

Research article

Recent releases and dispersal of non-native fishes in England and Wales, with emphasis on sunbleak *Leucaspis delineatus* (Heckel, 1843)

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Abstract

The introduced range of the European cyprinid, sunbleak *Leucaspis delineatus*, in England was previously limited to parts of southwest England but has now expanded across Southern England. Natural dispersal mechanisms cannot explain their increased distribution and fish stocking was not a factor. Thus, the accidental movement of either their eggs or larvae via anglers' nets was believed to be the mechanism by which these fish were accidentally moved between waters over 100 km apart. This dispersal pathway is difficult to regulate, as is the release of unwanted non-native aquarium and pond fish into open waters by the public. This latter pathway has resulted in the recent releases of species including walking catfish *Clarias batrachus*, Asian weatherfish *Misgurnus mizolepis* and white catfish *Ameiurus catus*.

Key words: introductions, alien species, sterlet, walking catfish, armoured catfish, fathead minnow

Introduction

The legislation regulating the keeping or release of non-native fishes in England and Wales has been described as providing a robust framework for preventing introductions of invasive, pest fishes, whilst enabling the release of ecologically-benign angler-targeted species into enclosed fisheries (Hickley and Chare 2004; Copp et al. 2009a). Despite these regulations, unwarranted introductions and the dispersal of established fishes still occur (e.g. Copp et al. 1993, 2006a, b; Britton and Davies 2006a, 2006b, 2007). This is generally related to recent introductions and dispersal mechanisms, whether accidental or intentional, which are usually linked to human activities that are difficult to regulate (Copp et al. 2005a). Increasingly common is the release of unwanted pet fish, either from aquaria or garden ponds, into ponds and water courses (Wheeler 1998; Copp et al.

2005b, 2006b; Rixon et al. 2005; Duggan et al. 2006), and the diversity of species being reported is of particular concern (e.g. Ellis 2006).

An introduction and dispersal pathway that has proved difficult to regulate is the movement of fish as a consequence of angling activity. An example is the intentional or accidental translocation and introduction of ruffe *Gymnocephalus cernuus* (Linnaeus, 1758) to parts of the UK north of its native range, which has been attributed to their use by anglers as live bait for targeting the piscivorous pike *Esox lucius* Linnaeus, 1758, (e.g. Winfield et al. 1996). Less well documented is the dispersal of non-native fishes via angling gear, including wet 'keep nets' that are transported between angling venues. Although dispersal by this pathway is poorly documented, Beyer (2008) discussed it as a plausible dispersal mechanism for small pest fishes, especially those that spawn readily on

various types of substratum, including anglers' keep nets, enabling their transfer between waters on this medium. Two such species are the topmouth gudgeon *Pseudorasbora parva* (Temminck and Schlegel, 1846), a native of southeastern Asia, and the sunbleak *Leucaspis delineatus* (Heckel, 1843) (Figure 1), which is native to many parts of north and central Europe. Both species were introduced accidentally to locations in southwest England in the 1980s and are considered invasive (Farr-Cox et al. 1996; Pinder and Gozlan 2003; Pinder et al. 2005). Unlike topmouth gudgeon, whose spatial distribution extends across much of England and Wales, albeit generally limited to enclosed lakes (Pinder et al. 2005), sunbleak have previously been limited to waters in southwest England (Pinder and Gozlan 2003), with two specimens recorded in northeast England (Skegness, Lincolnshire), but an established population was not subsequently recorded (Farr-Cox et al. 1996). However, recent records suggest a movement eastwards that cannot be explained by natural dispersal. Consequently, the aim of the paper is two-fold: 1) to update the distribution of sunbleak in England and Wales with evaluation of the dispersal mechanisms responsible for any changes; and 2) to document recent releases of non-native fishes in England and Wales, identify their introduction pathways and discuss their management implications.

Methods

Reports of species occurrences were collated from various sources, including scientific journals, the angling press, national newspapers, personal communications and recent field surveys. Where specimens of sunbleak were suspected within samples, identification used the criteria of Pinder (2001), in particular the presence of a short lateral line and a soft ray count of ≤ 14 in the anal fin. Confirmation of identity was made for a sub-sample of specimens using pharyngeal bones, which were extracted and compared with descriptions in Pinder (2001).

