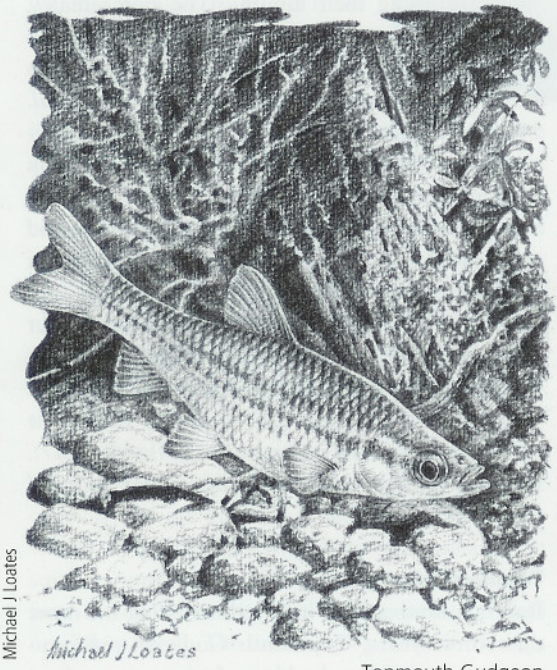
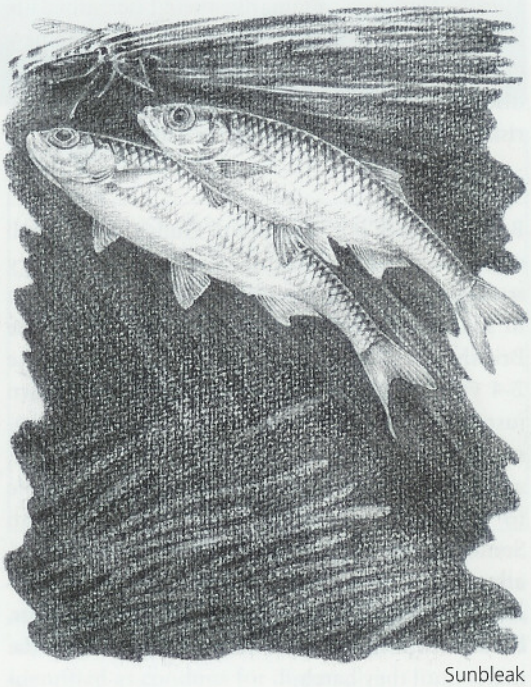
Sunbleak and Topmouth Gudgeon – two new additions to Britain's freshwater fishes



Topmouth Gudgeon



Sunbleak

Adrian C Pinder and Rodolphe E Gozlan

Throughout the world, it is commonly accepted that the introduction of new species to a stable ecosystem can upset the environment and the species already present. Aquatic ecosystems are no exception and, with a dramatic increase in world travel and trading over the last century, are increasingly at risk from biological invasion.

The various threats posed by the introduction of alien species are many and can manifest themselves in the form of direct predation on native species, competition for food, introduction of new diseases or parasites, or potential to cause change to the environment.

Globally, among vertebrates, introductions of freshwater fish species have been among the most numerous (Crivelli 1995), and the introduction of non-native fishes to the UK is not a new phenomenon. The Carp *Cyprinus carpio* was first introduced for aquaculture in the 15th century (Balon 1995), and during more recent times introductions that have successfully colonised UK watercourses include the Ide *Leuciscus idus*, Bitterling *Rhodeus sericieus*, Zander *Sander lucioperca* and Pumpkinseed *Lepomis gibbosus*. The motives responsible for these introductions vary from ornamental fish-keeping and angling interest to, in the case of Grass Carp *Ctenopharyngodon idella*, their use as

a biological herbicide to control the excessive growth of aquatic weed.

Sunbleak and Topmouth Gudgeon

This article highlights two of the most recent introductions to the fish fauna of Great Britain: Topmouth Gudgeon *Pseudorasbora parva* and Sunbleak *Leucaspius delineatus*. Over the last three years, various aspects of the biology and ecology, including the reproductive behaviour, habitat requirements and early development, and the distribution of these two species have been studied by the authors at the Centre for Ecology and Hydrology in Dorset. Here, we summarise their fascinating life histories and assess the current status of these new additions to the British aquatic fauna. We also discuss the future of these species in Britain and the risks that they pose to our native fishes.

