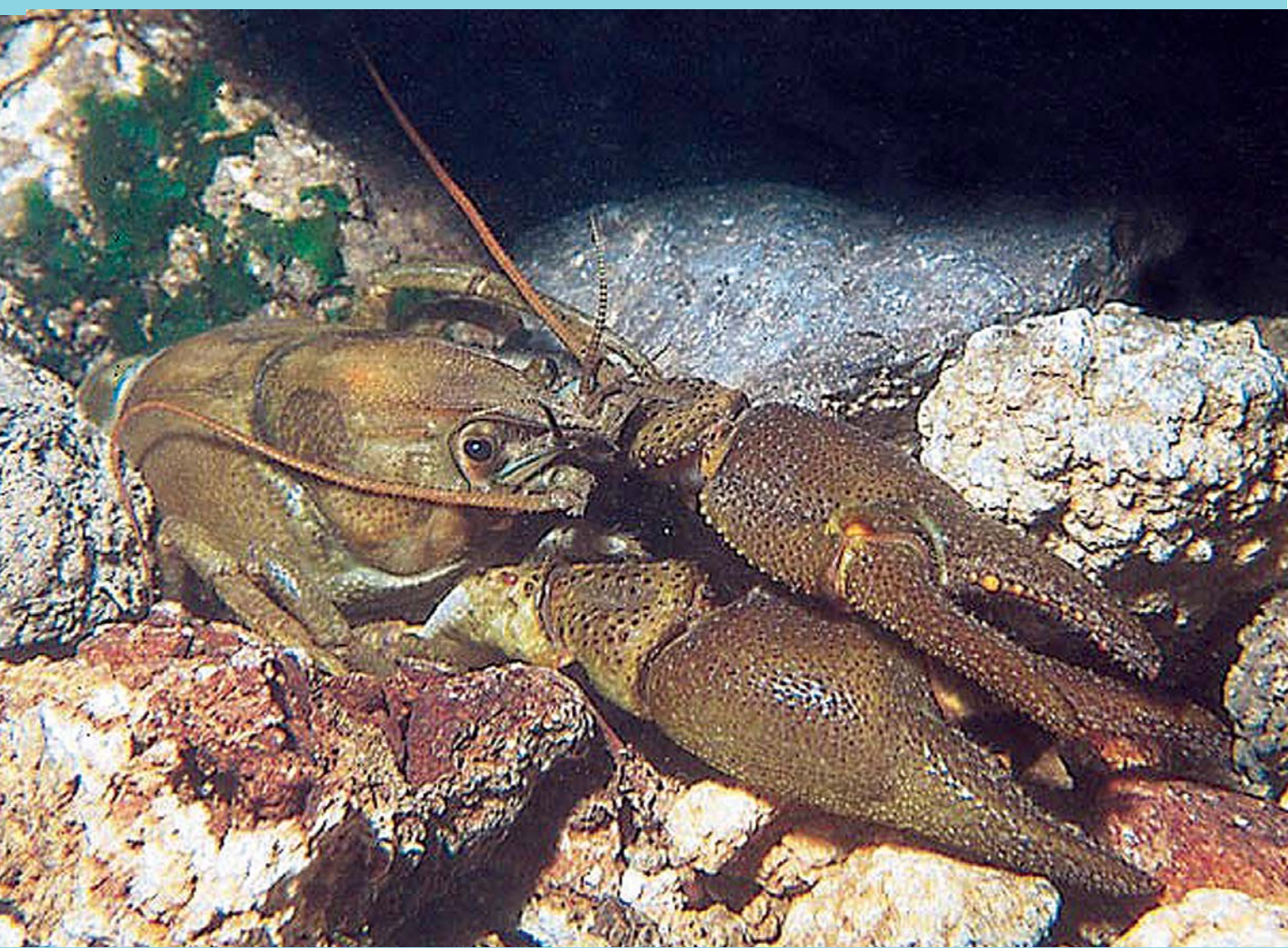
Ecology of the White-clawed Crayfish

Austropotamobius pallipes



Conserving Natura 2000 Rivers

Ecology Series No. 1

Ecology of the White-clawed Crayfish

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Cover: Adult white-clawed crayfish. Photo by Paul Glendell/English Nature

Conserving Natura 2000 Rivers

This account of the ecology of the white-clawed crayfish (*Austropotamobius pallipes*) has been produced as part of **Life in UK Rivers** – a project to develop methods for conserving the wildlife and habitats of rivers within the Natura 2000 network of protected European sites. The project's focus has been the conservation of rivers identified as Special Areas of Conservation (SACs) and of relevant habitats and species listed in annexes I and II of the European Union Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora (92/43/EEC) (the Habitats Directive).