Results

Specimens of sunbleak were found in 2003 at a lake fishery used for catch and release angling in the vicinity of East Grinstead, East Sussex (Table 1) but have remained undocumented until

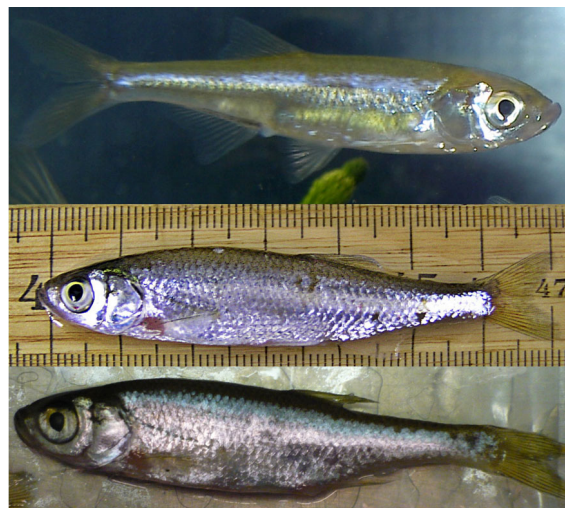


Figure 1. Sunbleak *Leucaspis delineatus* from water bodies in southeast England held in an aquarium (upper photo: R.E. Gozlan) or taken from aquarium stock (middle photo: J.R. Britton), and from an angling lake near Tunbridge Wells, Kent (lower photo: G. Zięba).



Figure 2. Distribution of sunbleak *Leucaspis delineatus* in Southern England, with previous (Pinder and Gozlan 2003) and recent records (Table 1) indicated as filled and open circles, respectively.

Table 1. Recent records of non-native fishes observed in the wild in England and Wales, including the Latin and common names, the year of record and general locations, geographical locations ('–' indicates that even an approximate geographical location is not available) and references.

Latin name	Common name	Year	Location	Coordinates, latitude/longitude	Reference
<i>Leucaspius delineatus</i>	sunbleak	2003	near East Grinstead, East Sussex	51°09'31"N 00°01'25"E	K.J. Wesley (unpublished)
" "	" "	2006	near Uckfield, East Sussex	51°01'07"N 00°00'47"E	Present study
" "	" "	2008	near Tunbridge Wells, Kent	51°05'31"N 00°14'06"E	Present study
" "	" "	2008	near Tunbridge Wells, Kent	51°07'19"N 00°19'14"E	Present study
<i>Acipenser ruthenus</i>	sterlet	1986	Near Heathrow Airport, Surrey	51°28'18"N ¹ 00°27'23"W ¹	K.J. Wesley (unpublished)
" "	" "	2002	River Frome, East Stoke, Dorset	50°40'48"N ¹ 02°11'06"W ¹	R.E. Gozlan ²
" "	" "	2004	Pirton, Hertfordshire	51°58'16"N 00°19'54"W	G.H. Copp & K.J. Wesley (unpublished)
<i>Ameiurus catus</i>	white catfish	2005	Epsom Common, Surrey	51°20'06"N 00°18'09"W	Britton and Davies (2006a)
<i>Catostomus commersonii</i>	white sucker	1992	River Gade, Hertfordshire	51°44'39"N 00°29'18"W	Copp et al. (1993)
" "	" "	2004–2005	River Gade, Hertfordshire	51°45'56"N ³ 00°28'57"W ³	Copp et al. (2006a)
<i>Channa micropeltes</i>	giant snakehead	2008	River Witham, Lincolnshire	53°10'35"N 00°34'27"W	G.D. Davies (unpublished)
" "	" "	2009	near Wakefield, West Yorkshire	–	G.D. Davies (unpublished)
<i>Clarias batrachus</i>	walking catfish	2009	River Thames, London	51°29'40"N 00°03'50"E	G.D. Davies (unpublished)
<i>Colossoma macropomum</i>	red-bellied pacu	2009	River Torridge, Devon	–	G.D. Davies (unpublished)
<i>Hypostomus plecostomus</i>	armoured suckermouth catfish	2000–2002	Epping Forest, Essex	51°37'44"N 00°01'58"E	K.J. Wesley (unpublished)
" "	" "	2009	near Wigston, Leicestershire	–	(Anonymous, London Metro 2009) ⁴
<i>Misgurnus mizolepis</i>	Asian weatherfish	2003	a private property in Sussex	–	A. Scott ⁵ (Cefas-Weymouth, unpublished)
<i>Pimephales promelas</i>	fathead minnow	2008	near York	53°50'38"N 00°51'45"W	P. Stebbing (unpublished)
<i>Pseudorasbora parva</i>	topmouth gudgeon	2008	a commercial fishery in Kent	51°06'52"N 00°25'25"E	www.areelchallenge.co.uk/g rassc.htm (last accessed on 28 October 2009)
<i>Pygocentrus sp. (nattereri)</i>	piranha	2005	Oulton Broad, Suffolk	52°28'18"N 01°42'33"E ¹	Ellis (2006)

