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LONG– TERM OBSERVATION OF GLOW-WORM *Lampyris noctiluca* POPULATION TRENDS IN A DOMESTIC GARDEN ENVIRONMENT

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Abstract

A 13-year study counting glow-worm numbers in a domestic garden environment has demonstrated that nightly counts of glowing females show random fluctuations over the season and between years. The total population count also varies considerably from year to year but there is some indication that there may be some periodicity between 'boom-and-bust' years.

Keywords: *Lampyris noctiluca*, glow-worm, survey

Introduction

During the time that my wife and I lived in Bembridge we took part in the annual glow-worm hunt to count the glow-worms in St Helens church yard. This was held on a Friday and Saturday evening in mid July, a time when numbers should be at or around their peak. In 2008, we moved to Fishbourne and one evening during our first summer at the new house we discovered that we had glow-worms of our own. Despite not living in the immediate area, we continued to be regular attendees at the annual event in St Helens, scrambling around in the dark looking for glowing females until the event was discontinued shortly after.

Having glow-worms so close to hand meant that we could enjoy seeing them every evening during the summer and watch how their lives progressed from day to day. We could also count them to see how their numbers changed through out the season rather than just taking a snapshot over a couple of nights each year as had been done at St Helens. This has built up a multi-year record showing how the population changes from year to year and night to night.

Introducing the glow-worm

Environment and life cycle

Although glow-worms *Lampyris noctiluca* are relatively widespread and common, our mainly urban lifestyle that distances us from the natural world, together with a restricted viewing opportunity as they only display for a few hours a night in mid-summer, means that very few people will have ever encountered one.

Glow-worms are not actually worms; they are instead beetles being described in a similar way to silkworms which are in fact caterpillars of the silk moth. How or why the term 'worm' came to be used here is not known. The Online Etymology Dictionary shows that in Old Russian the word *vermie* means insects and Lithuanian *varmas* also means insect, and some other European languages also call them worms, It is possible that a word sounding similar to 'worm' has been used in the description of these creatures from before the creation of the English language as we know it.

Glow-worms seem to have relatively simple requirements in life: an open area that is generally undisturbed, has remained free of pesticides for some time, and has an abundant food source - slugs and snails (Tyler, 2002).

They have a two-to-three-year life cycle. A few weeks after being laid, the eggs hatch and the larvae go in search slugs and snails, killing and eating them by injecting them with paralysing digestive juices. If their chemical defences allow them to avoid other predators, and becoming prey themselves, they hibernate for the winter and re-emerge the following spring to continue feeding until they hibernate for a second winter (Tyler, 2001). When they re-emerge in the spring of their second year, they either continue feeding for another summer, or if they have built up enough reserves, pupate into adults. At this stage they have no mouth parts and do not feed; their sole purpose is to reproduce.

Adult glow-worms are sexually dimorphic; the female resembles the larval stage and is about 20mm in length with two bioluminescent segments at the end of her body. (Fig. 1) Because the female carries the eggs for the next brood, she does not waste energy by being able to fly. Instead, she displays her glowing body parts and waits for males to find her.

Fig .1: Female glow-worm
Courtesy of Wikipedia Commons

While the female could be described as being a rather ugly looking creature, the male, which is only about half the size of the female and able to fly, could be described as rather dapper; much more like a beetle with his wing cases resembling neat shiny coat tails. (Fig. 2)

The flightless females find suitable vantage points to advertise themselves each evening by displaying the glowing segments in their tails. To conserve energy, they rarely move very far, if at all, from night to night making them easy to count and track. The males also conserve energy by flying at a relatively low height, approximately 1.5m above the ground. They have very

good vision and, they are attracted to the female's green glow that resembles a green light emitting diode (LED) indicator commonly used on electronic equipment. This is used to good effect in surveys that attempt to determine the number of flying males in an area; green LEDs that emit a wavelength of light closely matched to that of the females are used as lures. The males show a preference to females that have a brighter glow as this signifies greater fertility; they are however put off by lures that are too bright (Tyler 2011).