One of the main products is a set of reports collating the best available information on the ecological requirements of each species and habitat, while a complementary series contains advice on monitoring and assessment techniques. Each report has been compiled by ecologists who are studying these species and habitats in the UK, and has been subject to peer review, including scrutiny by a Technical Advisory Group established by the project partners. In the case of the monitoring techniques, further refinement has been accomplished by field-testing and by workshops involving experts and conservation practitioners.

Life in UK Rivers is very much a demonstration project, and although the reports have no official status in the implementation of the directive, they are intended as a helpful source of information for organisations trying to set 'conservation objectives' and to monitor for 'favourable conservation status' for these habitats and species. They can also be used to help assess plans and projects affecting Natura 2000 sites, as required by Article 6.3 of the directive.

As part of the project, conservation strategies have been produced for seven different SAC rivers in the UK. In these, you can see how the statutory conservation and environment agencies have developed objectives for the conservation of the habitats and species, and drawn up action plans with their local partners for achieving favourable conservation status.

Understanding the ecological requirements of river plants and animals is a prerequisite for setting conservation objectives, and for generating conservation strategies for SAC rivers under Article 6.1 of the Habitats Directive. Thus, the questions these ecology reports try to answer include:

- What water quality does the species need to survive and reproduce successfully?
- Are there other physical conditions, such as substrate or flow, that favour these species or cause them to decline?
- What is the extent of interdependence with other species for food or breeding success?

For each of the 13 riverine species and for the *Ranunculus* habitat, the project has also published tables setting out what can be considered as 'favourable condition' for attributes such as water quality and nutrient levels, flow conditions, river channel and riparian habitat, substrate, access for migratory fish, and level of disturbance. 'Favourable condition' is taken to be the status required of Annex I habitats and Annex II species on each Natura 2000 site to contribute adequately to 'favourable conservation status' across their natural range.

Titles in the Conserving Natura 2000 Rivers ecology and monitoring series are listed inside the back cover of this report, and copies of these, together with other project publications, are available on the project website: www.riverlife.org.uk.

Introduction

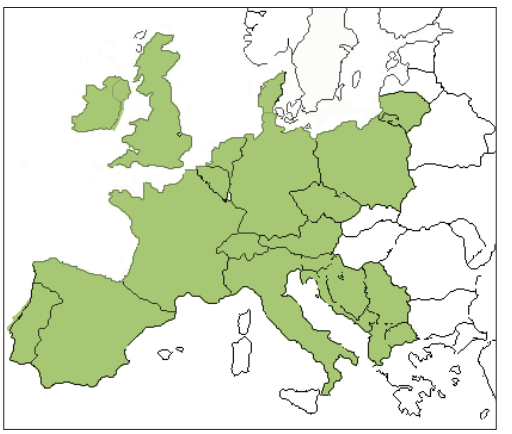
Crayfish are the largest, most mobile freshwater invertebrates, and are considered keystone species wherever they occur. The white-clawed crayfish (*Austropotamobius pallipes* Lereboullet) is Britain's only native crayfish. It can easily be distinguished from introduced species, such as the North American signal crayfish, by its pinkish-white underside, as well as other key characteristics.

David Holdich and David Fox/University of Nottingham

Both photos by R. Lowther

The white-clawed crayfish is Britain's only native crayfish. The female (left) has a broad abdomen for carrying the brood, while the male (right) has larger claws. The male also has a pair of specialised appendages on the abdomen underside for introducing the spermatophore onto the underside of the female during mating.

