Crucian Carp (Carassius carassius L.)

Distribution

This fish can be found in west, central and eastern Europe as well as much of Asia. It is native to south-eastern England, but now exists, albeit in only a few places, in the north and the west of England. It favours rich lowland ponds, where there is abundant macrophyte growth, usually inhabiting the littoral zone (Holopainen et al. 1988). Occasionally it can be found in slow flowing rivers and canals. It requires water above 20 C to reproduce successfully. It is tolerant of low dissolved oxygen levels and can survive several months in anoxic water at low temperatures via anaerobic metabolism.

Life history

Maturity is reached in 3-4 years and crucian carp may live typically up to 10. It is doubtful that this species recruits on a regular basis in this country.

Feeding

Feeding is omnivorous and plastic with respect to lake conditions. Food eaten includes benthic invertebrates, Cladocera, macrophytes, algae and detritus.

Penttinen and Holopainen (1992) investigated seasonal feeding activity and ontogenetic dietary shifts in crucian carp in a small (1.5ha), shallow (maximum depth 1.6m) forest lake in Finland. From gut analyses they could distinguish five size-classes of crucian carp. Fish <3 cm ate mainly planktonic Cladocera, especially *Bosmina longispina* and *B. longirostris*, but also included benthic Cladocera and chironomids. Rotifers, which were numerically dominant in the pond, were not eaten. Fish 3.5-6.0 cm ate mainly chironomid larvae, especially Orthocladiinae and Chironominae, but also benthic Cladocera (mainly *Chydorus sphaericus*). The diet of 6.0-10.0 cm fish was similar to that of 3.5-6.0 cm fish, except that benthic Cladocera were replaced by planktonic forms like *Bosmina longispina*. Fish >10.0 cm ate chironomid larvae or planktonic crustaceans, but not benthic Crustacea. Crucian carp >13 cm ate mainly chironomid larvae and Odonata. Seasonal changes were apparent and reflected changes in prey availability.

Interactions

In ponds that are subject to annual winter anoxia, monospecific populations may occur and are characterised by high densities (>29 000 ha^{-1}) with individuals growing slowly and being short-lived (Holopainen et al 1988). Crucian carp can exist in polyspecific communities, but at lower densities (1-25 ha^{-1}) and individuals may reach large sizes (20-40 cm).

Angling methods and induced effects

Few anglers specifically fish for crucian carp, though most enjoy catching them along with other species.

Implications for water chemistry

Holopainen et al. (1992) examined the effects of crucian carp on lower trophic levels using a small (1.5ha), shallow (maximum depth 1.6m) forest lake divided into four and stocked at low (4.4-5.5 g m^{-2}) and high (10.4-13.7 g m^{-2}) density. No other fish spieces were present. Trappings showed that most (74-88%) of the fish remained within 5m of the bank. In the high fish density, turbidity was greater due to resuspension of the sediment and increased algal abundance, probably linked to an increase in nutrients via defecation. Fish effects were reduced in parts of the sections which had dense macrophyte cover.

Implications for zooplankton

Crucian carp have the potential to consume large herbivorous zooplankton. Because crucian carp are littoral dwellers and adept at feeding in structurally complex areas, macrophyte refuges may not safeguard zooplankton from predation.

Implications for phytoplankton

Crucian carp may increase standing crop of phytoplankton by decreasing grazing by zooplankton and increasing nutrient availability.

Implications for macrophytes

Crucian carp do not grow to a large size and although they may physically disrupt macrophytes, the impact will be reduced by the low numbers and small size of fish.

Dace (Leuciscus leuciscus L.)

Distribution

Dace are typically riverine fish and can be found across much of Europe and Asia. Being a fish favoured as bait to catch predators such as pike, they are often released if unused at the end of fishing. This has resulted in dace being distributed to many parts of the British Isles from its native south east, though it is absent from middle to northern Scotland. Dace can usually be found in the middle reaches of clean, fast flowing rivers and streams. They can also be found in some stillwaters.

Life history

Breeding takes place from February to April and the eggs are laid on shallows below stretches of riffle. Dace mature in their second to fourth year and can live for up to 7 or 8.

Feeding

The young feed on plankton and as they grow, larger food items can be taken from the benthos or from the surface of the water.