¹Approximate geographical coordinates; ²Cited as a personal communication in ICES (2003);; ³Coordinates for the stream stretch cited in reference for 2004–2005 extend from 51°45'56"N, 00°28'57"W to 51°43'20"N, 00°27'32"W; ⁴A dead specimen found by S. Brown and reported in numerous local and national daily newspapers; ⁵Alasdair Scott, Centre for Environment, Fisheries & Aquaculture Science (Weymouth, Dorset), cited as a personal communication by Copp et al. (2007).

now (Table 1). This location lies over 100 km east of the previously-reported distribution of sunbleak in England and cannot be explained by natural dispersal mechanisms (Figure 2). In September 2008, sunbleak was subsequently detected during a fish sampling excursion in another lake fishery, located adjacent to a small tributary of the River Ouse, East Sussex (Table 1). The fishery manager reported that the species had been initially observed two years earlier and had been misidentified as bleak *Alburnus alburnus* (Linnaeus, 1758), a native species. Evidence, in the form of frozen fish samples, was also provided of sunbleak from a lake fishery located further east, in the vicinity of Royal Tunbridge Wells, Kent (Table 1; Figure 2). Although permission could not be obtained to sample that water body specifically for sunbleak, a survey of a floodplain lake 3.2 km downstream (Table 1) was also found to contain sunbleak. Given that southern England was subjected to an extreme flood event in July 2007, it is very likely that sunbleak in the upstream water body were dispersed by the flood waters and thereby entered water bodies further downstream.

The collation of recent fish records revealed that non-native fish species continue to be released into the wild in England and Wales. For example, whilst Britton and Davies (2006b) described at least 30 lakes containing non-native species of the *Acipenser* genus, further releases continue to be reported (Table 1). Other released species of particular note are a giant snakehead *Channa micropeltes* (Cuvier, 1831) found dead on the banks of the River Witham near the village of North Hykeham, Lincolnshire (Table 1), an armoured suckermouth catfish *Hypostomus plecostomus* (Linnaeus, 1758) in St-John's Pond of Epping Forest (Table 1), a reproducing population of Asian weatherfish *Misgurnus mizolepis* (Günther, 1867) found in a small garden pond at an undisclosed location in Sussex county, established populations of fathead minnow *Pimephales promelas* Rafinesque, 1820 in two small private ponds near the village of Laytham, Yorkshire (Table 1), where reproducing populations of golden orfe *Leuciscus idus* (Linnaeus, 1758) were also present, and a red-bellied pacu *Colossoma macropomum* (Cuvier, 1816) found dead on the banks of the River Torridge, Devon. All are either accidental or intentional releases of fish previously held in aquaria or garden ponds (Table 1).