Adults may reach over 12 cm from the tip of the rostrum (snout) to the telson (tail plate), but more often are less than 10 cm. The rostrum has smooth sides converging towards the base of a small triangular apex. The dorsal surfaces are covered in a fine mat of hairs. The body is smooth, generally brown to olive in colour, and has a pitted appearance. There is a single pair of post-orbital ridges. On the shoulders of the carapace behind the cervical groove is a row of spines, which are present in fully formed juveniles as small tubercles. There is a very sharp spine on the shoulder of the carapace, even in juveniles, that can easily be felt with a finger. This does not occur in signal crayfish and is a good way of distinguishing between the two species.



JNCC

The white-clawed crayfish is found across Europe, but populations are declining due to human disturbance.

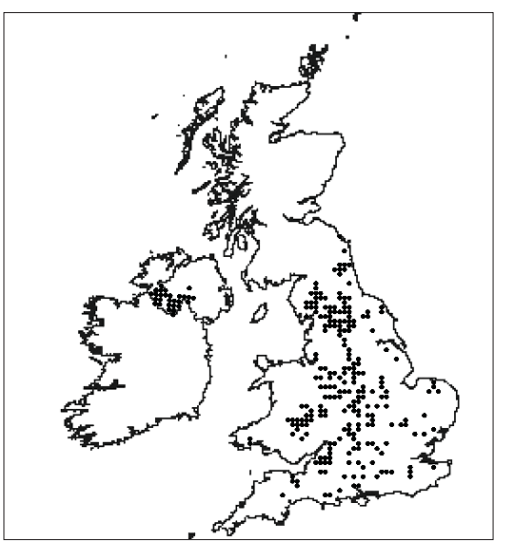
Adult males have larger claws than females and are more territorial, particularly in the mating season. The top side of the claws is rough. Females develop a broader abdomen, which accommodates the brood. Males can also be distinguished from females by the specialised first two pairs of appendages on the undersides of the abdomen. The appendages function like a plunger to introduce a white spermatophore mass onto the underside of the female during mating. The spermatophore has on occasions been mis-identified as a symptom of crayfish plague. The abdominal appendages of the female are more hairy than those of the male and are used to support the mass of eggs, which is glued to them after laying.

Status and distribution

European distribution

The white-clawed crayfish is listed under annexes II and V of the EU Habitats Directive and Appendix II of the Bern Convention, and protected under Schedule 5 of the Wildlife and Countryside Act (1981). It is a priority species under the UK Biodiversity Action Plan, and a Species Action Plan has been prepared to encourage measures for its survival. The populations in the British Isles represent the greatest concentration of the species in Europe.

The white-clawed crayfish is confined to Europe and ranges east to west from former Yugoslavia, Slovenia, Italy, Switzerland and Austria, to Spain, France and the British Isles, where it reaches its most westerly and northerly limits (Holdich 1996). Isolated populations are also known from Germany and Portugal. European populations are more sporadic now than earlier in the century due to habitat modification, pollution and crayfish plague.



JNCC

Many populations of the white-clawed crayfish have been eliminated from Britain, but they still represent the greatest concentration of the species in Europe.

UK distribution

The white-clawed crayfish was formerly widespread in Britain where conditions were suitable. Large populations were previously known from central Ireland, the Welsh Borderland and England, except for the extreme south west (Holdich & Rogers 1997a; Holdich *et al.* 1999b). Since the early 1980s, many populations have been eliminated by crayfish plague and most are now concentrated in northern and central England.

Stephanie Peay

A 'berried' female white-clawed crayfish overwinters with her eggs glued to the underside of her abdomen.

Not all areas considered suitable are currently occupied by the white-clawed crayfish. In Ireland the species may be restricted to the mouths of rivers flowing into large lakes (>2000 ha), possibly due to heavy predation pressure from fish such as eels. The white-clawed crayfish does not naturally occur in western Wales or Scotland, although some introduced populations have survived there for many years.

Life history

Many population studies have been carried out on the white-clawed crayfish, particularly in Ireland and northern, central and southern England (Pratten 1980; Brewis & Bowler 1983; Mees 1983; Matthews & Reynolds 1995). The Irish work has been mainly confined to lakes, while the English studies have concentrated on populations in rivers.