Angling methods and induced effects

Stillwater dace populations rarely reach large numbers and it is unlikely that anglers would specifically set out to catch this species in lakes.

Implications for water chemistry

Dace, at low densities, would probably have little direct effect on water chemistry.

Implications for zooplankton

Dace may eat zooplankton, but there has been little work done on stillwater populations.

Implications for phytoplankton

Dace will exert little direct effect on phyoptoplankton.

Implications for macrophytes

Dace would probably have little effect on macrophytes.

Eel (Anguilla anguilla L.)

Distribution

Eels reproduce in the Sargasso Sea and the young migrate to freshwater habitats. Young elver eels arrive in the British Isles between January and June. Males do not penetrate far into the freshwater system, whilst females tend to travel the furthest and move into standing water. They may travel across land to gain access to small water bodies.

Life history

Eels make spawning migrations when they reach about 9-19 years old, though this may be delayed if conditions for growth are poor. Females grow more quickly than males and are typically about 46 cm long at the time of migration compared with males which are 36 cm .

Feeding

Lammens et al. (1985) in a three year study of Tjeukmeer, a large shallow eutrophic lake, found small eels (<30cm) to eat more chironomids (especially Chironomus plumosus) and gammarids than large eels, which ate mainly fish and Mollusca. Eels were observed to feed by swimming slowly, with their heads touching the bottom, but moving laterally. De Nie (1987) examined 1806 eel guts from Tjeukemeer and found that small eels (<250mm) fed mainly on the pupae of chironomids such as Chironomus plumosus and Einfeldia carbonaria, whilst those >250mm fed on underyearling smelt (Osmerus eperlanus), underyearling perch and bivalve molluscs. The >250mm eels became piscivorous when underyearling fish were available, selectively eating the smaller individuals. Mann and Blackburn (1991) investigated the interaction of eels with trout and salmon in a chalk stream and found that eels <400mm ate chiefly Ephemeroptera nymphs, Trichoptera larvae, Chironomidae, Simulium larvae, Gammarus and Asellus. Eels >400mm ate mostly Diptera larvae, Gammarus, Asellus, crayfish and fish, the principal species being the bullhead, Cottus gobio. It was concluded that eels were largely benthic foragers, whilst the salmonids fed mainly on midwater and surface prey.

Interactions

Eels are size selective piscivores favoring small (underyearling) fish. This could reduce the abundance of zooplanktivorous young fish and could have an impact on the presence of zooplankton and hence phytoplankton.

Angling methods and induced effects

Eels are fished for commercially and also by anglers. Commercial fisherman use passive nets into which the eels swim and become entrapped. Anglers use rod and line methods with either worm or fish as bait. Little in the way of bait addition is used.

Implications for water chemistry

The feeding manner suggests that eels will disturb little sediment and hence have little effect on turbidity or internal nutrient loading.

Implications for zooplankton

Eels do not appear to eat zooplankton, though they may suppress zooplanktivore abundance.

Implications for phytoplankton

Eels may indirectly increase grazing on phytoplankton by reducing zooplanktivore abundance.

Implications for macrophytes

If present in large numbers, eels potentially could reduce zooplanktivore abundance and improve the underwater light climate.

Roach (Rutilus rutilus L.)

Distribution

Roach can be found in much of Europe and Asia. In the British Isles, it is common in all areas apart from north and north-west Scotland. Roach are tolerant of temperatures up to 38 C and are able to live in waters with dissolved oxygen above 5 mg l^{-1}.

Life history

Males mature in their second or third years, whilst females do so in their third or fourth. Roach often live for 10-12 years. Spawning takes place when the water temperature is above 12 C, usually between April and June. Eggs are laid and fertilised in weedbeds, though other structures may be suitable. Recruitment is usually variable and dependent on temperature.

Feeding

The young are planktivorous and become omnivorous with age. Neiderholzer and Hofer (1980) studied the importance of season and temperature on feeding and found them to be omnivorous throughout the year. Roach forage inefficiently upon sediment-dwelling prey (e.g. chironomids (Winfield et al.1992)) and selectively eat large visible food particles (Lammens et al. 1987). Schiemer and Wieser (1992) and Uiblein (1992) describe how roach rely almost exclusively on directed search methods, even in low visibility, and can show a large degree of selectivity. Roach in eutrophic waters, lacking other, superior zooplanktivores, may become pelagic feeders. Perrow and Irvine (1992) showed that roach fed selectively on both the larger cladoceran species and also on the largest individuals from each species.

