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Recent observations of "mystery star jelly" in Scotland appear to confirm one origin as spawn jelly from frogs or toads

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Stories of strange jelly deposits in the countryside have a long history going as far back as the Middle Ages (McKenny Hughes, 1910). An association between jelly and shooting stars seems to have become widespread, even appearing in popular literature such as Walter Scott's "The Talisman". The jelly has been known by different names such as star jelly, star gelly, star shot, star shoot, star slough, star fall'n, or pwdre ser (Welsh: rot of the stars). However, even in the Middle Ages more enlightened investigators considered that the jelly may derive from frog viscera discarded by predators. Baylis (1926) examined star jelly samples collected from Dartmoor and in one case the jelly was accompanied by oviducts and ovaries with black eggs along with remnants of an alimentary tract and bladder of a frog or toad. This seemed to confirm the theory that jelly deposits originated from predation on frogs or toads. Baylis (1926) pointed to weasels, stoats, badgers, crows, or buzzards as likely suspects. In their guide to animal tracks and signs, Bang & Dahlstrom (1972) show a photograph of similar jelly deposits which they attributed to frog oviducts discarded by buzzards.

In the past few years, the occurrences of masses of translucent jelly-like material deposited in gardens, parks and hillsides throughout Scotland have generated a lot of interest among walkers, ramblers, and naturalists. A BBC Radio Scotland "*Out of Doors*" programme in 2008 highlighted the 'mystery' and urged listeners to send in details of any sightings to their webpage and comment on what they thought the jelly might be.

The webpage (http://www.bbc.co.uk/scotland/outdoors/articles/jelly/) received over 350 postings from October 2008 to February 2009 with 132 sightings of star jelly from Britain (including 47 from Scotland) as well as some sightings from other parts of the world. The sightings occurred through all seasons of the year. Nine of the British sightings referred to deposits of black globules, resembling fish roe or caviar, associated with the jelly, which supports the frog spawn theory. Around a dozen photos of star jelly were submitted to the website gallery including one from Moffat in October 2008 where the jelly mass was accompanied by a mound of black eggs. Another photo showed two large slugs (*Arion ater*) mating and producing a sizeable globule of jelly in the process that may explain some jelly cases. One anecdotal account from Cumbria claimed the jelly resulted from frogs being eaten by buzzards and a similar account, from Sweden, cited marsh harriers as the culprits, skinning and dismembering toads. Many respondents also suggested herons may regurgitate spawn jelly from frogs as it swells up after they have been swallowed. Additional suggestions for the source of the jelly included blue-green algae (Cyanobacteria), bryozoans, diatoms ('rock snot'), tree sap, slime mould, stag (or sheep) semen, deer phlegm, sheep afterbirth, slug slime, fish/eel slime, or otter anal jelly/spraint. Most of the ideas lacked any supporting evidence and some others were wildly speculative such as jellyfish, nappy jelly, garden silica gel, aircraft toilet discharge, drilling polymer, chemical sprays, or silica from meteorites.

Fig. 1. Egg mass collected near Cochno Loch, 2007.

Following the BBC programme star jelly samples were collected in 2009 and examined by Hans Sluiman, an algae expert at the Royal Botanic Gardens in Edinburgh, and DNA testing was undertaken by Andy Taylor, a mycologist at the Macauley Institute in Aberdeen. The jelly samples had no obvious cellular structure but proved to be

contaminated by fungal and bacterial growth and the DNA results were inconclusive.

Fig. 2. Star jelly and eggs, collected in the Menteith Hills 2008.

The star jelly 'mystery' was taken up by the popular press with short articles appearing in The Times (Reid 2009, Simons 2009, http://www.thetimes.co.uk) though these added little in the way of scientific explanation. Following this the Open University's iSpot website (http://www.ispot.org.uk/node/101544), where nature watchers share their observations, claimed to have solved the mystery with a series of photos taken in the Mendips in February 2010. They showed various lumps of jelly strewn on grass including jelly globules dotted with black eggs (similar to laid frog spawn), jelly globules without eggs, and separate masses of black eggs all clearly originating from a frog. The website also showed a number of photos of crystal brain fungus (*Exidia nucleata*) that forms similar jelly masses on rotting wood. At least one of the 'crystal brain' photos is of jelly on grass and is likely to be star jelly.

Fig. 3. Star jelly, collected in the Ochil Hills, 2010.

The purpose of this note is to add a little more evidence to the discussion based on some recent direct observations of star jelly in Scotland and hopefully dispel some of the myths about the phenomenon. A couple of these records originally appeared on a blog webpage (http://fredandsarah.blogspot.com/search/labe/star%20jelly) set up by one of us (Sarah Longrigg) but are repeated here to bring them to a wider audience. The other two findings were by SEPA scientists Nicole Ross and Myles O'Reilly:

1. Kilpatrick Hills, Cochno Loch (NGR NS 490 764), observed by Sarah Longrigg, 28 March 2007. A small deposit, a couple of centimetres diameter, comprising around 100 black eggs (but no jelly) lying on dead grassy vegetation (Fig. 1).