The subspecies occurring in the UK is *Austropotamobius p. pallipes*. Genetic investigations have indicated a strong relationship between French and British populations of this sub-species (Grandjean *et al.* 1997a), and that genetic variability between populations from a wide geographical area in Britain is low

Sue Scott

The presence of juveniles indicates a healthy breeding population of white-clawed crayfish.

Stephanie Peay

Crayfish are associated with overhanging banks, where they take refuge beneath cobbles, rocks and vegetation.

Stephanie Peay

Adult crayfish may dig numerous burrows in the soft mud of riverbanks, particularly during the winter.

(Grandjean *et al*. 1997b).

Crayfish can live for more than 10 years, and usually reach sexual maturity after three to four years. Breeding takes place in autumn and early winter (September to November) when the water temperature drops below 10°C for an extended period. This time may vary with latitude and altitude, although changes in day-length may also be involved in triggering the response.

Females overwinter with a clutch of eggs held beneath the tail. The number of eggs carried may range from 20 to 160, but is usually less than 100. Females as small as 23 mm have been found carrying eggs (Rhodes & Holdich 1982). Some females may lose their eggs during the lengthy incubation period (Rhodes & Holdich 1982; Lowery 1988). Eggs hatch on the female and juveniles become independent at the second stage of development, when they are extremely prone to predation.

The timing of release of juveniles varies from June in the south to August in the north. Similarly, the moulting and growth period may extend from May to October in the south, compared to July to September in the north. Individuals are particularly vulnerable after moulting, until the exoskeleton has hardened. Adults may grow to 120 mm total length (tip of rostrum to tip of telson) and reach 90 g wet weight, although they are often much smaller. Occasionally, specimens up to 150 mm total length have been recorded; this may indicate an age of 12 years or more (Brewis & Bowler 1983). Males tend to be larger than the females and are more territorial.

The presence of juveniles and a varied size range of adults is indicative of a breeding population. Lowery (1988) and Holdich & Rogers (1997a) review studies on the breeding and growth of white-clawed crayfish in the British Isles. A useful summary of crayfish biology and a key to the species can be found in Gledhill *et al*. (1993).

Migration into deeper water may occur in the winter – for example in pools in rivers and the hypolimnion in lakes. There are records of the white-clawed crayfish burrowing into river banks,

particularly in the winter months (Huxley 1879; Cornish 1902; Hogger 1988). The burrows can apparently be quite numerous under certain conditions (Rogers WD, pers. comm.).

The white-clawed crayfish is largely nocturnal, although it can be seen foraging in the shallow margins of lakes as dusk approaches on warm summer evenings. Individuals affected by crayfish plague may exhibit daytime activity.

Habitat requirements

Crayfish distribution in the British Isles is largely determined by geology and water quality. The white-clawed crayfish occurs in areas with relatively hard, mineral-rich waters on calcareous and rapidly weathering rocks. It is found in a wide variety of environments, including canals, streams, rivers, lakes, reservoirs and water-filled quarries. The information in this report is restricted to a description of the ecological requirements of the species in rivers. However, populations in isolated lakes and ponds nearby may become increasingly important as alien crayfish populations continue to expand.

The white-clawed crayfish is typically found in watercourses of 0.75 m to 1.25 m deep, but the species may occur in very shallow streams (about 5 cm of water) and in deeper, slow-flowing rivers (2.5 m). It may be more abundant in watercourses flowing north-south due to the increased shading this aspect provides (Holdich D, pers. obs.). It is not known to inhabit saline waters, although it has the capacity to survive in the short term in levels equivalent to 75% seawater (Holdich *et al.* 1997).

The white-clawed crayfish typically occupies cryptic habitats under rocks and submerged logs, among tree roots, algae and macrophytes, although it usually emerges to forage for food. Juveniles in particular may also be found among cobbles and detritus such as leaf litter. Adults may burrow into suitable substrates, particularly in the winter months. In habitats with flowing water the white-clawed crayfish may be found associated with:

- Undermined, overhanging banks.
- Sections exhibiting heterogeneous flow patterns with refuges.
- Under cobbles (juveniles) and rocks in riffles, and under larger rocks in pools.
- Among roots of woody vegetation, accumulations of fallen leaves and boulder weirs.
- Under water-saturated logs.