Feeding mode may show daily changes, as demonstrated by Braband et al. (1990) who investigated the roach of Lake Gjersjoen (area 270ha, average depth 23m) and found roach to perform horizontal migrations between the littoral and the pelagial. Whilst in the littoral, roach fed on sediment, detritus and zoobenthos but at night fed on zooplankton in the pelagial.

Persson (1983b) found that roach from a shallow eutrophic lake may consume detritus, algae (including the blue-green genera Microcystis and Oscillatoria), Cladocera (Daphnia cucullata and Bosmina longirostris), Copepoda, flying insects, chironomid larvae and pupae, Chaoborus, Rotifera (Keratella cochlearis), as well as

Trichoptera larvae and gastropods. Seasonal differences were also apparent, with cyclopoid copepods being consumed more in the spring and early summer, with the cladocerans being eaten in autumn. If macrophytes or filamentous algae e.g. Spirogyra are abundant, they may form a large part of the diet (Giles et al., 1990)

Interactions

Roach are plastic in both their mode of feeding and habitat selection, showing both zooplanktivory and benthivory.

Angling methods and induced effects

Anglers fishing for roach usually rely on small amounts of bait such as maggots, bread and hemp. The pupae of maggots, 'casters', are often used. The low amount of bait needed will have little effect on the ecosystem.

Implications for Water quality

Whilst roach may penetrate the sediment, it is doubtful that significant levels of turbidity or internal loading are generated. However,Horppila and Kairesalo (1992), using enclosures, suggested that roach excreta may affect water quality. Such temporal and spatial production of high nutrient patches could greatly increase local nutrient availability for phytoplankton.

Implications for zooplankton

Roach can feed efficiently on zooplankton and have the potential to affect zooplankton community composition. Roach are not able to feed on zooplankton in structurally complex environments such as weedbeds and these may offer zooplankton a refuge from predation by roach (Diehl 1988).

Implications for phytoplankton

Roach commonly occur in large numbers and can reduce zooplankton abundance and locally increase nutrients, especially P. These effects could have a positive impact on phytoplankton standing crop. Roach can consume blue-green algae (Persson, 1983b) and may directly reduce abundance of these genera though evidence of this yet comes from few sources.

Implications for macrophytes

Roach do eat macrophytes, but it is not known if it is only dead plants or whether living sections are taken (Neiderholzer and Hofer 1980).

Rudd (Scardinius erythrophthalmus L.)

Distribution

Rudd are common in much of Europe and can be found in Ireland, parts of England as well as the Channel Islands and some places in Wales. They are largely absent from Scotland, though a few breeding populations are known.

Life history

Breeding takes place in late May or early June when the water temperature rises above 15 C and generally occurs over weed beds. It may hybridise with other cyprinids. Maturity is usually reached in their third year and some fish can live for up to 17 years.

Feeding

Rudd are generally planktivorous when larval, adopting a largely benthic feeding strategy as they grow, though prey items may be taken from the surface. Rudd were inferior to roach at feeding on open water zooplankton, but superior in habitats of medium complexity (ca. 500 stems m^{-2}, Johanson1987). Rudd could only compete with roach if there was a large littoral zone or there was much surface food (Neiderholzer and Hofer 1980).

Interactions

There is no specific information.

Angling methods and induced effects

Anglers usually do not fish specifically for rudd and catch them alongisde other species such as roach.

Implications for water chemistry

Rudd will probably have little direct effect on water chemistry.

Implications for zooplankton

Zooplankton may be eaten by rudd even in structurally complex places such as weed beds. The value of macrophyte beds as zooplankton refuges may be reduced if the density of rudd is high.

Implications for phytoplankton

Rudd have little direct effect on phytoplankton.

Implications for macrophytes

Rudd, if present in very large numbers may promote dominance by phytoplankton through predation on zooplankton.

Perch (Perca fluviatilis L.)