Basic biology

Both Sunbleak and Topmouth Gudgeon are small cyprinids possessing highly developed life-history strategies which have undoubtedly assisted them in successfully colonising bodies of water in the British Isles. The majority of cyprinid species take 2-4 years to become sexually mature and spawn just once a year. The females scatter many thousands of eggs over aquatic macrophytes or gravel, and these are then left unguarded and vulnerable to predation. Unusually for cyprinids, both Sunbleak and Topmouth Gudgeon become sexually mature at one year old and are batch spawners, with females laying several batches of eggs, between April and July, which are guarded by the males until they hatch.

This combination of attributes means that a relatively low number of eggs (when compared with other cyprinid species) are produced, but with the parental care ensuring higher than average hatching rates. Also, as the brood is spread across an extended period, larvae are less vulnerable to changes in environmental conditions, thus enhancing survival rates (Gozlan *et al.* 2003a).

Sunbleak

Sunbleak closely resemble Bleak *Alburnus alburnus* in appearance, but are a smaller species not exceeding 8cm in length and rarely living for more than three to four years. They are gregarious and live in large shoals close to the water's surface, where they typically feed on zooplankton and terrestrial insects.

Whereas most British freshwater fish grow relatively rapidly for the first few years, until they become sexually mature, in Sunbleak growth is most rapid during the first summer, beyond which energy reserves are reallocated from somatic growth towards gonad production, resulting in Sunbleak becoming sexually mature at one year old (Gozlan *et al.* 2003a).

During spawning, males, which are smaller than females, take up territories around the stems and underside of the leaves of water-lilies and other flat-surfaced structures. The males then clean any accumulated bio-films from the spawning substrate, using their mouths. The ripe females, which develop swollen, distended ovipositors during spawning, join the male and travel at high speed across the spawning substrate (Gozlan *et al.* 2003b), depositing strips of up to 80 highly adhesive eggs. A female Sunbleak can typically deposit a strip of 40 eggs in less than one second. After the female has spawned, the male guards the eggs and encourages other females to deposit their eggs at the same nest site. The male then guards the eggs until they hatch, which takes approximately four days at 22°C (Pinder & Gozlan in press).

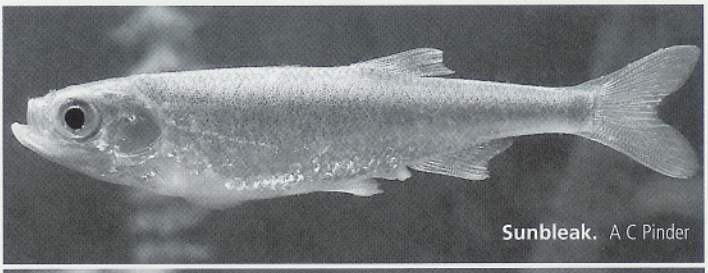
In contrast to its alien and invasive status in the UK, the Sunbleak is considered rare or vulnerable throughout much of its native range (Lelek 1987). It is also listed as protected under Appendix III of the Bern Convention.

Topmouth Gudgeon

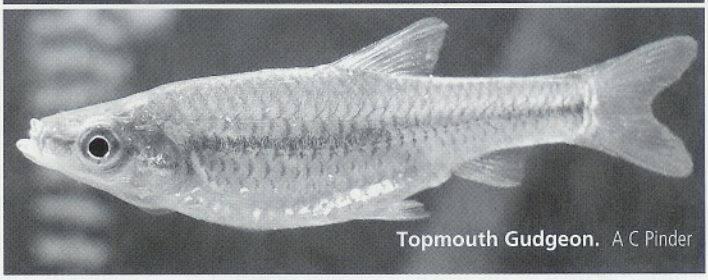
Rarely attaining 8cm in length or living for more than three years, Topmouth Gudgeon predominantly occupy the bentho-pelagic zone, where their diet consists of algae, benthic invertebrates, zooplankton, molluscs and also the eggs and larvae of other fish species (Xie *et al.* 2000). As opportunistic feeders, Topmouth Gudgeon will also take food from the water's surface, where feeding on terrestrial insects and other floating objects is accompanied by an audible clicking noise. This behaviour is responsible for these fish being referred to by some as 'clicker barbs'.

