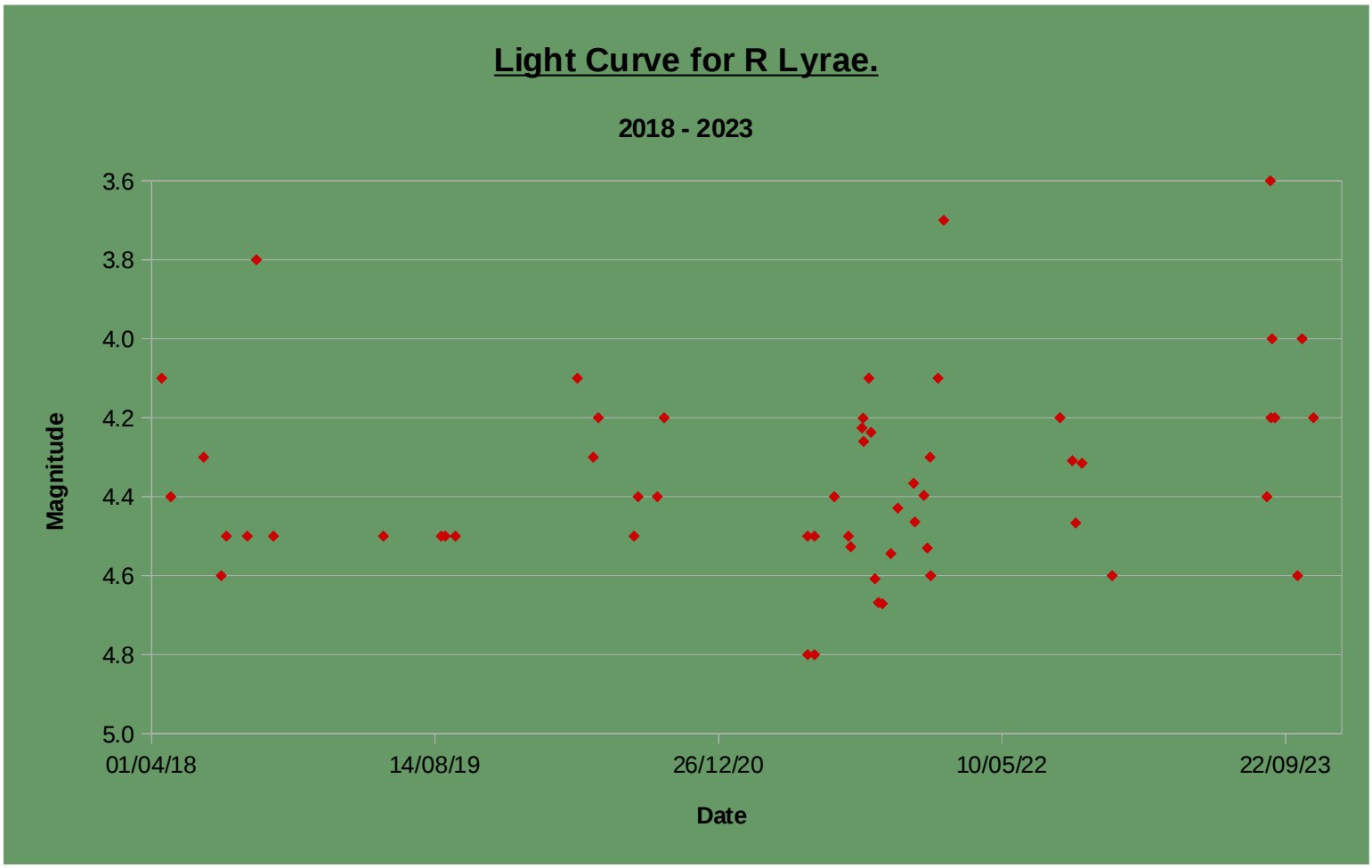
RX Leporis.