Fig. 2 : Male glow-worm
Courtesy of Wikipedia Commons

It may be thought that by advertising themselves so prominently that the females would be subject to predation, but this does not seem to be the case. Studies have found that night-time predators such as toads and mice soon learn that creatures that glow are distasteful, and they are left undisturbed. (De Cock *et al* 2003).

During or shortly after mating, the females cease glowing and climb down into the understory where they then lay up to 100 eggs which will hatch a few weeks later. With her life's purpose complete the female then dies. Females that are not mated will have stored enough energy during their larval stage to be able to glow for two to three weeks before their light fades and they too die.

From miser's fire to war hero with an uncertain future

In our past glow-worms must have been quite common for them to have been incorporated into weather lore through two old English weather lore sayings:

When the glow-worm lights her lamp
The weather is always damp
and
To see many glow-worms is a sign of a storm

Male glow-worms, like other insects, are reluctant to fly when there is wind and rain, (Tyler, 2011 and Hopkins *et al*. 2015), so more un-mated females are seen glowing during wet and windy weather.

References to glow-worms and fireflies in historical texts where they survive are mainly poetic in nature. Buddhist scriptures place glow-worms near the bottom of the list of luminous objects and Middle Age Arab references to glow-worms are equally contemptuous, stating that their light is "Weaker than the fire of al-Hubahib", a well known miserly character who would light a very small fire in case any desert travellers were drawn to it; in Arab culture a host must be generous to traveller guests. This idea of contempt seems to have become widespread, during the fifteenth and sixteenth centuries in both France and England the term 'glow-worm' was used as an insult.

Glow-worms also had their place in medieval alchemy where they formed the critical ingredient for 'Liquor Lucidus', a magical substance that could be used to fuel either a long-lasting or according to some, an everlasting lamp. There are many recipes, each with either unsavoury or dangerous ingredients that sound like they have come straight from a Shakespearian tragedy.

During the scientific revolution of the 17th century experiments carried out by Boyle using Hooke's air pump began probing the mechanisms of the glow-worm's light. It was found that removing air from around a glow-worm caused it to stop glowing, and when the air was returned it began to glow again; the air or something in the air was needed to enable a glow-worm to glow. It was not until the late 19th century and the work of the French scientist Dubois that the organic molecules he named luciferine and luciferase were found to be involved in the production of bioluminescence. (Harvey 1957)

In more recent history, during the First World War glow-worms provided a useful source of light for reading maps and for this have been honoured on the Animals in War memorial in London's Hyde Park alongside the more expected horses, dogs and birds.

The future for glow-worms as it is for much of our wildlife is showing worrying trends with many sites showing declining numbers. (Atkins *et al* 2016 and Gardiner *et al* 2020). The reasons appear to be those that affect many other species; habitat loss or degradation, pesticide use, changing weather patterns, particularly drier summers affecting their prey, and light pollution even at low levels affecting the ability of males to find mates. (Bird *et al*. 2014 and Van den Broeck *et al*. 2021).

The survey

Site description

The survey site is a private garden at NGR SZ552922. The garden is by modern standards regarded as large, being approximately 90 x 30m sloping down by 6m from SW to NE. Apart from essential maintenance, the garden has been left essentially unchanged since taking over the property in 2008. The front has a tarmac driveway and two areas of grass separated by a tarmac path and flower beds. The front garden is bounded on either side by mixed hedging and at the front by a leylandii hedge. The front verge is grass and wildflowers that are left uncut during the spring and summer. Both the verge and front garden suffer from light pollution from streetlights to the south west and south east on the opposite side of the road. The eastern side is shaded to some extent by the front hedge. The rear garden is separated from the front by the house and garage, a 2.5m brick wall with a wooden gate and dense shrubs and is mostly shaded from the streetlights. The rear garden is mainly grass with a number of out-buildings and two paved areas. The eastern side is bounded by leylandii hedging and the western side by larch lap fencing and some fruit trees. The north and north-west border are essentially an extension of the woodland to the north of the property each about 2.5 metres wide and left generally un-managed.