The white-clawed crayfish is omnivorous but primarily carnivorous, eating macroinvertebrates and carrion when available (Goddard 1988). Worms, insect larvae, snails, small fish, macrophytes and algae are the principal components of the diet. Calcified plants such as the charophytes are attractive to crayfish as they offer a ready source of calcium during the moulting process. Allochthonous material in the form of dead leaves may provide an important source of food.

Stephanie Peay

Ideal habitat for crayfish: shallow water with a rocky substrate and soft banks for burrows.

Water quantity

Populations occur in both still and running water. White-clawed crayfish are able to survive in rivers with a strong flow, as long as suitable refuges such as weirs and boulders are present. They can occur in shallow riffles and in streams less than 0.5 m wide with just a few centimetres of water (Rogers & Holdich 1995). However, low water levels caused by natural droughts or over-abstraction can be devastating to local crayfish populations, increasing their vulnerability to predation.

Water chemistry

The white-clawed crayfish is principally found in clean, alkaline waters. Most populations in the British Isles are associated with waterbodies in areas with chalk, limestone or sandstone deposits where calcium (5 mg l^{-1} minimum) and pH (6.5–9.0) levels are suitable.

The majority of records for the white-clawed crayfish occur in UK Environment Agency General Quality Assessment Class A and B waters, although records do exist for lower classes (Holdich & Reeve 1991; Environment Agency 1997). Populations are also known to exist where intermittent pollution occurs, such as below the storm overflows of sewage treatment works, where individuals may be covered in microbial growth.

Oxygen

Little work has been done on oxygen tolerance of crayfish in the field, but if levels drop below 5 mg l^{-1} for more than a few days in summer months this may cause stress (Westman 1985).

BOD

The white-clawed crayfish is particularly susceptible to acute pollution incidents caused by spills of organic material with a high biochemical oxygen demand (BOD), such as cattle slurry or silage. Foster & Turner (1993) found that increased ammonia levels and reduced oxygen levels (which may occur as a result of pollution incidents involving sewage and farm waste effluents) caused significant mortalities of the white-clawed crayfish in a simulation.

Stephanie Peay

Beds of macrophytes provide ideal refuges for white-clawed crayfish, particularly in shallow water.

Turbidity

The delicate gills of crayfish are easily clogged by sediment and this may cause physico-pathological changes in the long term. Construction operations often cause marked and extensive turbidity in water, coupled with an increase in iron content (Peay 2000). Floods are likely to have a similar effect, but only in the short term.

Noble crayfish (*Astacus astacus*) in Scandinavia have been reported as surviving 30 mg l^{-1} iron and 1000 mg l^{-1} suspended solids in cages below a dredging area (Westman 1985), although it is not known for how long or which age of crayfish was used. No work of this nature has been carried out with the white-clawed crayfish.

Siltation

White-clawed crayfish are not usually found inhabiting substrates covered in mud or silt, although they may cross such areas while foraging. Land-use change, the draining of lakes or ponds, and lowering or widening a stream or river bed can increase siltation and reduce water flow, resulting in a change in the channel flora and creating unsuitable conditions for crayfish.

While they are known to occur in sections of river where the banks are poached by cattle, such activity can have an adverse effect on a population by increasing turbidity and decreasing dissolved oxygen concentrations as a result of sediment and excrement entering the water (Holdich 2000).

Temperature limits

The white-clawed crayfish reaches its northern limits in northern England, although an introduced population occurs in northwest Scotland, where the Gulf Stream ameliorates winter temperatures. Crayfish may escape some of the winter extremes by migrating into deeper water or by burrowing into the banks. Minimum lethal temperatures are unavailable (Lodge & Hill 1994). The 1–4°C that prevails under ice in winter is not usually lethal to cool-water crayfish. However, Brewis and Bowler (1983) attributed high winter mortality of white-clawed crayfish in a northern England stream to chronic stress caused by low temperature (and/or lack of food).

