Artificial Islands Created through Industrial Activity Contribute to Environmental Education and Evolutionary Ecology

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Abstract: The distinction between what is part of the ‘natural’ world and what is ‘artificial’ in the sense of having arisen through human activity can be difficult to make given that humans are a part of the natural world and thus human activities are a part of nature in a broad sense. Nevertheless, ‘natural’ conditions and those created by human industrial activity are normally understood to differ from one another. In this study we introduce an example where a nature reserve, formed as a byproduct of quarrying, provides a useful resource for continued industrial activity, environmental education and scientific research.

Keywords: Attenborough Nature Reserve; environmental education; industrial activity; artificial islands; Wildlife Trusts

1. A nature reserve created from a quarrying work

The roles of nature reserves in UK are focused both on conservation of biodiversity and on offering citizens views and opportunities to experience nature first hand. In the UK many reserves are managed by organizations called Wildlife Trusts, which are found in each province. Activities in reserves include preserving natural habitats and vegetation, maintaining accessible paths, undertaking educational campaigns, maintaining facilities such as bird watching bases, supporting nature hikes for school students and running exhibitions in nature centers. Professional rangers and volunteer staffs work together, to maintain nature reserves and to hold events. The Nottinghamshire Wildlife Trust is one of 47 Natural Trust in UK and manages around 70 nature reserves. Among those nature reserves, The Attenborough Nature Reserve (ANR) is a characteristic artificial lake land area created from a quarrying work by the company CEMEX, which produces concrete and owns this area. The nature reserve, which is designated as a Site of Special Scientific Interest (SSSI), was opened by the world famous naturalist Sir David Attenborough in 1966 and records of animals and plants species have been accumulated since then including over 250 bird species.

One of prominent features of the nature reserve is that the park has over a hundred artificial islands made by clay in a middle of lakes. Clay is a waste product extracted during the process of quarrying because concrete normally loose strength if it contains clay. Clay is therefore separated and removed from gravel and piled up in one place, eventually forming an artificial island. The process of island creation began nearly 80 years ago and some a hundred uninhabited islands have emerged since then. The reserve possesses seven lakes (Beeston Pit, Works Pond, Main Pond, Church Pond, Tween Pond, Clifton Pit and Coneries Pond) and grassland and marsh areas, covering 145 hectares in total.

It is always difficult to protect the natural environment whilst also encouraging visitors to the area. The ANR is

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fortunate to have some largely inaccessible islands and marsh areas, which suffer little disturbance and which benefit the visitors because they offer excellent habitats for wildlife such as birds, which can be seen by visitors from more accessible areas. For example, we can observe herons (one of the largest birds in UK) nesting on islands using binoculars from the opposite side of mainland over lakes. Those birds may prefer to nest on islands because predators do not frequently cross water to the island and attack their nests. The high quality of the islands as habitat is illustrated by the observation that those herons that migrated from a flock inhabiting a hill opposite side of the river Trent in 2007 chose the artificial islands as a nesting ground rather than their original habitats. This artificially created habitat also attracts rare species including Grasshopper Warbler, Willow Tit, Tree Sparrow, brown long-eared and whiskered bat (CEMEX, 2012). The reserve was also featured by the BBC in the autumn of 2013 when a White-winged black tern, which can be seen normally in Asia and Africa was found in ANR attracting around 1,000 visitors.

In addition to being a good wintering spot for migratory birds and a nesting site for many of other bird species, probably because of combination of rich flora, fauna, and aquatic areas we can also observe many invertebrates on those artificial islands and mainland (non-island area) including invertebrates such as insects, spiders, mollusks and earthworms. Such invertebrates likely support animals at higher trophic levels.

2. Environmental education and sustainability of Attenborough Nature Centre

The Attenborough Nature Centre is eager for various environmental educations including exhibitions in the building. One of the reason why the reserve was nominated 9th ranking in the top ten "Eco places in the world" in 2007 was because of its excellent Nature Centre, which is built upon sustainable, eco-friendly principles, and which has conference rooms, a fair-trade cafe, a stand selling nature guide books and field equipments, a garden with education areas and bird feeders, and rangers office as an information control centre of ANR. The Attenborough Nature Centre and many of the paths are wheelchair friendly. We observe a wide range of age of visitors to the ANR, indicating that the reserve is widely accessible.

