Dippers (*Cinclus cinclus*) as bioindicators of health and resilience of freshwater ecosystems in the face of complex ecological change (Ref IAP2-18-77)

University of Stirling, Biological & Environmental Sciences
In partnership with Centre for Ecology & Hydrology (CEH), Scottish Natural Heritage & RSPB Scotland

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- river birds, environmental change, biodiversity, conservation evidence

Overview
Freshwater ecosystems are of critical importance because they integrate effects of environmental pressures across landscapes and catchments and are more than twice as important as other broad habitat types in terms of ecosystem service delivery per unit area (Natural Capital Asset Index). Monitoring freshwaters effectively and understanding their response to multiple environmental stressors is, however, challenging.

Dippers are the quintessential river bird of Britain and, as a predator, are likely to provide a convenient and effective sentinel of the health of our riverine ecosystems and their response to various forms of environmental management. Dippers are proven sensitive indicators of anthropogenic pressures such as acidification from air pollution (e.g. Vickery, 1992). However, in the past 30 years, acid deposition has declined greatly following controls on emissions, while more environmentally benign forestry practices may have helped to mitigate impacts of conifer plantations on upland stream acidification. Water pollution from industrial and urban point sources has also been strictly regulated leading to improved water quality. The declines in dipper populations, and those of other riparian birds (e.g. grey wagtail, common sandpiper, goosander) revealed by Bird Atlas 2007-2011, are therefore a conundrum.

Dippers are predicted to be highly responsive to the changes in temperature and flow regimes that will arise from climate change over the 21st century (Saether et al., 2000). While Dippers are adversely affected by severe winters these have been eclipsed by mild wet winters in recent decades which are reflected in overall increases in river flow and variability, most notably in the west of the country. Water colour is generally increasing ("brownification") in upland freshwaters as the constraining effects of acidification on decomposition rates and solubility of organic carbon are lifted, alongside increasing precipitation and...
temperature (Battarbee et al., 2014). There is a growing case that effects of more variable river flow regimes and increased water colour on aquatic invertebrate prey and Dipper foraging efficiency may be affecting Dipper demographic rates (e.g. Taylor & O’Halloran, 2001), and thus contributing to declines in this and other river birds. Finally, while there is good evidence for chemical improvement of acidified upland freshwaters, most assessments suggest that biological recovery of acid-sensitive invertebrates and fish is lagging some way behind (Battarbee et al., 2014). The current status of Dippers may be an extension of this trend upon which other stressors have gradually been superimposed.

Scotland has a rich archive of detailed climate projections, land cover maps, recent management histories, and high quality historical and current data on river flow, chemistry and invertebrate populations. Combined with the multiple detailed historical studies of Dipper ecology and demography from different parts of the country this provides a unique opportunity to test how the changing balance of environmental pressures on freshwaters is integrated in its impact on a charismatic and accessible bio-indicator species. It also presents an opportunity to explore if various local and catchment scale management interventions, ultimately intended to benefit biodiversity and ecosystem service delivery, are captured in improved Dipper performance. Native riparian tree planting and peatland restoration, for example, are measures that might be expected, via a range of mechanisms, to benefit Dippers.

The overall aim of the project is to understand the environmental basis for spatial and temporal changes in Dipper distribution and breeding densities and how these reflect local and catchment level influences versus climatic factors. Specific objectives are to:

1. Determine the level of Dipper population recovery in known acidification hotspots in Scotland (Dumfries & Galloway) based on repeating surveys undertaken in the late 1980s and compare this with trends on catchments unaffected by acidification.
2. Identify if flow, stream colour and invertebrate prey densities can better predict spatial and temporal variation in Dipper foraging efficiency and breeding success now than 30 years ago.
3. Model correlates of long-term Dipper population change at regional and national scales, and, in so doing, identify aspects of current catchment management that may need to be the focus of future conservation management interventions.

**Methodology**

Objective 1 will use historical data on Dipper densities, distribution and breeding success collected from catchments previously severely impacted by acidification (Dumfries & Galloway, late 1980s – Vickery, 1992), and a ‘control’ catchment uninfuenced by acidification (Midlothian, 1979-1991 – Wilson, 1996). Further data will be available from additional well studied catchments such as the Tweed and Devon and we will also collaborate with BTO Scotland to identify suitable upland river reaches with regular Waterways Bird Surveys. The project will repeat data collection in these study areas using the original census methods.