The ultimate upper lethal temperature over an extended period for the white-clawed crayfish was found by Bowler (1963) to be 30°C. However, at such temperatures in the field, oxygen levels are likely to be reduced, and the combination of the two parameters may be lethal. Firkins and Holdich (1993) found high mortality of white-clawed crayfish at 28°C, although some individuals were able to survive higher temperatures.

Channel structure and management

The white-clawed crayfish has been recorded from a variety of habitats with different channel structures, ranging from relatively wide rivers to drainage ditches. Vertical banks and overhanging vegetation have been highlighted as important features in determining crayfish abundance (Naura & Robinson 1998).

Substrate

The white-clawed crayfish can be found on a wide range of substrates, particularly if suitable refuges are available. Hard substrates are preferred to soft, muddy ones. Extended shallows and open sections without refuges and vegetation tend to be avoided. Refuges can take many forms, including large boulders and water-saturated logs, rocks and cobbles, slates, crevices in man-made walls, accumulations of fallen leaves, tree roots, holes in banks, constructions such as piers and fishing platforms, and man-made debris. In addition, the presence of beds of aquatic vegetation such as water crowfoot (*Ranunculus* spp.) and watercress (*Rorippa nasturtium-aquaticum*) can provide shelter.

Vegetation

White-clawed crayfish utilise vegetation for cover and for food. They may be found amongst blanketweed (*Cladophora* spp.); willow moss (*Fontinalis* spp.); or vascular plants such as water crowfoot and watercress. Their association with such vegetation may be due to their foraging behaviour. Overhanging bankside vegetation has been highlighted as an important factor in determining crayfish abundance, as this provides shade, food and cover.


Both photos by Sue Scott

The North American signal crayfish, identifiable by the red underside of its claws, is a serious threat to the native crayfish. It can be a vector of crayfish plague, and competes for food and shelter.

Habitat composition – key features

Smith *et al.* (1996) identified the key habitat features that determine the success of white-clawed crayfish populations. They concluded that once a threshold concentration is exceeded, (5 mg l^{-1} for calcium, pH 6.5) the chemistry of the water had little influence on crayfish abundance. They found a strong positive relationship between crayfish abundance and the proportion of:

- Vertical bank present
- Channel width overhung by a plant canopy more than 0.5 m above the water surface
- Bank length with tree root systems projecting into the water.

These features all contribute to a favourable habitat, providing the crayfish with refuges, a source of food and protection from strong currents and predators. Such bankside features should be retained, enhanced or restored where the white-clawed crayfish is to be protected or reintroduced.

Naura and Robinson (1998) used River Habitat Survey data, developed by the UK Environment Agency, to try to predict the distribution of the white-clawed crayfish. They found that the variables most associated with crayfish presence were overhanging boughs, extensive steep banks, the presence of submerged vegetation, boulder/cobbles as a bank substrate, and tree shading. Those most often associated with crayfish absence were eroding cliffs, banks poached by cattle, bank substrates of gravel, pebble and sand, and artificially reinforced banks. They suggest that as well as giving shade, overhanging vegetation provides a direct source of food and supports species that form part of the crayfish diet.

Foster (1993) found a relationship between refuge size and body size in the white-clawed crayfish. When crayfish are found in cobbled areas it is probably because boulders or vegetation are also present. Cobbles only provide a suitable habitat for juvenile crayfish when they are small enough to fit between the interstices. Similarly, tree roots can provide suitable habitat for juveniles, and for adults if the roots are large.

Threats

Introduced species

The white-clawed crayfish is susceptible to predation and competition by larger, faster-growing and more aggressive introduced species, particularly the North American signal crayfish (*Pacifastacus leniusculus)* (Holdich & Domaniewski 1995; Holdich *et al.* 1995b). Signal crayfish can act as vectors of crayfish plague,

Disinfection procedures and thorough drying of equipment should be undertaken if moving from waters containing alien crayfish to those containing the white-clawed crayfish.

The white-clawed crayfish can suffer from porcelain disease, thelohaniasis, in which the underside becomes opaque, as seen in the individual on the right. The crayfish on the left has a normal underside. The disease rarely causes mass mortality.

Both photos by David Holdich

but not all harbour the fungus.