Topmouth Gudgeon have many life-history characteristics in common with Sunbleak. However, subtle differences are evident. In contrast to Sunbleak, male Topmouth Gudgeon are larger than the females and exhibit secondary sexual characteristics such as tubercles around the mouth, and the body coloration becomes much darker, particularly

on the fins. At this time, territories are established which are defended aggressively by the males. Spawning substrata have previously been reported to include the underside of rocks and broadleaved floating macrophytes. Our studies have shown that, like Sunbleak, Topmouth Gudgeon can successfully spawn on any flat-surfaced object, although they show a preference for structures with a cavity, which are easier to guard from other fish, including their own species.



Sunbleak. A C Pinder



Topmouth Gudgeon. A C Pinder

Preliminary investigations into the spawning behaviour, carried out by the authors, suggest that bigger males are most successful in defending territories from conspecifics and in attracting gravid females. This is in agreement with the findings of Katano & Maekawa (1997), who stated that females choose males with larger body size as their mates. Females will spawn with several different males in a day, depositing several batches of eggs in each territory.

The eggs of Topmouth Gudgeon superficially resemble those of the Sunbleak, but have a thicker chorion and are encased in a jelly-like substance which is highly adhesive. Eggs are released in smaller batches than those of Sunbleak, usually four to ten at a time. The male guards the eggs until they hatch. The incubation period of the eggs is approximately seven days at 20°C. Katano & Maekawa (1997) recorded mean fecundity as 1,049 eggs per female, with a maximum of 6,285.

Internationally, Topmouth Gudgeon are regarded as a highly invasive pest species.

Habitat

Sunbleak

During the first few weeks of development, Sunbleak are found in shallow marginal habitats where water temperatures are generally higher, supporting blooms of zooplankton and facilitating optimum growth conditions. As the larvae become more developed (around 40 days), these marginal habitats are abandoned in favour of deep water away from the banks. Here, they form shoals, swimming just below the water's surface.

Identification

Sunbleak

Olive-green back, silver sides and abdomen with iridescent blue sheen along flanks
Anal fin rays III/10-13
Distinctly short lateral line terminating before dorsal fin
Upturned mouth

Topmouth Gudgeon

34-38 lateral scales with dark edges
Dark band of lateral pigment (often absent in larger (>5cm) individuals)
Dorsal and anal fins strongly convex
Upturned mouth

In the winter the shoals disperse to deeper water. Sunbleak prefer slow-flowing rivers and associated backwaters, drains, canals and stillwaters, although fast-flowing rivers have previously been identified as conduits for dispersal.

Topmouth Gudgeon

During early development, Topmouth Gudgeon disperse from the nest site to the benthos, where they hide between and under stones. It is not until all the fins are completely formed that they can be found in the open water of shallow marginal habitats. Topmouth Gudgeon are not a closely shoaling species and spread themselves across a broad range of the habitat types available to them. They are less specific than Sunbleak in terms of habitat choice and can thrive in streams, rivers and stillwaters, although they are reported to favour shallow, still or slow-running waterbodies, preferentially with macrophyte beds (Adamek *et al.* 1996).

Distribution and current status in the UK

The original importation of both species is believed to have occurred during the mid-1980s through an ornamental-fish supplier near Romsey, in Hampshire. Figure 1 shows an up-to-date distribution map for both species and the only known site of introduction to the UK.

Figure 1 Present distribution of Sunbleak (black) and Topmouth Gudgeon (grey) in the UK. The arrow shows the location of the original importation of both species, although Sunbleak are no longer present at this site.

