

**SPECIAL ISSUE ARTICLE**

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# Demonstrating the practical impact of publications in *Aquatic Conservation* – The case of crucian carp *Carassius carassius* in the East of England

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**Abstract**

1. The contribution of nearly three decades of research, much of it published in *Aquatic Conservation: Marine and Freshwater Ecosystems* (AQC), to the conservation of the crucian carp *Carassius carassius* in the East of England, including work coordinated by the Norfolk Crucian Project, is summarized.
2. Although recent genetic studies indicate that this species was probably introduced to England about the same time as common carp *Cyprinus carpio*, the crucian carp is considered a cultural heritage species worthy of conservation in eastern England.
3. This research covers the environmental biology of the species in the East of England, documentation of the species' decline in the county of Norfolk, and the pond management practices implemented in Norfolk to rehabilitate existing and fully terrestrialized pond habitat specifically for crucian carp conservation.
4. The AQC papers that contributed to this line of research showed that England offers a particularly favourable environment for crucian carp growth and reproduction. These AQC articles provided the evidence base to complement crucian carp conservation initiatives in the London area (mainly the counties of Essex and Hertfordshire), as well as forming the basis for the designation of crucian carp as a Biodiversity Action Priority species in the county of Norfolk.
5. The broader impact of the work in the East of England was to inspire the recently-formed English National Crucian Conservation Project, which aims to promote the conservation of crucian carp and its habitat, and to encourage the development of well-managed crucian fisheries.
6. These evidence-based conservation initiatives, perhaps the first throughout Europe, have witnessed a reversal of the species' fortunes in England, which is effectively an ideal geographical region in which to promote the conservation of this species within a wider, European context.

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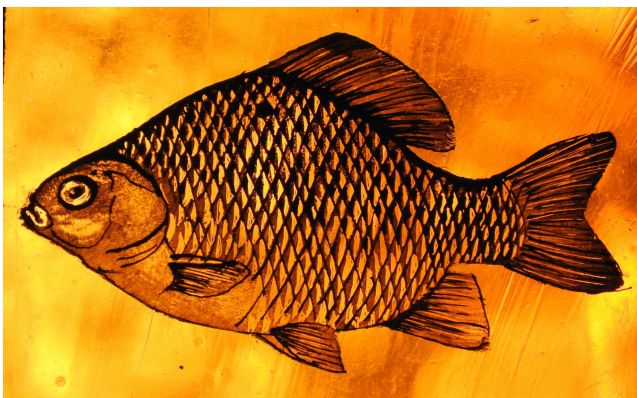
## KEYWORDS

body condition, freshwater fish, geographical comparisons, life-history traits, pond conservation and rehabilitation, threatened species

## 1 | INTRODUCTION

This article summarizes the beneficial impact that research articles published in *Aquatic Conservation: Marine and Freshwater Ecosystems* (AQC) have had on management initiatives in support of the conservation of crucian carp *Carassius carassius* (L.) in England (Figure 1). Before the 1980s, the environmental biology of crucian carp in Great Britain (GB) was virtually unstudied except for Marlborough (1966, 1967) and studies of crucian distribution in river floodplain water bodies (e.g. Copp, 1991). This lack of knowledge provided the incentive for the first detailed study in GB of a crucian population, which was reported in the AQC article by Copp, Černý, and Kováč (2008), where the disputed status of the species in GB was highlighted. Indeed, an earlier AQC article, by Maitland and Lyle (1991), listed the species as being non-native, whereas articles by the late Alwyn Wheeler (Wheeler, 1977, 1998, 2000), curator of fishes at the Natural History Museum in London, considered crucians to be 'probably indigenous', 'native', and 'probably native', respectively, to south-east England. Consequently, the initial studies of English crucian populations in the 1990s (Copp, Černý, et al., 2008; Copp, Warrington, & Wesley, 2008) and in 2007–2008 (Tarkan, Copp, Zięba, Godard, & Cucherousset, 2009) assumed the species to be native. Note, however, that a recent genetic study has revealed a high likelihood of crucians having been introduced to England during the same era (15<sup>th</sup> century) as the common carp *Cyprinus carpio* L. (Jeffries, Copp, Lawson-Handley, Sayer, & Hänfling, 2017).