Consequently, mixed populations of white-clawed crayfish and non-indigenous crayfish may arise. Such populations may exist for three to four years, but eventually the white-clawed crayfish is eliminated through competitive exclusion. All mixed populations of white-clawed crayfish and signal crayfish known to have existed before 1992 are now entirely composed of the latter. Some signal crayfish populations are expanding at a rate of 1 km per annum (Holdich 2000).

Any introduced crayfish species in the same or nearby waters should be treated as a threat to the survival of the white-clawed crayfish. Even if they are not vectors of crayfish plague (for example, the narrow-clawed crayfish (*Astacus leptodactylus*) and the noble crayfish (*Astacus astacus*), they may be superior competitors for resources. Introduced crayfish species may also have a negative effect on populations of bullhead (*Cottus gobio)*, stone loach (*Barbatula barbatula*), macroinvertebrates and plant communities (Ibbotson *et al*. 1997).

Non-native crayfish are extremely difficult to contain, and readily escape from holding facilities. There are currently no known methods for eliminating them. Removal of the larger animals is likely to exacerbate the problem, as large males may control numbers to some extent by predating on the smaller individuals, thereby reducing productivity. The Environment Agency and English Nature are jointly funding research into methods for the control or eradication of alien crayfish species, using chemical signals and pheromones.

Disease

The white-clawed crayfish suffers from two main diseases: thelohaniasis, or porcelain disease (caused by *Thelohania contejeani*), and aphanomycosis, or crayfish plague (*Aphanomyces astaci*) (Alderman & Polglase 1988).

Thelohania contejeani, a protozoan, rarely causes mass mortality. It may be present in 10% of a population without apparent harm, but problems may occur if a higher prevalence is reached. Infected

individuals have a porcelain white coloration to the tissues (particularly the tail muscles) when viewed from the underside, and should be removed from any stock used for re-introduction purposes.

Note: This coloration should not be confused with secretion from glair glands, which give a similar coloration to the lateral margins of the underside of the tail in females coming into breeding condition in autumn.

David Alderman/CEFAS

Crayfish plague is very difficult to identify as the range of clinical signs is huge. However, some symptoms include those in the individual above: necrotic white musculature on the right side of the anterior abdominal segments (left side of image), plus the same in the final segment and in the musculature of the telson itself.

Aphanomyces astaci, an oomycete fungus, is carried by North American species, particularly the signal crayfish. It is thought to have been introduced to Britain with imported signal crayfish from Sweden in the 1970s (Lilley *et al*. 1997), and the first positive outbreak was recorded in 1981. It is lethal to the white-clawed crayfish and causes mass mortality. Many populations have been eliminated, for example from the River Thames, the Severn, the Avon at Bristol and the Trent. The fungus is very difficult to see with the naked eye. Its effect can be seen in behavioural abnormalities, such as the phenomenon of 'walking on stilts', in which infected individuals stand on the tips of their walking legs (Alderman & Polglase 1988). Brown patches may also appear on the membranes between the leg and tail joints.

Note: This should not be confused with brown spots characteristic of bacteria causing burn spot disease, nor with a white mass on the underside of females in the autumn, which is the spermatophore attached during mating.

The spores of the fungus can be carried by a variety of means: in water, on fish, in mud on boots, and on fishing equipment. The disease is very difficult to control and outbreaks are impossible to predict. Recent outbreaks have been recorded in East Anglia (1999) and on the river Ribble (2000).

The restocking of rivers previously infected by plague is a possibility, as long as the source of infection is no longer present. Recent research has shown that plague may persist in a river system for over a year. There is little evidence for natural recolonisation. A reintroduction protocol for the white-clawed crayfish has been published as part of **Life in UK Rivers**.

Other diseases caused by bacteria are known to cause mass mortalities in crayfish but have not been studied in detail in British crayfish populations.

Predators

The white-clawed crayfish is preyed upon by a large number of predators including fish (perch, chub, trout, pike and eel), mammals (mink, rat and otter), and birds (heron and crow), particularly during low flows. In addition, juveniles may be preyed upon by insect larvae (Hogger 1988). Water voles also prey on crayfish and may be attracted to the bait in traps used for recording work, where they will drown if trapped under water.