For Objective 2 we will identify, on the basis of the National River Flow Archive (NRFA), sites with long term flow data (usually post 1955) and pair these with the nearest stream reaches with Dipper surveys. A subsample of rivers spanning a gradient in post 1970 increases in overall stream flow and flow variability will then be studied in more detail. At these sites we will either directly monitor stream colour or extract this from matched SEPA river chemistry monitoring data. At each site we will collect stream invertebrate data in spring and autumn using Surber sampling to provide an area-standardised assessment of invertebrate densities.

Dipper territory densities and fledging dates will be determined at each study site based on regular observation and placement of camera traps at nest locations. We will also use nest visitation rates by adult birds post hatching as one indication of foraging success. Regular timed observation periods will be used to determine if birds engage in different modes of feeding depending on flow or water colour (e.g. shallow wading versus energetically more costly diving).

Diet will be assessed through collection of fresh faecal pellets and regurgitant from margins and emergent boulders favoured by feeding Dippers. Pellet collection will be timed to occur within a few days either side of stream invertebrate sampling. We will compare faecal pellet/regurgitant content and available invertebrate prey from direct stream sampling to derive prey electivity indices and will assess if electivity varies with site characteristics such as stream power, water colour, flow variation and ambient flow conditions.

For Objective 3 the project will work at a larger scale combining measures of land use (e.g. urbanisation, arable and grassland cover, commercial forestry, and grouse moor management) and river chemistry, drift geology (e.g. extent of peat in catchment), flow and invertebrate biomonitoring data (SEPA and NRFA data) with data on long-term population trends of Dippers (e.g. regional tetrad atlases, and the national Bird Atlas 2007-2011). Using structural equation modelling, the
student will identify, direct and indirect mechanisms influencing Dipper population trends at regional and national scales. We will then validate these models against independent datasets on Dipper status from the wider UK acquired via potential collaborators in NW England, south Wales and SW England.

We will also evaluate, via models and case study comparisons, if specific practices such as river restoration, native tree planting, peatland restoration or AES, known to have positive effects on physical habitat quality, water quality, flow stability and invertebrate densities, also translate into improved Dipper performance. To do this we will incorporate data on land cover change, catchment management plans, recorded river restoration projects, and Environmental Stewardship Schemes into the large scale datasets already established for Objective 3. Our analyses will establish the relative benefit of these measures to river health, via Dippers, and help to pinpoint the mechanisms behind such relationships.

The project will also benefit from co-supervision by conservation science specialists from RSPB (Professor Jeremy Wilson & Dr Juliet Vickery) and SNH (Prof Des Thompson) who also offer expertise in Dipper ecology.

Timeline

Year 1 Repeat breeding surveys in areas with historical data on Dipper populations, including activity time budgets and assessments of prey availability.

Year 2 Medium scale surveys of breeding performance and diet/feeding behaviour quantification in streams covering a gradient of flow variation and colour.

Year 3 Modelling of large scale spatial variation in Dipper population trends to identify drivers and responses to management.

Year 3.5 Finalising thesis and submission including preparation and submission of 2-3 journal manuscripts.

Training & Skills

The student will develop skills including bird census methods, invertebrate survey and analysis, experimental design and advanced data analysis, and interpretation of long term datasets.

The research findings will be published as journal articles led by the research student in leading ecology journals. Given the public interest in the changing status of familiar and charismatic birds we expect that such articles will attract a high media interest. The student will contribute regular progress updates to RSPB, SNH and University of Stirling social media feeds and have the opportunity to write for the RSPB magazine Nature’s Home. They will also present results at conferences including the Scottish Ecology, Environment and Conservation Student Conference, British Ecological Society annual conference, RSPB's Annual Science Meeting, and will offer talks to the Scottish Ornithologists’ Club branch network to bring the project to a wider birdwatching audience.

RSPB will offer a two week placement per year for the student to work within the RSPB Centre for Conservation Science at their Scotland HQ in Edinburgh. This will provide a broader induction into the relationship between conservation science and the use of that science by conservation policy makers, land management advisers, and reserve managers.

References & Further Reading


Further Information

Further information and informal enquiries contact: Prof Nigel Willby n.j.willby@stir.ac.uk tel 01786 467805.