Discussion

Of the four locations in East Sussex and Kent containing sunbleak, the lake fishery in the vicinity of Uckfield has not been the subject of any fish stockings of any kind in at least ten years, the use of live bait is not permitted and illegal stocking is highly unlikely (the site is gated and staffed throughout daytime, when the gates are open). This venue is south of that observed to have sunbleak in 2003, but they are located in different stream catchments separated by the watershed between the Thames and Sussex Ouse river catchments. Thus, their appearance in the lake was neither as a contaminate of a fish stocking action nor via natural dispersal. Anglers using fisheries of this type are allowed to use landing nets and keep nets to hold their catch until the end of their visit and are known to move from one angling venue to another, often separated by over hundreds of kilometres. When doing so, they store their keep nets in "stink bags" between the venues so as to avoid soiling the angler's vehicle whilst keeping the nets moist. The dissolved oxygen requirements of fish eggs are known to increase during incubation (Davies 1975), and although no data are available sunbleak eggs, Arnold and Längert (1995) reported that hatching ceases only below $3.0 \text{ mg O}_2 \cdot \text{L}^{-1}$ at 21°C . In the absence of other possible forms of introduction, and given that sunbleak is known to readily spawn on anglers nets (Beyer 2008), the only plausible means by which sunbleak could arrived in the venue near Uckfield is as a contaminant (as eggs and/or young fish) of an angler's net or stink bag.

One of the most commonly reported contaminants of fish consignments is the topmouth gudgeon (e.g. Bănărescu 1964; Pinder et al. 2005), which in England has been linked specifically with the consignments of ide and its ornamental variety, 'golden orfe' (Copp et al. 2005a, Copp et al. in press). However, another species that has recently been linked to golden orfe consignments as a contaminant is the fathead minnow (Table 1). In 2008, the ornamental 'rosy red' variety of fathead minnow was discovered in two ponds in northern England that had been stocked with larvae of golden orfe in about 1996. Given there were no subsequent introductions onto the site, this suggests that these fathead minnow were introduced as a contaminant of the golden orfe consignment. The

fathead minnow population remained unrecognised by the landowner, probably due to its resemblance with young golden orfe, and was only discovered during a health audit of the farm ponds in 2008. All fish at this site were eradicated with rotenone on 15 February 2010.

Although reproducing fathead minnow populations have been observed in garden ponds in both Scotland (P. Maitland, personal communication) and England (G.H. Copp, personal observation), the fathead minnow populations in the Yorkshire ponds were the first observed in the United Kingdom to have established self-sustaining populations 'in the wild' (see Wheeler et al. 2004). England is only the fourth country in Europe in which feral fathead minnow populations have been reported, with establishment reported for Belgium, France and Germany (Elvira 2001), though of these three only the population in Belgium is well documented (Verreycken et al. 2007). Another North American species rarely encountered is the white sucker *Catostomus commersonii* (Lacepède, 1803), which has been reported for only one European location, the River Gade in the town of Hemel Hempstead, England, in the early 1990s (Copp et al. 1993). The specimen was assumed to be a discard or escapee from a fish farm upstream of the town, but the re-occurrence of the species in the same stretch about ten years later (Copp et al. 2006a) suggests either the release (or escape) of captive fish or alternatively the presence of a small groups of reproducing fish at some as yet unknown upstream location.

The unauthorised release of pet fish, either from aquaria or garden ponds, is known to have increased in intensity (i.e. the proportion that non-native species comprise in ponds) over the last two decades (Copp et al. 2005b). This also seems apparent in the rise in sightings of sterlet *Acipenser ruthenus* Linnaeus, 1758, which is only known to have been sighted once prior to 2000; since then, there have been at least two recent confirmed reports (Table 1), one in the River Frome, Dorset and one in Blacksmith's Pond, Pirton, Hertfordshire. But, reports by anglers for *Acipenser* spp. (<http://www.wildaboutbritain.co.uk/forums/water-life-forums/9165-sturgeon-british-waters.html>) suggest a much greater number (Britton and Davies 2006b). The present study also reveals that the diversity of species is also increasing, with reports of armoured suckermouth catfish, Asian weatherfish, white catfish *Ameiurus catus* (Linnaeus, 1758), fathead minnow, giant