Type	Typical Range	Period
SR	5.1 – 6.7	80d



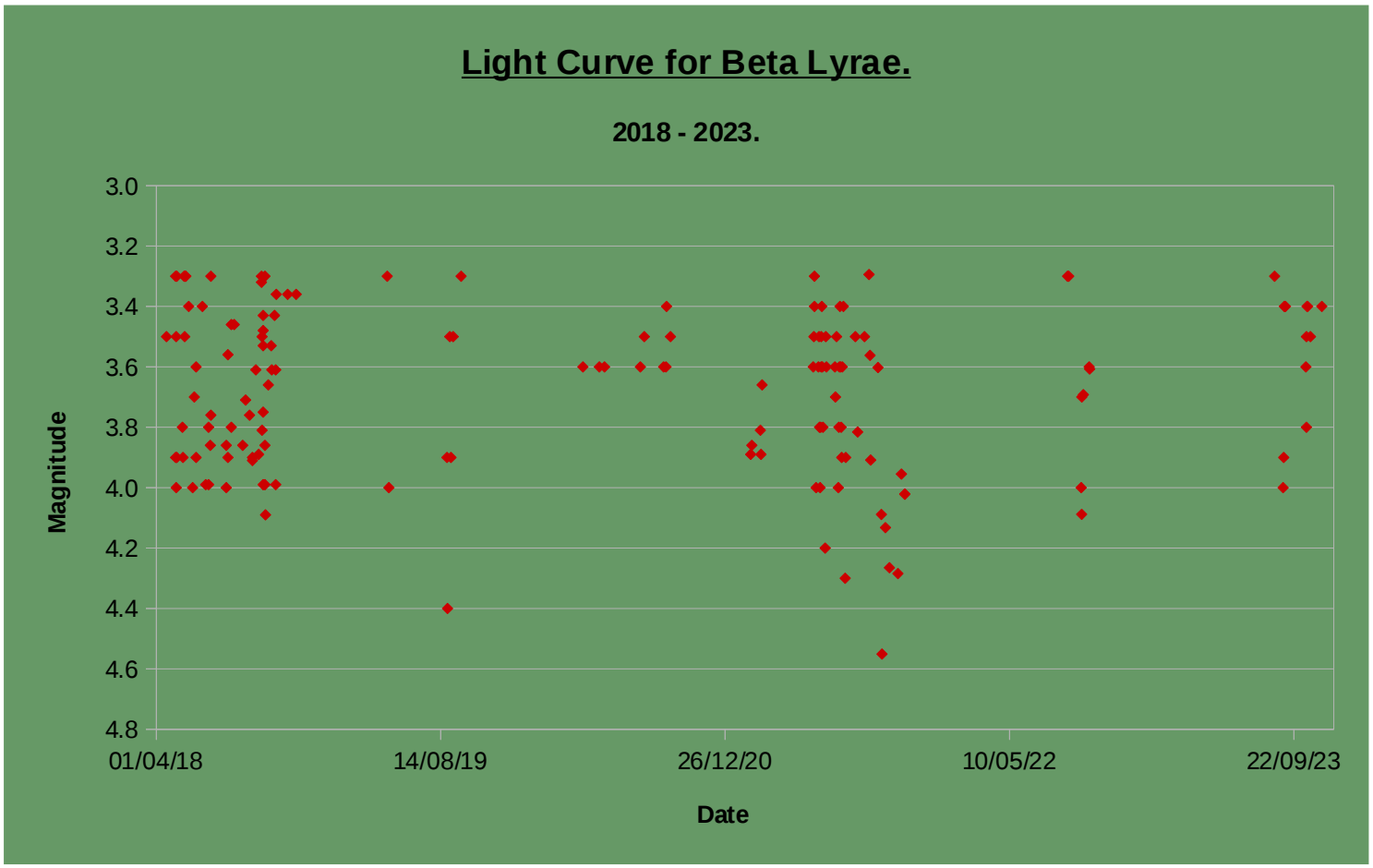
R Lyrae.