Distribution

Perch are found in lakes and slow-flowing rivers throughout Europe. They are widespread throughout the British Isles, but are absent from the north and north west of Scotland. Kitchell et al. (1977) described the optimum habitat for perch as being shallow to moderately deep, having an extensive littoral and shoreline area with an abundance of sand, gravel and macrophytes.

Life history

Perch spawn from mid-March to June, when the water temperature is between 10 and 15 C. The eggs are laid in ribbons on submerged macrophyte stands (Treasurer 1988). Males become mature sometimes in their second year whilst females take one to two years longer. Perch can live up to 10-13 years. Koone et al. (1977), in a review of factors affecting year-class-strength of perch, found temperature to be important with cold summers producing a weak year-class and warm summers producing strong ones.

Feeding

Initially, the young are planktonic and feed in large shoals. Guma'a (1978) investigated the food of underyearling perch and found that as they grew they ate different items - ciliates, algae and diatoms, rotifers, cyclopoid nauplii and copepods, Bosmina obstusirostris, Daphnia hyalina, Diaptomus gracilis, chironomid larvae, imagos and pupae, Polyphemus pediculus, Bythotrephes longimanus, Caenis and Ephemeroptera nymphs, Crangonyx pseudogracilis and fish larvae. This trend was attributed to gape limitation, which ontogenetically altered, thus increasing the range of available prey items. Furnass (1979) showed that perch select prey on sight and not on taste or smell or by detection of-prey induced water movement.

Once their fins are developed, perch move inshore, adopting a littoral residence, and feed on benthic macroinvertebrates such as chironomid larvae and pupae, Corixids, Sialis and Asellus (Giles et al., 1990; Bergman, 1991). Perch are very adept at removing prey from complex habitats (Winfield 1986), though foraging ability is affected by low light levels (Diehl 1988). Perch may penetrate the hypolimnion at times (Persson 1986), returning to the littoral or sublittoral at night (Kitchell et al. 1977). In mesotrophic lakes, adult perch can feed on large zooplankton and maintain high growth rates according to Thorpe (1977). If the lake is eutrophic and the cyprinid biomass is high, then severe competition for zooplankton can force juvenile perch to feed on benthic macroinvertebrates at an early age, and this increases intraspecific competition between small perch, as they can feed only inefficiently on benthic invertebrates at this size (Persson 1983a; Persson and Greenburg 1990b; Bergman 1990).

With age and depending on conditions such as prey availability, perch may become piscivorous (Eklov 1992).

Interactions

Large perch may be piscivorous and feed on young zooplanktivorous fish, but this stage is usually reached only in clear waters (Bergman 1991). In turbid waters, if present at all, perch are only small in size, but may be numerous (Bergman 1991; Persson1987a). Roach are superior zooplanktivores and force perch to become benthivorous at an early age and a small size. Benthic feeding efficiency is related to predator size and ability to detect prey and the small visually-hunting perch are not able to fully utilise littoral food sources (Persson 1983a; Persson and Greenburg 1990b) and hence never grow large enough to become piscivorous.

Angling methods and induced effects

Anglers fish for perch using maggots, worms or dead fish. There is little prebaiting involved.

Implications for water chemistry

Perch do not disturb the sediment whilst feeding and will not directly affect turbidity or nutrient release, except through excreta production.

Implications for zooplankton

Depending on the environmental conditions, perch may consume zooplankton whilst they are larvae, juveniles and adults. Perch are visual feeders and may select zooplankton by visual cues and can feed on both cladocerans and copepods. The potential for an impact on zooplankton will be large. Treasurer (1992) examined food consumption of larval perch in two Scottish lochs (shallow kettle holes, average depth 1.2-1.5m) and predation by 0+ perch on zooplankton was much greater than that by the adults. Structural refuges (eg 600-900 stems m^{-2}) may not be effective at protecting zooplankton from predation by perch (Diehl 1988) although normal densities of nymphaeids act efficiently as refuges for Daphnia against perch predation (B. Moss and R. Kornijow, unpublished data). Perch may also forage in the hypolimnion, thus denying zooplankton a deep water refuge.

Implications for phytoplankton

Perch may alter the abundance of herbivorous zooplankton and release P rich excreta.

Implications for macrophytes

Perch have no direct action on macrophytes.