snakehead, red-bellied pacu and piranha *Pygocentrus* sp. (nattereri Kner, 1858) in the wild (albeit as dead specimens in the latter three species) all being post-2000. In the case of the Asian weatherfish, this species was being imported under the Latin name *Misgurnus anguillicaudatus* (Cantor, 1842) but under scrutiny was found to be *M. mizolepis*, and a self-sustaining population of the species was found in a plastic-lined pond in Sussex. The population was subsequently eradicated by drain-down and removal of all contents of the pond, and the potential confusion over the identity of *Misgurnus* species led to a legislative amendment under The Prohibition of Keeping or Release of Live Fish (Specified Species) (Amendment) (England) Order, 2003, associated with the Import of Live Fish Act 1980. Confusion over species identities is a major problem in determining fish distributions and in attempts to control invasive species. A prime example of misidentification is the topmouth gudgeon, which has been mistaken for a grass carp *Ctenopharyngodon idella* (Valenciennes, 1844) at a fishery in Kent (Table 1) and for a riffle minnow *Leuciscus souffia* Risso, 1827 in the upper Thames Estuary (Araujo et al. 1999; see also Copp et al. 2007).

Of particular note with introductions of warm-water species in the UK is the Church Street Canal, St-Helens, Lancashire (Lever 1977), as this location sustained reproducing populations of redbelly tilapia *Tilapia zillii* (Gervais, 1848) and guppy *Poecilia reticulata* Peters, 1859, and a few other warm-water species, including a walking catfish *Clarias batrachus* (Linnaeus, 1758), until the nearby power station ceased operations and the canal waters returned to ambient temperatures (Lever 1996). Of these, the walking catfish has recently been found again in open waters (Table 1). A dead, partially decomposed specimen of the Genus *Clarias* (approximate measurements: total length = 400 mm, total body weight = 450 g) was discovered by an angler along the River Thames at Woolwich, South-East London (Table 1) in March 2009. Using general morphological characteristics and an observed series of lateral white spots (Robins 2008), the specimen was identified as *C. batrachus*. Unlike the specimen found in the Church Street Canal in 1963, which was sustained by the heated waters from a power station, the Thames specimen was found dead, presumably having succumbed to thermal intolerance. Similarly, a guppy population was

also known to have persisted in the heated effluent of a power station along the lower River Lee, Essex (Meadows 1968) until the facility ceased operations (Lever 1996). Another such report is that of the armoured suckermouth catfish. Although a live specimen has been found during the summer months in a pond of Epping Forest (Table 1), a more recent find was a dead specimen on the banks of the Grand Union Canal at Wigston, Leicestershire.

These continued reports of released non-native fish are potentially concerning. For species such as *C. batrachus*, the ecological risk of their release remains low; their survival is impeded by low temperatures and the only risk lies in their potential transfer of novel pathogens into the native fish assemblage. However, small-bodied nest-guarding species, such as sunbleak and topmouth gudgeon, are capable of establishing abundant populations over a relatively short time frame, and the ecological risks are considerably higher, such as through their role in disease transmission (Beyer et al. 2005). The fathead minnow has been available in the aquarium trade in Europe for at least two decades, but this species, which is also a small-bodied nest guarder, has established itself in few European countries (Verreycken et al. 2007; Table 1) and does not appear to present the same level of risk to the environment as sunbleak and topmouth gudgeon (Copp et al. 2009b). However, the risk posed by fathead minnow could change, in particular if the species is currently in a lag phase, pending a subsequent invasive phase (Crooks and Soule 1999).

Invasive small-bodied species such as topmouth gudgeon and sunbleak have been described as a major threat to native fishes in England and Wales through aspects such as increasing competition for resources and the transfer of novel and non-native pathogens (Gozlan et al. 2005; Pinder et al. 2005; Britton et al. in press). Thus, there is a desire to prevent the further dispersal of pest fish that could potentially lead to adverse environmental consequences. However, the ability of legislators and regulatory bodies to prevent fish releases and dispersal is constrained by the manner in which these occur. Often, such fish releases are completed in ignorance and by people without understanding the ecological consequences of their actions (Copp et al. 2005a), suggesting that a key requirement to prevent further releases of non-native aquarium and pond fishes is through improved education and awareness campaigns.

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