Type	Typical Range	Period
SR	3.8 – 4.4	46d



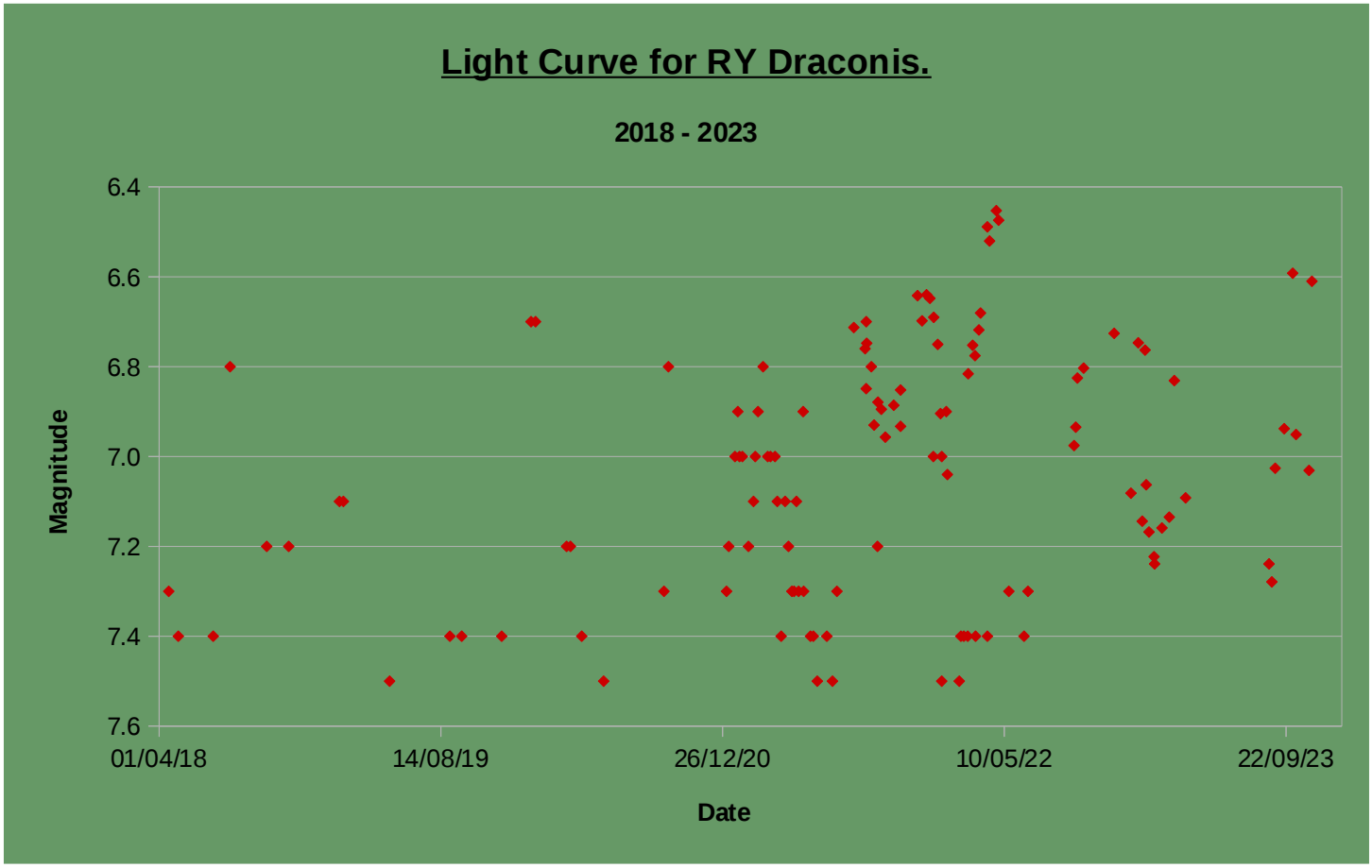
Beta Lyrae.