Pollution

White-clawed crayfish are extremely vulnerable to pollution incidents, particularly those involving biocides and silage. Cypermethrin is of high toxicity to freshwater organisms, including crayfish, which are extremely susceptible to very low levels of related biocides – for example deltamethrin at 0.1 g l^{-1} (Holdich *et al.* 1999a). Biocides entering a waterbody, particularly organophosphates and pyrethroids, can cause large mortalities, such as occurred on the Sherston Avon (Spink 1999). The use of sheep dip in areas where crayfish occur should be avoided.

A study on the crayfish *Astacus fluviatilis* showed sensitivity to levels of biocides as low as 0.0042 mg l^{-1}, while at concentrations of 0.208 mg l^{-1} the toxic effects were rapid. An Environmental Quality Standard for the protection of freshwater life has been proposed at 0.1 mg l^{-1} (Annual Average) and 1 mg l^{-1} (Maximum Allowable Concentration).

Summary

Water Quality

- Clean (at least UK Environment Agency General Quality Assessment Class B, preferably Class A), well oxygenated and mesotrophic water.
- Calcium levels above 5 mg l^{-1}.
- pH levels in the range 6.5 to 9.0.
- Temperature within seasonable limits.
- No potential source of biocides such as sheep dips in the catchment, and an absence of local effluents likely to lead to a high BOD, for example, farm and fish farm effluent.

Water Quantity

- Water present at all times of the year (although crayfish can survive under stones in ephemeral watercourses, they are more vulnerable to predation).

Physical habitat, shelter and food

- Refuges present in the form of cobbles or rubble interspersed with larger structures (boulders, slates or logs), as well as stands of submerged vegetation on the bed or at the base of the banks. Exposed tree roots below the water level are particularly attractive to crayfish.
- Areas of vertical bank that are undercut to some extent to provide shelter for crayfish. Banks containing a variety of sizes of rubble are particularly suitable.
- A certain amount of bankside vegetation overhanging the body of water to provide shade, a source of food, and cover.
- Stands of submerged vegetation such as watercress, willow moss and water crowfoot, to provide food and cover.
- A varied fauna and flora present to provide a source of food and calcium for this omnivorous invertebrate.
- Algae such as blanketweed should not dominate the habitat.

Channel structure and management

- Banks should not be poached by cattle.
- Factors likely to lead to a decline of submerged plant communities should be absent; for example, deposition of sediment and changes to channel structure.

- Work likely to lead to the destruction of refuges and banks such as dredging operations and channelisation should be avoided.
- Factors likely to lead to an increase in sediment should be locally absent - for example, mining operations and pond construction or maintenance.

Disease

- The prevalence of thelohaniasis in the crayfish population should not be above 10%, and preferably zero.
- Plague vectors (North American crayfish) should be absent from the catchment.
- Non-indigenous crayfish that might compete for resources, and large numbers of predatory fish (chub, eel, perch, pike and trout) or mammals such as mink should be absent.

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Life in UK Rivers was established to develop methods for conserving the wildlife and habitats of rivers within the Natura 2000 network of protected European sites.

Set up by the UK statutory conservation bodies and the European Commission's LIFE Nature programme, the project has sought to identify the ecological requirements of key plants and animals supported by river Special Areas of Conservation.

In addition, monitoring techniques and conservation strategies have been developed as practical tools for assessing and maintaining these internationally important species and habitats.

The white-clawed crayfish is Britain's only native species of crayfish - the largest and most mobile of freshwater invertebrates. Once widespread in streams and rivers, the white-clawed crayfish is now under threat across its natural range and today the populations in these islands represent the greatest concentration of the species in Europe.

Sensitive to poor water quality, susceptible to disease and vulnerable to competition by aggressive alien crayfish species, the white-clawed crayfish is one of the species at the heart of a major European effort to conserve key freshwater animals and plants and the river habitats that sustain them.

This report describes the ecological requirements of the white-clawed crayfish in a bid to assist the development of monitoring programmes and conservation strategies that are vital for its future.

Information on Conserving Natura 2000 Rivers and Life in UK Rivers can be found at **www.riverlife.org.uk**

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