2. Menteith Hills, Lochan Allt a' Chip Dhuibh (NGR NN 571 040), observed by Sarah Longrigg, 28 March 2009. A deposit of whitish coiled jelly around 3 cm in diameter accompanied by a small mass of about 100 black eggs. A second small deposit of black eggs was present a few centimetres away (Fig. 2).

3. Ochil Hills, Warroch West Burn, 5 km NW of Dalqueich (NGR NO 04266 05822), observed by Nicole Ross and Nikki Broad, 20 Sept. 2011. The jelly was found on grass about 50 m away from the burn on a rough sheer-sided (sheep) path. A SEPA survey ecologist, Nikki Broad, discovered the jelly accidentally by putting her hand in it while scrambling up the path. The jelly consisted of an oval mass just a few centimetres long. The coloration was whitish, but partially translucent (Fig. 3).

4. Glasgow, Rouken Glen Park (NGR NS 54790 58370), observed by Myles O'Reilly, 9 Oct. 2011. The jelly was found on a grassy area (close to the walled garden) and not far from the Auldhouse Burn river. There were three masses of whitish and semi-transparent jelly with a total volume of around 120 ml (Fig. 4*a-d*). Lying adjacent to the jelly was a small deposit, volume around 5 ml, of decaying black eggs. Samples of the jelly and the eggs were collected for DNA analysis at the University of Glasgow. Unfortunately the DNA results proved inconclusive as the jelly and the eggs were contaminated by bacteria. However, microscopical examination of the eggs indicated they were consistent with ova and ovary remnants of frogs or toads. The eggs have a darkly pigmented hemisphere and a paler hemisphere which is characteristic of the common frog (Fig. 4*e-f*).

Although other types of organisms such as slugs, slime moulds or fungi often produce jelly masses these are generally of a different size, colour, or texture (Sterry & Hughes, 2009). Fungal jellies, such as crystal brain are associated with rotting logs or branches. Blue-green algal jellies (properly called Cyanobacteria) such as *Nostoc* or *Gloeocystis*,

are generally quite small with a greenish colouration.

The association of frog (or toad) eggs with some of the recent Scottish records of star jelly adds further confirmation that the most frequent source is spawn jelly extruded from frogs (or toads) following predation. Like most occurrences of star jelly, three of the above observations were on open and exposed hillsides, suggesting that a bird of prey such as a buzzard could have been responsible.

Fig. 4. Rouken Glen, 2011. (*a*) star jelly and egg remnants, (*b*) close up of egg remnants, (*c*) close up of star jelly, (*d*) star jelly with ruler (cm), (*e*) detail of egg and ovary remnants, (*f*) eggs teased apart (mm scale marks).

Different predator species may be involved in different localities with foxes, mink, herons, and buzzards among the suspects. The increase of the population of buzzards in Scotland in recent years (RSPB, 2013) may perhaps explain an increased number of sightings of star jelly. Although the DNA analysis has to date been inconclusive, the visualevidence is sufficient to be confident that most sightings probably derive from either frogs or toads.

The peak time for star jelly without eggs seems to be the autumn. The presence of eggs may seem more likely in spring, but some eggs are already present in frog ovaries in autumn. The oocytes of the common frog develop in annual batches, taking three years to reach full maturity in the autumn

prior to ovulation. So any adult female in autumn will have a batch of eggs ready to lay the following spring, plus two further batches at earlier stages developing to be ready for subsequent years. The eggs would normally only leave the ovary at mating time. As they pass down the oviduct each egg is surrounded by jelly. The jelly is made and secreted by tubular glands in the oviduct wall. Its volume is relatively small until the encapsulated eggs leave the oviduct and are fertilised in water; the jelly then expands enormously as it absorbs water (Duellman & Trueb, 1986).

If a predator catches and dismembers a frog the ovary will be torn apart, releasing the eggs close to the oviduct remnants. The oviducts may be stimulated to release their jelly by the trauma of the attack, and since it does not have the eggs to surround, it emerges as an amorphous mass. It will then absorb water from the soil or rain, producing the large masses that people see. If the predator removes the frog's body and takes the ovary as well, people will not see any eggs and only oviduct remnants and/or jelly will remain contributing to the 'mystery'.

It is evident that satisfactory natural explanations for the star jelly 'mystery' have been available for a long time.

For jelly originating from frogs or toads queries remain regarding what particular predators are involved and their exact mode of operation. Are the frogs or toads dismembered and the jelly or eggs discarded or are they swallowed and remnants subsequently disgorged?

How jelly deposits became associated with shooting stars in the Middle Ages is unclear. Perhaps a flying bird disgorged some jelly which then appeared to fall from the sky. It is noteworthy that, in the current 'information age', fanciful ideas and weird speculation are just as rampant as in the past. It seems the appetite for mysteries is as strong as ever. To the uninformed observer strange jelly masses scattered in the countryside will always seem a little mysterious and no doubt some wild ideas will persist on the worldwide web for some time to come!

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