Sunbleak

Originating from continental Europe and Russia, Sunbleak are well distributed from the Caspian Sea to the North Sea and from the Volga to the Alps and Pyrenees. In England, initial dispersal from the original location in Hampshire is believed to have occurred via the River Test, which was used by the fish as a conduit to disperse and subsequently colonise Broadlands Lake farther down the Test floodplain. At this time, Broadlands supplied other fisheries with fry, for stocking purposes, and this is how the introduction to Stoneham Lakes, in the Itchen valley, occurred (Farr-Cox *et al.* 1996).

The origin of the Somerset population is unclear, but the first available record is from 1990, when Sunbleak first appeared in the Kings Sedgmoor Drain. From here they have spread rapidly, and are now extremely common throughout drains, rivers and connected waterbodies of the Somerset Levels. They are also present in several stillwaters in this area and at a complex of fishing lakes near Sherborne in Dorset. The mechanisms for dispersal to these stillwaters is unknown, but it is likely that the fish were introduced either unintentionally or intentionally by man.

Topmouth Gudgeon

Native to China, Korea, Japan and the River Amur basin, Topmouth Gudgeon were accidentally introduced into Romania in 1960, mixed with commercial carp species imported to an aquaculture facility bordering the lower River Danube. From here they quickly dispersed throughout the Danube system, and within three decades they could be found through much of Europe and Russia. Today, this species is distributed throughout Europe and is also present in North Africa. With this super-fast rate of invasion, it is perhaps not surprising that in 1996 Domaniewski & Wheeler reported the first record of Topmouth Gudgeon in England.

An investigation into the current status of Topmouth Gudgeon in the UK (Gozlan *et al.* 2002) revealed that the original introduction occurred at the same ornamental-fish farm facility in Hampshire as did that of Sunbleak. From this site the species is now present in Tadburn Lake, a tributary of the River Test and an ornamental pond in High Wycombe (as reported by Domaniewski & Wheeler 1996), and at stillwaters in Staffordshire. Since these records were published, other populations have now been reported at stillwaters in Cumbria and Cheshire (J Shelly pers. comm.) and in Epping Forest, north-east London (G Copp pers. comm.).

Dispersal

There are many potential modes of dispersal for both Sunbleak and Topmouth Gudgeon. The small adult size of both species means that they can easily escape from enclosed stillwaters and quickly colonise connected waterbodies. This is how Topmouth Gudgeon have come to be resident in Tadburn Lake, which drains the original introduction site and joins the River Test approximately 4km downstream. The use of a wide range of spawning substrata also means that eggs can be laid on floating macrophytes. The authors have observed lily leaves covered in Sunbleak eggs floating over the outflow of Stoneham Lakes, in Hampshire, into the River Itchen catchment. The possibility of spawning on the flat surface of boats or trailing plastic fenders, as discussed by Gozlan *et al.* (2003a), also enables both species to disperse quickly between catchments via canal networks. Reports of Sunbleak spawning on angling paraphernalia could again result in translocation

between catchments, if more than one venue was visited on the same day by an angler. Laboratory experiments have shown that Sunbleak eggs in particular exhibit a degree of tolerance of dehydration. With the difficulties associated with distinguishing the early life stages of both species from those of native cyprinids (Pinder 2001), the unintentional transfer along with native species is a real concern.

In the case of Sunbleak, further dispersal from the current range is restricted by the absence of connecting waterbodies from the Somerset Levels system and the Rivers Test and Itchen. Further dispersal is, however, likely, either accidentally with transfers of other species or through intentional release into the wild by aquarists. If Sunbleak were to be introduced to the Bristol Avon, which borders the Somerset Levels, this would open up connections to the UK canal network, allowing access to some of the large lowland rivers, such as the Thames and Great Ouse, and the fenland drains of East Anglia, which support many miles of ideal habitat for this species.