This revision of crucian carp as a non-native species does not, however, diminish the species' high cultural heritage importance, which is apparent in the affection shown for it in historical natural history and angling literature (Rolfe, 2010) and indeed well illustrated for the present day by the species' depiction in a contemporary stained-



**FIGURE 1** Crucian carp image in a stained-glass window of St Peter's Church, Guestwick, Norfolk (WGS84 latitude and longitude: 52.800268, 1.055829). Photo: D. North, Norfolk Wildlife Trust

glass window of St Peter's Church in the village of Guestwick, Norfolk, eastern England (Figure 1). Furthermore, aside from cultural considerations, there are very good reasons to conserve the crucian carp in GB (Jeffries et al., 2017; AQC article by Sayer et al., 2020). Specifically, relative to the crucian carp's native continental European range, where the species is in decline, the risks of hybridization and competition with the invasive congener, gibel carp *Carassius gibelio* (Hänfling, Bolton, Harley, & Carvalho, 2005; RAVON, 2019), are much reduced in GB.

Indeed, in recognition of the seriousness of the crucian carp's decline, during the 1990s and 2000s, crucian populations attracted local conservation attention, both in parts of the London area (reviewed in the AQC articles: Copp, Černý, et al., 2008; Tarkan et al., 2009) and internationally (Engler & Schwevers, 2006; Petrick, 1994/1995). This decline and related conservation measures were not reflected, however, in the species' IUCN Red List classification of 'Not endangered internationally' and 'No immediate action needed' (cf. Maitland & Lyle, 1991). That said, the current assessment of 'Least Concern' (IUCN, 2019) includes the caveat: 'population trend decreasing'. This contrasts with individual countries, such as The Netherlands, where crucian carp has the status of 'vulnerable' on the country's Red List (RAVON, 2019).

Independently, field studies in the 1990s, as published in AQC, examined the aquatic conservation role of small ornamental lakes and ponds in the south-eastern English counties of Norfolk (Sayer, Davidson, & Kelly, 2008) and Hertfordshire (Copp, Warrington, et al., 2008). The initial study of pond populations of crucians in Hertfordshire (Copp, Černý, et al., 2008) was expanded to include several ponds in the nearby Site of Special Scientific Interest of Epping Forest, Essex, to understand better the species' distribution (Copp, Wesley, & Vilizzi, 2005) and its environmental biology (AQC article of Tarkan et al., 2009). With support from the British Council (Tarkan & Copp, 2007), the study by Tarkan et al. (2009) was complemented by assessments of potential impacts on crucians by other non-native species, especially the crucian's Asian congener, goldfish *Carassius auratus* (Copp, Tarkan, Godard, Edmonds, & Wesley, 2010), and longer-term studies of crucian growth (Tarkan, Gaygusuz, Godard, & Copp, 2011).

## 2 | PRIMARY IMPACTS ON CRUCIAN CARP CONSERVATION

During the 2000s, the authors of the present article combined their efforts to study the decline of crucian populations in Norfolk (Sayer et al., 2011 and AQC article Sayer et al., 2020) as well as continuing their work in Essex and Hertfordshire (AQC articles by Tarkan et al., 2009, 2016). Complemented by the AQC article by

Sayer et al. (2012) on farmland pond management for biodiversity conservation, the combined databases and resulting articles in AQC (op. cit.) by Copp and Sayer provided background knowledge in support of the Norfolk Biodiversity Action Plan for Ponds (Norfolk Wildlife Trust, 2010). Collectively, the evidence base of this work laid the foundations for the initiation of the Norfolk Crucian Project (NCP), which was a major contribution to the designation in 2010 of crucian carp as a Biodiversity Action Plan (BAP) species for Norfolk (Copp & Sayer, 2010). Importantly, Tarkan et al. (2009, 2016) showed that, despite being at the very western extent of its range, the local habitat conditions (limited pond shading and terrestrialization) and climate of south-east England are highly suitable for crucian carp reproduction and growth. In addition, Sayer et al. (2012) demonstrated how derelict, overgrown ponds, which are unfavourable for crucian carp survival (Sayer et al., 2011), can easily be rehabilitated by periodic removal of sediment and riparian scrub.