Pike (Esox lucius L.)

Distribution

Pike are widely distributed throughout much of Europe, Asia and North America. They can be found in most of the British Isles except northern Scotland and generally occur in lakes but also in rivers. Pike can tolerate low oxygen conditions, down to 5.7mg l^{-1}. Its upper thermal limit is 29 C, with an optimal range being 19-21 C. (Diana 1983).

Life history

Pike spawn from February to May, when the water temperature rises from 4 to 11 C. Pike lay eggs on submerged macrophytes (Frost and Kipling 1967). Pike mature in their second to fourth year of life and may live for up to 15 (Wolfert and Miller 1978).

Feeding

The pike is long and thin and its large gaped mouth, broad snout, sharp teeth and heavy jaws make it ideal for consuming vertebrate prey. Its digestive tract is short, the stomach well defined and capable of producing digestive enzymes. It can act as a top predator in temperate waterbodies.

Pike tend to inhabit the shallow parts of lakes (Diana et al.,1977; Chapman and Mackay 1984) and adopt a solitary and sedentary way of life (Diana 1980; Nursall 1973), concealing themselves or being motionless until prey is within striking distance (Eklov 1992) or stalking it stealthily until it is in striking distance (Savino and Stein 1989 a&b). Pike may have prefered prey species (Coble 1973), but choice can be affected by availability (Baylerle and Williams 1968; Mann 1982) and vulnerability of prey species (Hart and Hamrin 1988). Pike will feed at low temperatures, often hardly above freezing, and can show growth during winter (Diana 1983).

Where the food of pike is low, they can eat either invertebrates (Chapman et al. 1989) or become cannibalistic. A low density of large pike can survive feeding on a high density of small pike, with the small pike feeding on invertebrates. Large pike may also eat any animal that is not too large to swallow and this can include ducklings, voles, frogs, newts etc (Solman 1945). Vollestad et al. (1986) studied habitat use, growth and feeding in four lakes of differing size and productivity in Norway. Pike were found to inhabit both the littoral and pelagial. With increasing turbidity, pike were found more in the pelagial, possibly indicating that pike may profit from an active hunting strategy if macrophyte-rich ambush sites are lacking. Slow growth of pike was attributed to a higher cost of searching in turbid water and low availability of large prey fish.

Grimm (1989) considered pike as a desired sport fish, threatened by eutrophication and the presence of carp and bream. He states that when vegetation is sparse, it tends to be occupied by large pike and so not available as a nursery ground for 0+ pike. In lakes with a reduced littoral zone, low fish stocks and an already established pike population, cannibalism will be prevalent and older pike can have an impact on pike recruitment (Mann 1982).

Interactions

He and Wright (1992) observed the impact of introducing pike into Bolger Bog, a small (1ha), shallow lake in Michigan, USA. They found that some fish species decreased, others increased and some showed no change. These corresponded to fish either being eaten by the pike, relieved of interspecific competition or those regulated by other factors. In clear waters, pike have the potential to reduce zooplanktivore abundance, but this will be reduced in a structurally simple and turbid environment.

Angling methods and induced effects

Pike anglers use dead fish or artificial lures to catch pike. No prebaiting is used.

Implications for water chemistry

Pike occur in low absolute numbers and generally do not disturb the sediment whilst feeding. They should thus have little direct effect on water chemistry.

Implications for zooplankton

Whilst underyearling pike are zooplanktivorous in the first few weeks of life, the total impact of pike on zooplankton will be low. Indirect impacts of pike,reducing zooplanktivore abundance, may lead to a reduction of selective predation on large zooplankton by fish.

Implications for phytoplankton

Phytoplankton are not directly affected by pike although food web effects may be important.

Implications for macrophytes

Pike may buffer macrophyte dominance by reducing zooplanktivore abundance.

Tench (Tinca tinca L.)

Distribution

Tench are widely found throughout Europe except the north. In the British Isles, it has been widely distributed and occurs in most of lowland England, Wales and Ireland. In Scotland, it is found in a few nutrient-rich lochs and in a few ponds. This fish generally occurs where there is plenty of weed cover and a muddy bottom. It is tolerant of stagnant water and low dissolved oxygen conditions (e.g. survival down to 0.7 mg l^{-1}) and can tolerate temperatures up to 35 C (Weatherley 1959), depending on acclimatization, as well as high concentrations of dissolved CO_2 (eg 33 ppm over 24 hours).