The sustainable design of the Nature Centre building includes large south facing windows that introduce natural light and allow heat in to the building in winter and ventilation in summer. Solar panels generate electricity that is used to heat water and energy efficiency is increased by reducing heat loss through thick rockwool insulation of walls and floor, and cork inside the roof. Recycled materials are used in interior areas such as conference room and natural materials such as rubber are used for flooring (Attenborough Nature Reserve, 2005).

A variety of events are held in the ANR. Talks and guided walk are offered once in a month as Beeston Wildlife Group and participation is straightforward, with no booking required. Exploring the reserve in this way allows visitors to learn far more about the environment than they would otherwise do, and gives the opportunity to ask questions. One of unique events is birthday party held for children called Wild Birthday Parties in that a birthday boy or girl and friends try observing animals and playing games. Such ideas no doubt attract children and help them to be interested in environmental topics. Other activities for young people include those for 'Young Rangers', which aim to educate young members in practical elements of conservation, bushcraft and wildlife surveys. The activity with young rangers helps to manage the nature reserve, therefore both participants and the reserve benefit from each other. Other 'wildlife watching events' are also held for younger children on a monthly basis.

An event to commemorate 50 years of the Nottinghamshire Wildlife Trust was held in ANR in August 2013 (Sexton, 2013). Sara Goodacre was one of the speakers at this event and gave a presentation about spiders biology and ecology for visitors. After the talk both Sara Goodacre

and Morito Hayashi took visitors on a walk through the reserve and explained how to collect spiders and observe spider ballooning behaviour in the field. It was impressive for us that young children - as well as their parents - were eager to search for arachnids by hand. They are already young ecologists with the potential to contribute to the next generation. Discussions begun within such family groups, in this case collecting spiders together, likely continues after the event itself. Both handling and observing insects are key to young people becoming familiar with their natural environment.

A further characteristic and impressive part of Attenborough Nature Reserve is the capable rangers and volunteer staffs who manage the reserve itself and the events described above on a daily basis. These individuals have been very supportive to our academic research as well. Morito Hayashi remembers very clearly the interest shown in the research by John Black, Clare Martin and the late Keith Corbett during an initial meeting. At that stage it was not clear which material should be used in initial study, but quickly the decision was made to attempt to study all of the spider species presents because Keith indicated that a record of species present would be of interest to those managing the reserve area. Since the spider work has begun, professional rangers Graham Bowden, Tim Sexton and other members have continued to offer support to our research, sometimes assisting in surveying the islands together. Sandy Aitkin, a highly experienced volunteer, has provided invaluable information about the historical events that have taken place during the creation and development of the reserve habitat.

The reserve is generally emphasized as a bird sanctuary, but many other organisms inhabit this SSSI. We plan to accumulate a record of those through our next project explaining later that our ultimate goal is to understand the flow of energy through food webs in ANR and how these vary through time and space. We hope to be able to describe the dynamics of ecosystems within the small archipelago and to accumulate knowledge of a wide range of organisms. We also believe that this kind of research can contribute to environmental education in the near future.

3. As a research site for evolutionary ecology

ANR is also a promising site for studies in the area of evolutionary ecology. The reserve has arrays of sequentially produced islands that are largely untouched since their creation. These can be studied in a way not dissimilar to that taken for far more ancient and physically isolated archipelagos such as the Galapagos, Bonin or Hawaiian islands, which have captured the imagination of scientists for hundreds of years (e.g. Chiba, 2005; Gillespie, 2004; Grant, 1998). Examples of study sites with such newly created islands (in an evolutionary timescale) and many replicates is difficult (Thornton, 2007). The ages of islands in the ANR can be accurately determined from historical records, with the oldest island being 80 years of age. There are around 100 new borne islands created through same material and process in the same water system in this area. This allows us to study the communities on an island at an early stage just after the island was created and to establish through comparisons among islands whether there are repeatable patterns occur. Our initial work (Hayashi and Goodacre, in preparation) suggests that there are differences in spider behaviour between individuals taken from young and old groups of islands, despite the fact that spiders disperse long distances aerially (Foelix, 1996; Thornton, 1997; Spiller et al., 1998; Thomas et al., 2003; Pearce et al., 2005; Reynolds et al., 2007).