The geographical distance between populations of Topmouth Gudgeon in Britain suggests that dispersal has occurred almost exclusively by anthropogenic means. Excluding the population in Tadburn Lake, which escaped from the original stock near Romsey, all other populations appear to be landlocked with no obvious connections to other waterbodies. On the other hand, if presently unrecognised invasions of the canal/river network have already taken place or occur in the future, we predict that the invasive capabilities that this species has already demonstrated across Europe will result in Topmouth Gudgeon becoming widespread and very abundant throughout Britain.

Threats to native fishes

Various threats have been highlighted regarding the introduction of these two species. However, no attempts have yet been made to quantify these risks. Because of the very fast reproduction rate of both species, population size can explode quickly and both have the potential to become numerically dominant over the native species after only one year of introduction.

Various authors have highlighted dietary overlap between both species and native cyprinids. However, only anecdotal evidence exists to

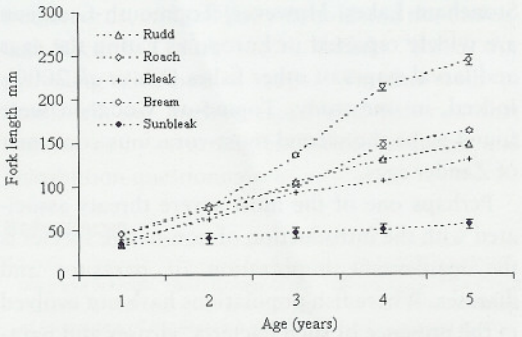


Figure 2 Growth in fork length (mm) and standard deviation of Sunbleak from Stoneham Lakes, Hampshire, compared with UK growth of Bream, Roach, Bleak and Rudd. From Gozlan *et al.* (2003a)

suggest that this aspect of competition has a significant effect on the recruitment of native species.

Because of the small size of the species, it is not just the young of the year that are competing for the same food items as native juveniles. Gozlan *et al.* (2003a) demonstrated how the slow growth of Sunbleak could result in four year-classes of this species competing for the same food as young-of-the-year Roach *Rutilus rutilus*, Bream *Abramis brama*, Rudd *Scardinius erythrophthalmus* and Bleak, during a period in their life history when they are at their most vulnerable (Fig. 2).

Another known risk associated with the introduction of alien species, is direct predation on native species. The introduction of Zander to the Great Ouse Relief Channel in 1963 (Wheeler & Maitland 1973) and the subsequent spread of this species are widely blamed for a decline in the value of invaded fisheries (Smith & Briggs 1999). Crivelli (1995) reported the consequences of the introduction of Zander to Lake Egridir, in south-west Anatolia, as being rapid and irreversible, resulting in the total extinction of several species endemic to this system.

Although Sunbleak and Topmouth Gudgeon may be considered beneficial in terms of providing forage species for predatory fishes, they also have the potential to prey directly on the larval stages of our native stocks, including large predatory species such as Perch *Perca fluviatilis*, Zander and Pike *Esox lucius*, during their early stages of development, and thus have a negative effect on the recruitment of these species.

Preliminary investigations by Gozlan *et al.* (2003a) found no evidence of piscivory when examining the stomach contents of Sunbleak from

Stoneham Lakes. However, Topmouth Gudgeon are widely reported in Europe as eating the eggs and larval stages of other fishes (Xie *et al.* 2000). Indeed, in one study, Topmouth Gudgeon were found to be the second most voracious consumer of Zander eggs.

Perhaps one of the most severe threats associated with the introduction of non-native species is the inadvertent importation of parasites and diseases. Where fish populations have not evolved in the presence of such bacteria, viruses and parasites, immune systems are too poorly developed to respond to these new threats and leave the native stock vulnerable to infection or infestation.

To date, there have been no reports of Sunbleak or Topmouth Gudgeon carrying any pathogens novel to the British Isles. In Europe, however, Topmouth Gudgeon are reported to act as a vector for the parasites *Anguillicola crassus* and *Clinostomum complanatum* and also as a carrier of Pike fry rhabdovirus (PFR).

Current legislation

As a precautionary approach to control the import and future spread of non-native fishes in England and Wales, DEFRA has introduced a licensing system for the import and keeping of live fish species considered to be undesirable additions to our native fish fauna.

