OR/17/020 Discussion

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Farr, G, and Graham, J. 2017. Survey, characterisation and condition assessment of *Palustriella* dominated springs 'H7220 Petrifying springs with tufa formation (*Cratoneurion*)' in Gloucestershire, England. *British Geological Survey Internal Report*, OR/17/020.

The geology, topography, hydrology and land use (e.g. high proportion of open woodland) within Gloucestershire is favourable for the formation of H7720 habitat, and this is reflected in the frequency in which this feature was found at sites. Bryophytes (particularly *Palustriella commutata*, *Pellia endiviifolia* and *Conocephalum conicum*) are associated with active tufa formation. These 3 relatively robust species were observed to be active in the formation of complex and prominent tufa dams with pools. These features tend to form where there is generally a slow 'trickling' water flow.

Tufa dams at Slade Brook are orange/brown in colour, possibly reflecting the influence of sediment from the Old Red Sandstone. Occasionally the tufa dams at Slade Brook are formed in association with the liverwort *Pellia endiviifolia* but generally they occur in the absence of bryophytes or associated just with algae. Unusually, the rare aquatic moss *Fissidens rivularis* was recorded from tufa-encrusted stones within the channel at Slade Brook. The pH recorded for Slade Brook (pH 7.4) was one of the lowest recorded during the survey and contrasted with the majority of sites on the Oolite that had a pH >8.

Open rocky woodland sites on the Oolite (the majority of sites surveyed) are dominated by *Palustriella commutata*. This moss is almost always actively associated with tufa formation and is responsible for the formation of complex tufa dam and associated pools which can greatly enhance the structure of these sites and their biodiversity (invertebrates and flowering plants).

At many sites, complexes of tufa dams and pools appeared to form in the absence of *Palustriella commutata*. In such cases the principle bryophytes involved are *Pellia endiviifolia* and *Conocephalum conicum*. However, these types of dams always occurred within close proximity to stands of *Palustriella commutata* and are considered to be part of the H7220 feature. Vertical dripping faces (stream banks or coastal cliffs) were often dominated by *Eucladium verticillatum* which can sometimes form large cushions with thick associated deposits of tufa.

Slope and water flow appear to be key factors which affect formation of and types of tufa structures. Steeper slopes or streams with faster flowing and deeper water appear to favour more simply structured tufa dams formed without the association of bryophytes (such as at Slade Brook) or merely tufa-encrusted stones with aquatic mosses such as *Fissidens pusillus*, *F. crassipes* and *Platyhypnidium ripariodes*.

Gently sloping sites with lower flow velocities tend to favour more complex development of H7220 habitat dominated by *Palustriella commutata* with *Pellia endiviifolia* and *Conocephalum conicum*. In addition, the water channels of gently sloping sites tend to naturally divide, resulting in further complexity of the tufa dams and pools created. Field observations suggest that *Palustriella commutata* typically starts growth on tufa-encrusted stones within a water channel and is therefore critically important to the formation of tufa dams in low flow sites.

H7720 does occur in open pasture below springheads, typically on tufa-encrusted stones, but the majority of sites occur in open broadleaved woodland. The largest and most structurally diverse

H7220 sites were associated with rocky open woodland, and there is good evidence that shading by planted conifers has a negative effect on the vegetation.

Two sites, in particular (Woodchester Park and Workmans Wood), stand out as having great potential for restoration. Both sites have one spring line with good H7220 habitat along with several other spring lines without H7220. Consequently, tufa-encrusted stones with *Palustriella commutata* are locally available for creation of dams to aid restoration.

Field experiments (Gradsinski, 2010[1]; Arenas et al, 2010) record the growth rate of tufa in active streams, by installing small limestone 'tablets' into the flowing water. Sedimentation rates (tufa formation) were variable with a maximum of 13.1 mm/year (Arenas et al, 2010) however Gradzinski (2010) note there was no common seasonal trend in tufa growth rates. Although growth rates were variable, both studies suggest that tufa formation will occur within relatively short time frames on suitable material introduced into the water courses. This has promising implications for restoration and suggests that if the correct materials are used (possibly local stones) that tufa formation and the establishment of an associated bryophyte flora will follow.

Several EU LIFE projects have focused on the restoration of petrifying springs , including: LIFE03[2] 'Kalktuffquellen Frankenalb'; LIFE 12 'Springday'[3] and LIFE14 'RigKilde'[4] (Full details of these restoration projects can be found on the EU LIFE website www.ec.europa.eu/environment/life/project/Projects. Removal of spruce, the shade from which caused tufa mosses to die off, and replacement with deciduous woodland has proved successful in (LIFE03[2]), as has the removal of organic material, which has negative effects on tufa springs (LIFE03[2]). LIFE12[3] project is investigating the design of rapids by using local stone in the watercourses. We contacted the project team but the project is not due to be completed until next year (2018) so they did not have any publications that illustrated their in stream engineering. LIFE14[4] is still in progress and is focusing on restoring the hydrology and increasing the area of favourable H7220 habitat.

References

1. ↑ GRADZINSKI, M. 2010. Factors controlling growth rather of modern tufa: results of a field experiment. In: Pedley, H M, and Rogerson, M (eds), Tufa and speleothems: unravelling the Microbial and Physical Controls. Geological Society, London, Special Publications, 336, pages, 119–142.
2. ↑ 2.0 2.1 2.2 LIFE03 NAT/D/000002 Kalktuffquellen Frankenalb — Measures of optimisation of petrifying springs with tufa formation (Cratoneurion) and their surroundings in the Franconian Alb (2003–2007). http://ec.europa.eu/environment/life/project/Projects
3. ↑ 3.0 3.1 LIFE 12 NAT/EE/000860 LIFE Springday — Conservation and restoration of petrifying spring habitats (code *7220) in Estonia 2013–2018. http://ec.europa.eu/environment/life/project/Projects
4. ↑ 4.0 4.1 LIFE14 NAT/DK/000606 RigKilde-LIFE — Restoration and conservation of petrifying springs (*7220), calcareous fens (*7210) and alkaline fens (7230) in Denmark 2015 to 2020. http://ec.europa.eu/environment/life/project/Projects

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