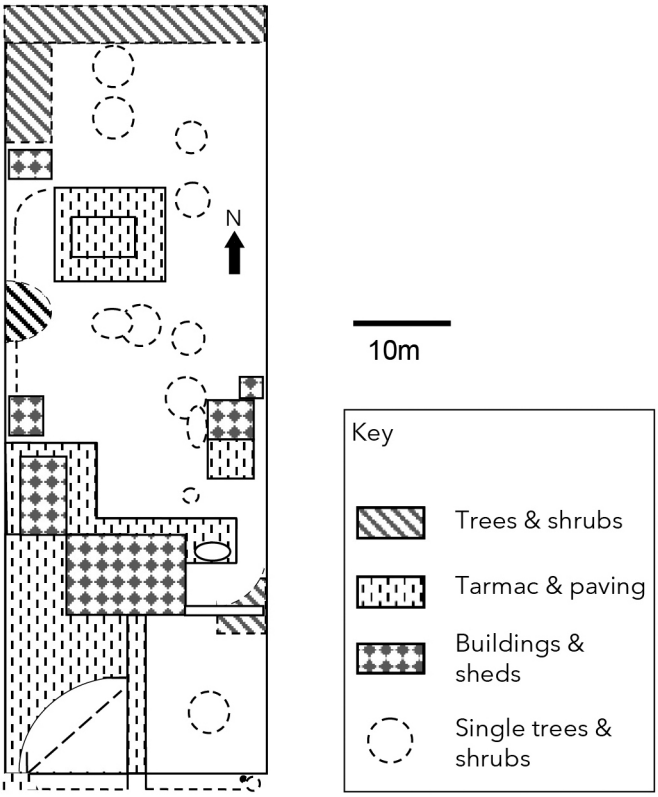

Fig 3: Plan of the survey site

Survey Method

A count of glowing females is made at about 10pm each evening from mid May, before any females are likely to start glowing, until at least 7 days after the last female dies, usually in the first week of September. The count is started about 30 minutes later during the few weeks around the solstice because of the lighter evenings. During the darker evenings, a torch is used to help prevent accidental harm to any toads or frogs that may be encountered. It is also used to check for mating pairs.

A record of the positions of all females is made during a slow stroll round both front and back gardens followed by a walk along the front verge. Usually just a mental record of their locations is made, as the numbers are low enough that memory is adequate. Occasionally the numbers are such that a paper plan is necessary, and even then, sometimes the numbers have been such that it has been quite hectic to make an accurate record, particularly if matings are taking place and some of the females are disappearing during the time taken to conduct the survey.

During wet weather a more hurried tour is made concentrating on the most likely locations. The front garden and verge can be very difficult to survey during wet conditions, the water droplets reflecting the streetlights can make it appear as though the ground is covered in glow-worms.

The positions are then plotted on a plan in a Word document with each new individual being given a unique alpha-numeric identification that is then also recorded in tabular form. Also noted in the Word document are any incidental sightings of other wildlife, usually toads and frogs, but occasionally a badger or fox.

Data is processed in a spreadsheet. Initially, only the nightly count was recorded with each night on a separate row, and a plot of count against date produced. In subsequent years, the sheet was expanded with each new year being added in the next column. A separate table was added for new emergences, allowing a plot of the cumulative count to be generated. For each night, minimum, maximum, average total count and cumulative count across all years are found and plotted. There is more information present in the raw data in the word document than can be processed in the spreadsheet without it becoming overly complex. Making this information more readily accessible is a planned future extension of the project that will require transcription of the word documents to a different format.

At the end of each season the year's record is collated into a report, along with the records for previous years for submission to IWNHAS recording database. The report consists of plots showing the maximum daily count and annual individual total count, minimum, maximum and average numbers seen each night over the duration of the survey, and a plot showing minimum, maximum, and average cumulative numbers. The annual count logs are appended showing the nightly count, cumulative count, and the location of each individual on a plan.