Type	Typical Range	Period
EB	3.4 – 4.3	13d



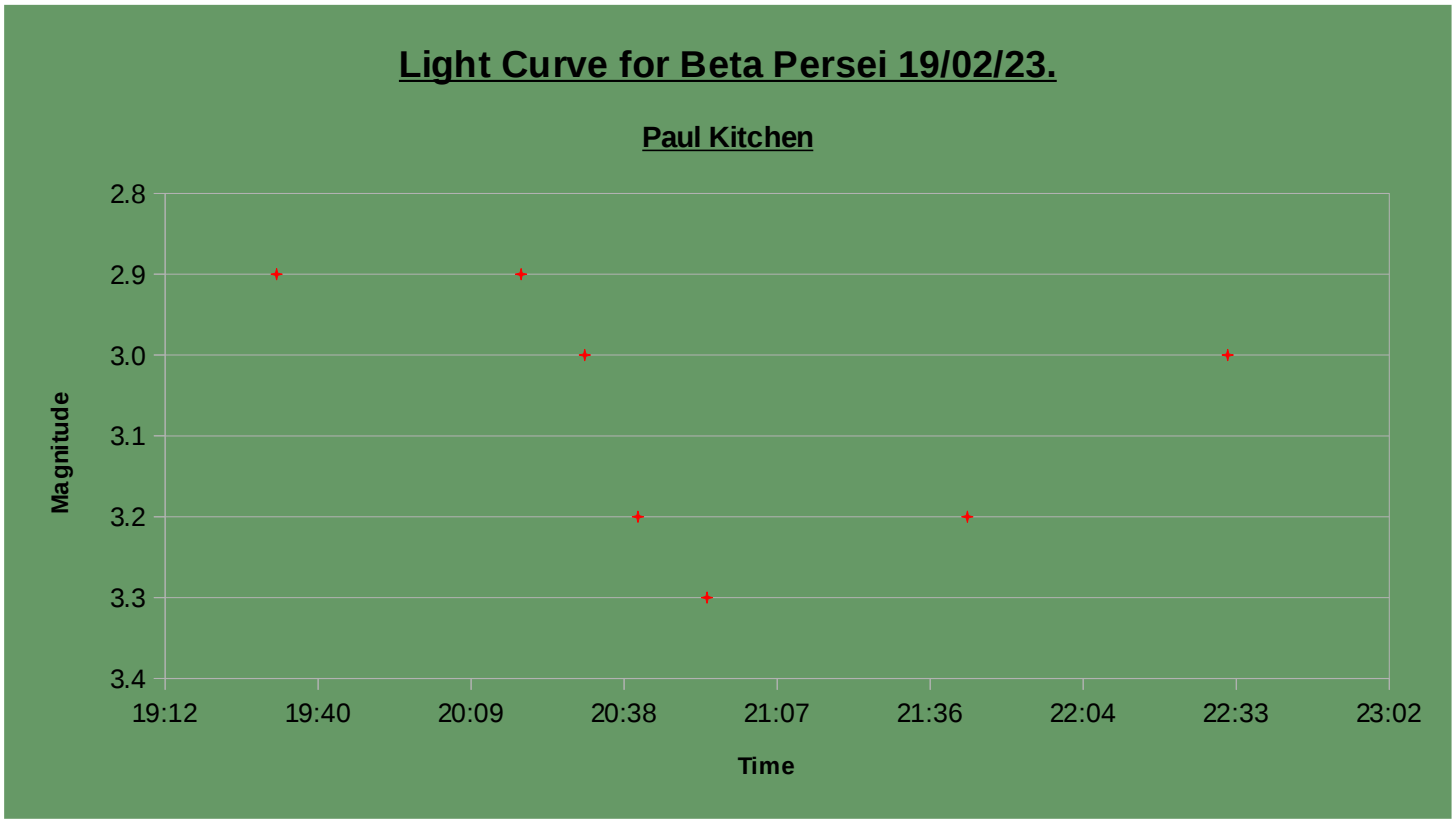
RY Draconis.

Type	Typical Range	Period
SR	6.4 – 7.8	200d



Beta Persei (Algol).