Although some local conservation initiatives were in existence for crucian populations in the London area (i.e. Conservators of Epping Forest, 2002; Lambeth Borough Council, 2005), the Norfolk crucian carp BAP was the first conservation plan for the species at a county-government level. This crucian carp Norfolk BAP and the NCP (AQC article by Sayer et al., 2020) provided the impetus for the creation in 2014 of the English National Crucian Conservation Project (NCCP) (Angling Trust, 2019), which is primarily an angling-focused initiative aiming to promote the conservation of the crucian carp, combined with encouraging the development of well managed crucian carp fisheries.

### 3 | SECONDARY IMPACTS ON POND HABITAT REHABILITATION AND CRUCIAN CARP CONSERVATION

In light of the likely 15<sup>th</sup> century introduction of crucians (Jeffries et al., 2017), the NCCP and the NCP's (Sayer, 2017) ongoing research collaboration between Cefas, UCL and international partners

(G.H. Copp, C.D. Sayer, A.S. Tarkan, unpublished data) now all focus on the angling culture and local heritage conservation aspects of crucians at the local level and the importance of managing ponds for their aquatic biodiversity value (Copp, Warrington, et al., 2008; Sayer et al., 2013). The NCCP-initiated local management plans for angling venues endeavour to protect the genetic integrity of crucian populations from the adverse impacts of hybridization with other introduced species, specifically goldfish and common carp (Hänfling et al., 2005; RAVON, 2019), including very recently the crucian's Asian congener, gibel carp *Carassius gibelio*, which has been confirmed by taxonomic experts as being present in at least one water body in England (M. Wintle, personal communication). However, the most comprehensive conservation initiative in support of crucian populations is the NCP, which combines research initiatives on crucian biology and the species restocking/introductions with the pond rehabilitation and resurrection initiatives of the Norfolk Ponds Project (Sayer & Greaves, 2020). This work supports the Norfolk Biodiversity Action Plan for Ponds (Norfolk Wildlife Trust, 2010) as well as the Norfolk crucian carp BAP. The NCP initiative of farmland pond rehabilitation and ghost pond resurrection are described in the AQC article by Sayer et al. (2012) and in Alderton, Sayer, Davies, Lambert, and Axmacher (2017), respectively. The benefits of coordinating the rehabilitation of pond habitats and crucian populations is the focus of the AQC paper of Sayer et al. (2020), which details the NCP's progress over the last 10 years, including the outcome of crucian carp conservation efforts with particular regard to crucian growth and recruitment following introductions or re-introductions. In terms of crucian carp conservation, the NCP has undertaken the rehabilitation, via extensive removal of woody vegetation and sediment, of 10 ponds, which previously harboured the species until they had become highly terrestrialized between the 1950s and 1980s (Figure 2). All of these ponds have recently been re-stocked with crucian carp, and eight ponds having seen successful crucian survival, reproduction and growth, with two ponds still retaining the species but with no evidence of recruitment thus far (C.D. Sayer et al., unpublished data). Overall, the NCP has stocked crucian carp into 18 suitable ponds and



**FIGURE 2** A Norfolk farmland pond in 2015: (a) just before pond rehabilitation by extensive scrub and sediment removal, and (b) three years after rehabilitation in 2018 showing major recovery of aquatic macrophytes. Crucian carp were lost from this pond owing to terrestrialization in the 1980s and 1990s and re-stocked by the Norfolk Crucian Project in 2016, with successful crucian carp recruitment confirmed in 2018

thus achieved an increase of 37% in the number of crucian-supporting ponds in Norfolk, thus helping to address the estimated 72% decline in crucian carp distribution between the 1950s–1980s and the 2010s (Sayer et al., 2011; Sayer et al., 2020).

In conclusion, the AQC papers covering the fields of crucian carp biological traits, which began with investigations in the County of Hertfordshire (AQC article Copp, Černý, et al., 2008), and farmland pond rehabilitation in Norfolk by the NCP provided the evidence base to complement the crucian carp conservation initiatives in the London area (Conservators of Epping Forest, 2002; Copp, Warrington, & Wesley, 2008), in Norfolk (Copp & Sayer, 2010; Sayer et al., 2011), and then more widely in England (Angling Trust, 2019). These initiatives, perhaps the first throughout Europe, have witnessed the start of a reversal of the species' fortunes. Indeed, in view of England's favourable environment for crucian carp (Tarkan et al., 2016 in AQC), it is effectively the ideal geographical region in which to promote the conservation of this species within a wider, European perspective.

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