Results

Figure 4 displays the daily maximum and annual total

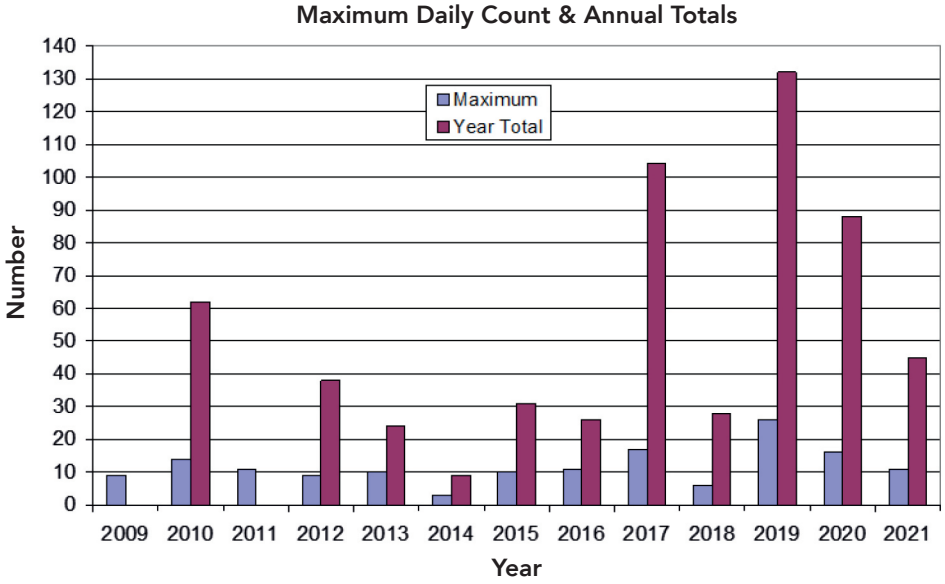

Fig. 4: Maximum nightly count and annual total count for 2009 to 2021

Total count for 2009 was not recorded and for 2011 data was lost

counts for the duration of the study 2009 to 2021; this shows that the population varies very dramatically from year to year.

Between 2010 and 2014 totals were in precipitous decline, which if it had continued at this rate would have led to them having disappeared entirely by 2015 or 2016.

That was not the case, and numbers started to recover, spectacularly. By 2017 over 100 individuals were seen and, in 2019 the total count of over 130 was the best on record.

In recent years numbers have started to decline again.

The reason for these large fluctuations in numbers or population migration is not known and can only be speculated upon. It may be a standard predator-prey relationship where instability resulting in population 'boom and bust' is expected or simply the weather conditions when the larvae hatch being unsuitable for their prey and very few hatchlings surviving to find their first meal.

What the study has shown is that given the right conditions glow-worm populations can be quite resilient; however, an isolated population such as we have here may be still be vulnerable. There appears to be some periodicity, both long and short term, in the data. There seems to be a two-to-three-year periodicity in the total annual count, together with a longer, approximately 10-year period between two observed maxima. The glow-worm's two-to-three-year life cycle may be of significance here but the data set is currently too short to place a high degree of confidence that this is not just random fluctuation.

The distribution of females over the site has also changed over the years. During the first few years most females were seen in the rear garden with only a few in the front, but after the near collapse in numbers in 2014 there was a shift to the eastern side of front garden which is shaded from the streetlights with many fewer sightings in the rear of the garden.

The 2021 season started on July 8 with the appearance of two individuals, a much later date than average, and four days later than the previous latest start, in 2013. One reason for this may have been the cold late spring weather that affected plant growth in the garden and almost certainly contributed to the