Island biology was instrumental in establishing the first evolutionary studies by Darwin (Darwin, 1939) and has revealed much in subsequent studies. One area that has remained unexplored however in these ancient archipelagos is the initial conditions of island ecosystems. How do organisms arrive, stay, survive and evolve in interactions in ecosystems in the initial stages of community formation? (Thornton, 2007). The clay substrate of each island is consistent throughout

the reserve reducing abiotic differences in environment, which could obscure other trends.

Access to the islands of the archipelago for fieldwork was achieved using a small kayak with visible outer clothes and floating vests borrowed from the Attenborough Nature Centre. Belongings such as GPS, camera, universal tubes, a notepad, plastic bags, felt-tip pens, kettles and phones were packed into waterproof bags. Sampling schedules were reported in advance to the ranger's office and a quarry manager in CEMEX. Any barges encountered whilst on the water were carefully avoided. Disturbance to bird life was also minimized at all times in order to reduce the probability that parent birds abandon their nests. Same-day collections are made from several islands of different age in order to remove potential bias in sampling brought about by temporal differences in season and/or climatic condition. Specimens were collected from one metre quadrats set up on litter surface on each island. Each quadrat was thoroughly searched because some spiders immediately found on the ground, but some others hide between leaf litters and start to move later. Normally three to four islands could be surveyed in a single day's fieldwork from early morning until dusk.

ANR is easy to access from the University of Nottingham (20 minutes by car) and which is advantage for efficient fieldworks and behavioural experiments needed fresh specimen, particularly given that it was necessary to respond to sudden changes of weather. Spiders were brought back to the lab and kept individually in universal tubes stood on a rack with a small amount of moisture. The system was optimized to check the health of specimens, to move them into our experimental arena, to describe what was observed, and to transfer them subsequently to the stereoscopic microscope for identification. The universal tube has an enough space for tiny spiders to create a nest and attack fruit flies supplied as food. Species identification was always performed after all of behavioural experiments were complete for the sake of blind testing, with specimens stored in a tube with a screw cap filled with 70 percent ethanol.

Our initial study on the evolution of behavioural traits in short periods throughout the artificial archipelago, which is finishing this year, but other organisms on islands are interesting as well. As mentioned before, there are many invertebrates inhabiting on those islands. Our next target is to analyze the food webs that exist in each island and to this end we have initiated a collaboration with taxonomists at the Natural History Museum in London. We plan to focus on this exciting trial once our current spider projects are complete.

4. The value of ANR

The Attenborough Nature Reserve offers a magnificent opportunity to address the question "How can we live with nature?" All efforts put into meticulous construction of the nature centre for sustainability, enthusiastically performed events, daily management works, and much more from the Wildlife Trust, volunteers, visitors and CEMEX, maintain this unique nature reserve. ANR is an excellent example showing both quality natural conditions and human activities can stand together. People naturally enjoy, observe, think, discuss and teach next generations through walking on paths between lakes where we cannot see any obvious traces of industrial activity. ANR is also precious as a model system to research ecosystems and island organisms. Perfectly preserved fauna and flora in the artificial archipelago and on the surrounding mainland are home to a diverse array of organisms as well. Such rarely seen conditions give us the chance to observe the initial conditions of island communities.

Acknowledgements

We thank G. Bowden, T. Sexton, J. Ellis, C. Martin, S. Aitkin, J. Black, A. Hindmarsh and the late K. Corbett from the Attenborough Nature Reserve for helping to coordinate fieldwork; and the Nottinghamshire Wildlife Trust and CEMEX for permission to collect samples. This work was supported by research fellowships from

the Japan Society for the Promotion of Science and Daiwa Foundation, Japan, and by the Miyagi University of Education, the University of Nottingham and the Natural History Museum, London.

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