The Prohibition of Keeping or Release of Live Fish (Specified Species) Order 1998 made under the Import of Live Fish (England and Wales) Act 1980 includes both Topmouth Gudgeon and Sunbleak. This legislation requires any individual wishing to keep any listed species as pets (in either aquarium or garden pond), or angling clubs wishing to stock a listed species, first to obtain a licence under the Act. Full details of the Act, including listed species and application procedures, can be obtained from DEFRA or at the website www.efishbusiness.co.uk.

Conclusion

It must be considered that any species has the potential to establish populations in the wild providing that there is suitable habitat available. However, if an introduced species can exploit an empty ecological niche, this greatly enhances its chances of success within the new ecosystem (Leveque 2000).

Both Sunbleak and Topmouth Gudgeon possess many attributes which have enabled them to establish large populations around the country. Many of these attributes have previously been hypothesised by several authors as important factors in determining the success of invasive aquatic species, and are summarised in Table 1.

Table 1 Some hypothesised general attributes of invasive aquatic species. From Ricardi & Rasmussen (1998).

1	Abundant and widely distributed in original range
2	Wide environmental tolerance
3	High genetic variability
4	Short generation time
5	Rapid growth
6	Early sexual maturity
7	High reproductive capacity
8	Broad diet (opportunistic feeding)
9	Gregariousness
10	Possessing natural mechanisms of rapid dispersal
11	Commensal with human activity (e.g. transport in ship ballast water, trade of ornamental species for aquarists)

Globally and, in particular, in the Great Lakes system of North America, the ballast water of ships has been identified as responsible for the vast majority of aquatic introductions. Transport of species from the inland freshwaters of the Caspian Sea is a particular problem. In Britain, the threat of invasion via this activity is greatly reduced as docking of international trading craft is restricted to coastal and estuarine waters, thus preventing access to suitable conditions for freshwater species. In Britain, the aquarist trade poses the biggest threat to freshwater aquatic biodiversity. In this country, fish are the third most popular pets after cats and dogs, and it has been estimated that 3.5 million households (about 13%) own ornamental fish (Elvira 2000). Indeed, both Sunbleak and Topmouth Gudgeon are reported to have been sold via the ornamental-fish trade through garden centres (Farr-Cox *et al.* 1996) and pet shops.

Presently, little is known about the consequences of such invasions and the potential impacts on the native ecosystem. To assess whether the presence of Sunbleak and Topmouth Gudgeon is a real threat to our native aquatic fauna, future research needs to address the following:

- do dietary overlaps exist between these species and natives?
- do the new species prey directly on the eggs and

larvae of native species?
- do the new species compete for habitat and space with the native species?
- how does the recruitment success of the new species compare with that of natives?
- does the presence of Topmouth Gudgeon or Sunbleak have a negative or positive effect on the recruitment, growth and population health of natives?

In the case of Sunbleak, since this species is established throughout the connected waterbodies of the Somerset Levels, it is undoubtedly here to stay, as any attempt to control or eliminate it would be futile. The fact that Topmouth Gudgeon are currently believed to be restricted to enclosed stillwaters allows some scope for the control or total eradication of this species. If unintentional or intentional introductions of either species should occur within the interconnected canal/river network of Britain, however, we predict that, because of their unusual life-history strategies and broad range of environmental tolerance limits, they will become widespread and very abundant within the right habitats.

If the British populations of these alien species are found to prey opportunistically on the eggs and larvae of other species, then their spread to natural lakes such as Windermere, in the Lake District, could prove devastating to the already endangered populations of native whitefish in that region.

The driving motive behind the production of this article has been to raise awareness of these species, with a view to gaining a better picture of the true distribution of these two new additions to the aquatic fauna of Britain.

Any reports of the further spread of either species, or the occurrence of any unidentified fishes from British fresh waters, would be welcomed by Adrian Pinder at the Centre for Ecology and Hydrology, Winfrith Technology Centre, Winfrith Newburgh, Dorchester, Dorset DT2 8ZD (e-mail: acp@ceh.ac.uk).

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