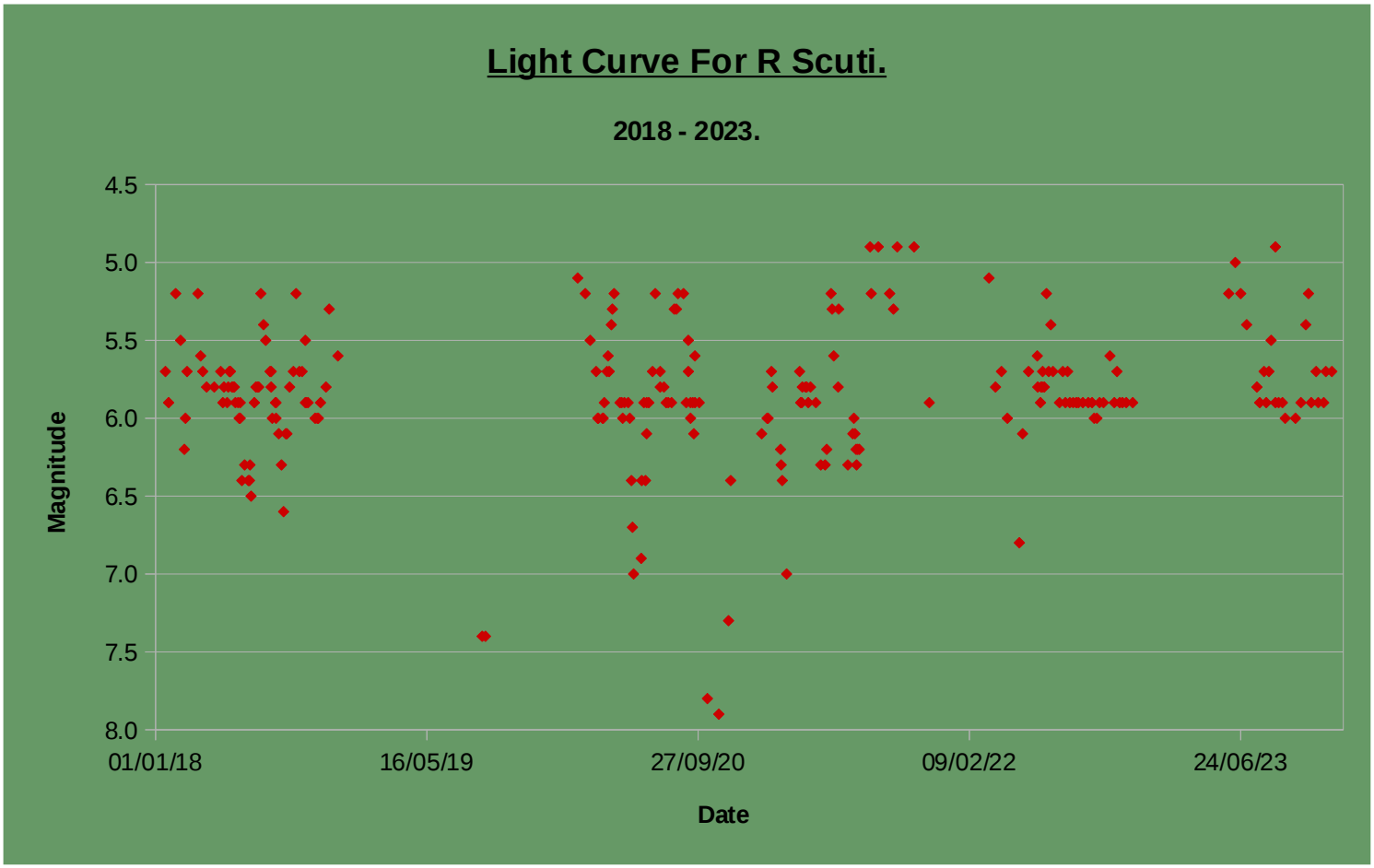
Type	Typical Range	Period
EA	2.1 – 3.4	2.9d



The light curve was generated by Paul Kitchen, who observed an eclipse of Algol on the 19th of February 2023.

R Scuti.

Type	Typical Range	Period
RV Tau	5.0 – 7.5	142d



R Trianguli.

Type	Typical Range	Period
LPV	6.0 – 11.7	266d