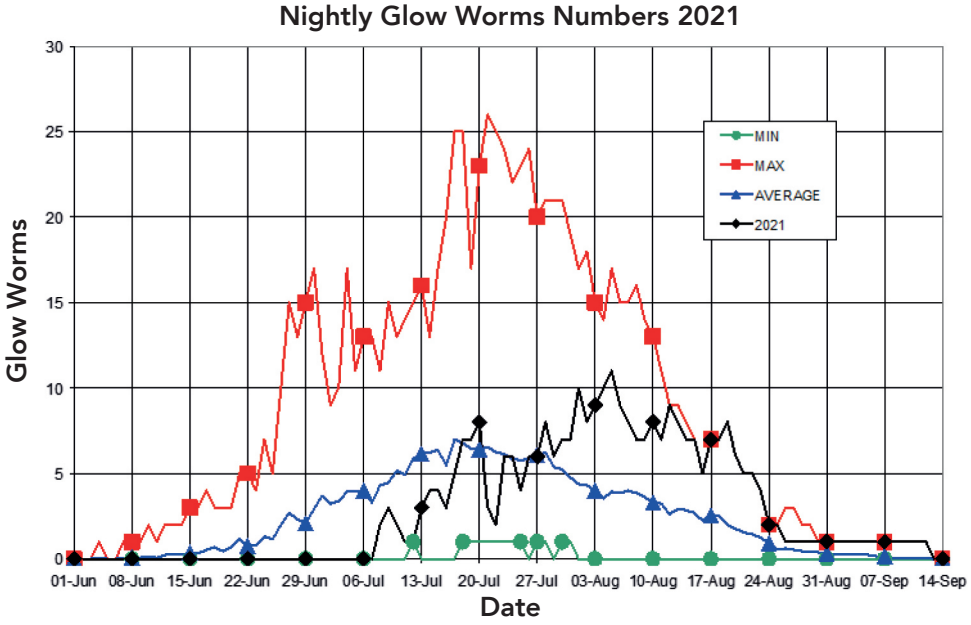

Fig. 5: Nightly counts, 2021, compared with minimum, maximum, average cumulative count on that date over the duration of the study

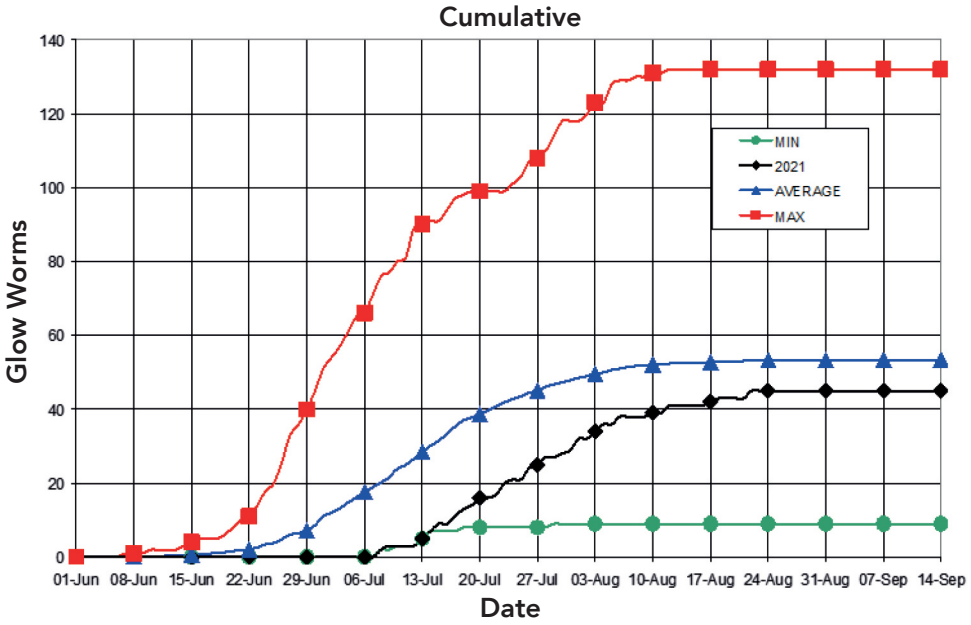

Fig. 6: Cumulative nightly counts, 2021, compared with minimum, maximum, and average cumulative count on that date over the duration of the study

failure of our blue tit nests. Despite the late start, the cumulative count increased at a rate that was only a little below average, (Fig. 6). It was feared at the start of the season that the total count would be very low, but the season ended with the annual total a little below average, though not worryingly so.