Life history

Tench mature at about 25-35cm and spawning takes place in weeded areas between late June and August (i.e. water temperature approaching 20 C, minimum 18 C). Succesful spawning is irregular due to a high temperature requirement. Most fish live for 6-8 years, though 10-15 is quite common.

Feeding

Feeding is initially on protozoans, rotifers and small crustaceans. As they grow, the tench depend more on benthic prey items such as worms, crustaceans, Mollusca and chironomid larvae. To do this, tench feed in a near vertical mode and are reputed to be able to penetrate up to 7cm of mud. O'Maoileidigh and Bracken (1989) state that tench move around slowly in shoals inhabiting the weed beds associated with sheltered limnetic zones. They examined gut contents of 62 tench and found (in decreasing numbers): Cladocera (Eurycercus lamellatus, Daphnia longispina and Bosmina spp.), Ostracoda, Hydracarina, Copepoda, Mollusca (Potamopyrgus jenkinsi and Valvata cristata), chironomid larvae and also in low numbers, Asellus, Gammarus, ceratopogonid larvae, dipteran larvae and adults, trichopteran larvae and coleopteran larvae. Giles et al., (1990) found that tench living in two gravel pits had different diets. Tench in the macrophyte-devoid Main Lake, fed largely on Daphnia hyalina. This population of tench was low (ca 0.5 kg ha^{-1}) when compared with the macrophyte-rich St Peters Lake (ca 59 kg ha^{-1}), where the diet consisted of a variety of benthic macroinvertebrates such as Sialis, Sphaerium, amphipods, Asellus aquaticus and Trichopteran larvae. Petridis (1990) evaluated the influence of grass carp on habitat structure and its subsequent effect on the diet of tench in a weedy section of the Lancaster canal. Tench ate Cladocera (Eurycercus lamellatus), Asellus aquaticus, chironomid larvae, Mollusca, Chaoborus and Sialis lutaris along with detritus. Tench were observed to search for food in the open water, blowing up the upper sediment layer and seeking prey items in the created cloud of mud. Tench were not seen to search for food far into the vegetation and this was reflected in their diet. In a cage experiment in a eutrophic pond in Sweden the density of tench was manipulated and the effects on lower trophic levels were studied. Predation by tench dramatically reduced snail abundance (Bronmark and Weisner 1992), which has implications for epiphyte grazing.

Interactions

There is no additional information

Angling methods and induced effects

Anglers fishing for tench are likely to use a lot of particle bait such as maggots, casters, sweetcorn and cereal-based groundbait.

Implications for water chemistry

Tench disturb the benthos and there is the potential to release nutrients and increase turbidity.

Implications for zooplankton

Zooplankton may be eaten, though this probably only occurs in macrophyte-devoid waterbodies.

Implications for phytoplankton

Tench probably have little direct effect on phytoplankton.

Implications for macrophytes

Tench do not feed in weed beds and do not uproot plants. They do, however, consume epiphytivorous molluscs, which may ultimately affect the interaction between macrophytes and phytoplankton.

Brown Trout (Salmo Trutta L.)

The brown trout is native to Europe and naturally colonised post-glacial Britain. Brown trout are usually riverine fish, though they seem to manage quite well in still waters. Spawning takes place from mid October to mid December and usually requires a clean deep gravel, over which flows oligotrophic water, though spawning may be successful in large lakes possessing a gravelly littoral zone. Trout usually consume benthic or mid-water invertebrates along with fish, newts, and crayfish. In lakes, trout patrol territories in search of food, relying largely on visual prey detection, though they can use their sense of smell or detect movement.

Rainbow Trout (Oncorhynchus mykiss Walbaum 1972)

This trout is native to the coast of North America and has been stocked in many ponds. There are few breeding populations in this country. They grow more rapidly than brown trout and can tolerate higher temperatures. Rainbow trout feed in a similar way to brown trout, though the former may be more active during the winter.

Taken together, trout do not impact directly on zooplankton or macrophytes and providing stocking levels are not excessive, will not be a threat to macrophyte abundance.