The nightly numbers for 2021 together with the maximum, average and minimum numbers seen on any night over the duration of the study is shown in Fig. 5 The shape of the plot for the number of glow-worms seen each night during 2021 was very much as expected, but shifted later in the year by approximately two weeks, with the maximum number of females seen in early August rather than mid July.

Looking at the nightly counts over a number of years (Fig. 7) the number of glowing females has a random distribution and is rarely close to a normal distribution curve. The distribution over the season shows significant variation from year to year with some years showing a sharp peak in numbers with others having a broad peak or even multiple peaks.

A similar long-term study of a site in Kent, Hickmot & Tyler (2011) also shows that nightly counts show considerable fluctuation. The total number of individuals seen each year at this site varies by a much greater range 9 to 131 compared to 96 to 266 in the Hickmot & Tyler study. This is probably due to this being a much smaller study area, the Kent site being over seven times larger enabling greater resilience in the population.

During the first eight years of the survey, it was

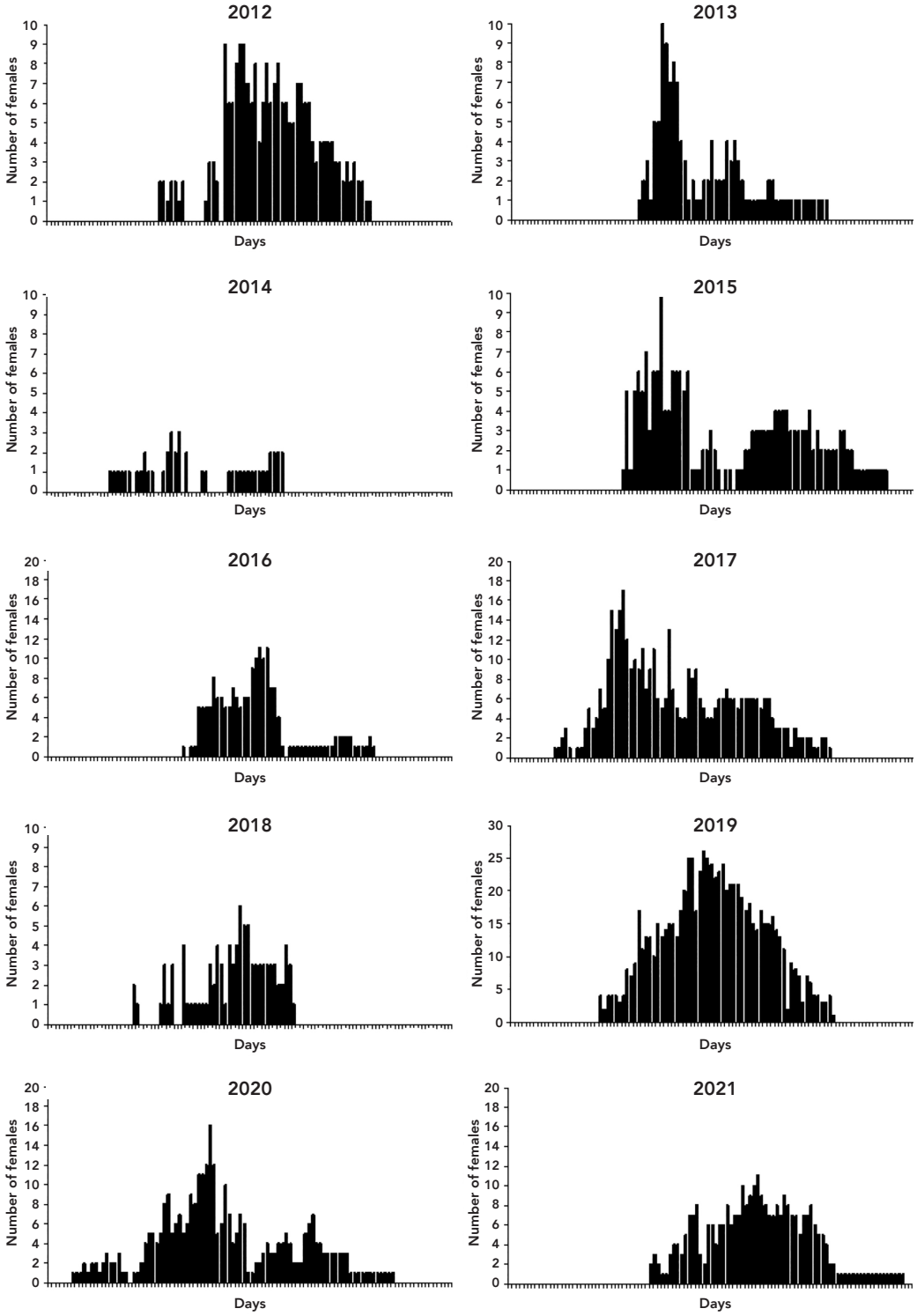

Fig. 7: Daily female counts from 1 June to 14 September between 2012 & 2021

investigated whether there was any correlation between the daily count and the visibility of the moon. No correlation was found with peak numbers occurring at any phase, and further investigation abandoned. During the summer, the moon is very low in the sky during the night and at this site is barely visible, being hidden behind local trees, so would perhaps not be expected to have much if any effect. This lack of correlation has also been found in another study. (Gunn & Gunn 2012)

The Hickmot & Tyler study shows good correlation between the total number of females seen during a season and the length of the season. The data taken here shows that while the variation in season length is very similar, the correlation between length of season and number of glowing females is significantly weaker (Fig. 8). This may again be due to the smaller sample size.

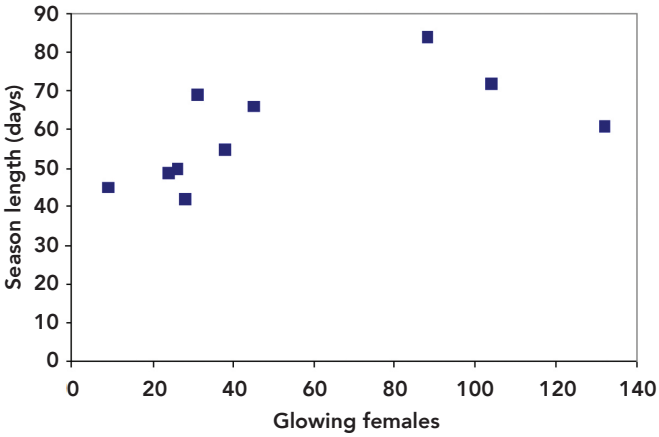

Fig. 8: Duration of season against total number of females 2012 to 2021

Future considerations

The annual counts were undertaken originally for enjoyment and to satisfy a personal curiosity to see how the number of females seen varied throughout the season. It was not until recently that it was discovered that there appear to be very few long term studies of glow-worm numbers at a single site, and that the data that have been taken may have more importance than it was thought that it would have when first started. The survey has now entered its 14th year and the amount of data now available for analysis is such that the spreadsheet is becoming unwieldy for all but the basic tasks of plotting daily and annual totals; the original aim of the study. The data is currently in two forms, a word document containing the primary source data with a map showing the approximate location of glow-worms seen, and a spreadsheet for data plotting. While this still remains adequate for the original purpose of the survey and will be continued, it does restrict its use in future or for comparison against other studies. For example Hickmot & Tyler 2011 found that the early and late females had longer glowing times than those that emerged in the mid-season. Qualitatively data taken here would appear to corroborate with this report, but the data will have to be transformed into a different format to verify it quantitatively.

I am sure that there is more potentially useful information that can be extracted from the data that has been taken and that it can be used for a wider purpose than originally conceived. With this in mind, and to allow easy future access to and analysis of the data by others, different storage formats are being investigated for use in the future. Once in the new format, powerful open source software data analysis packages, that were not available when the study was first started, can be used to process and display the information such that it that can be viewed in a web browser or easily exported to portable document format.

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