Monitoring native crayfish population in england

Environment, Nature

Crayfish (Astacoidea) are one of the most widespread invasive aquatic genera in the world, a large proportion of their global species have successfully invaded other continents after being introduced intentionally or accidentally (Gherardi 2010). Aquaculture has been one of the primary reasons for introductions to many European countries, with certain species such as Procambarus clarkii, the red swamp crayfish and Pacifastacus leniusculus Dana the signal crayfish (Savini et al, 2010). The North American signal crayfish (P. leniusculus) is one of eight invasive crayfish which is thought of first been introduced from Sweden in the south of England in the 1970's to household ponds (Holdrich et al, 2014). Since these introductions in England, populations have spread far and wide, reaching regions in Scotland where crayfish are not native (Crawford et al, 2006). Over the past three decades, a large proportion (40%) of invasive aquatic introductions have been in the form of fishing, water leisure activities and extensive aquaculture throughout Europe (Anderson et al 2015; Gallardo & Aldridge 2013). Holdrich et al (2014) suggests that humans can easily transport crayfish to new locations using equipment. An adult P. leniusculus can survive dry for a period of hours and only start to die at > 9 hours, making them easy to transport without water (Bahna & Anastácio 2014). Once signal crayfish have been translocated, they are quick to alter the physical environment. they achieve this through grazing, predation on other species, while also burrowing in the banks of rivers causing habitat degradation (Freeman et al, 2010). They are then quick to extend their range through connected water systems, Bubb et al (2006) found that P. leniusculus was

extending its range up to 2km per year on the river Wharfe and had the ability to move upstream if the conditions were right.

P. leniusculus ability to extend its range naturally, along with the added movement of human translocation in the past has created a conservation issue for native white clawed crayfish (Austropotamobius pallipes) populations in the U. K (_____). Aphanomyces astaci

Schikora is a pathogenic fungus carried by P. leniusculus, which is thought to causes large mortality rates in A. pallipes populations (__). It is asymptomatic and endemic in North American crayfish native populations and is thought to have minimal impacts on mortality for signal populations (Holdrich et al, 1999). The spread of the A. astaci disease has in turn meant that signal crayfish populations have had an advantage showing exponential growth over native crayfish populations across Europe (Kouba et al, 2014). With increasing fear that the U. K. native crayfish populations would be next to impacted by this disease in the late 1980's, the legislation in Britain changed to make it illegal to remove signal crayfish from the wild or sell them for aquaculture without a license under schedule 5 of the wildlife and countryside act 1981 (Holdrich et al 1997). Since that legislation change, species survey information shows that white clawed populations are now exclusively centred around central and northern England only, with populations declining more than 70% over three decades, which has resulted in them being listed as endangered by the International Union of Conservation of Nature (IUCN) red list (Grosset et al, 2006; Holdrich et al 2009; Peay & Fuereder 2011).

James et al (2017) suggests that not all signal crayfish may carry the A. astaci disease and that not all white clawed crayfish sampled in their investigation were found to be infected. As the pool of research on crayfish grows, more understanding on other factors which need to be considered are coming to light. By using molecular techniques different parasites can be examined in Astacoidea species: microsporidia (Thelohania contejeani) has been found to be well adapted to Astacoidea species, it was sequenced and detected in both P. leniusculus and A. pallipes along with three other strains of microsporidia in P. leniusculus, which poses the question, is A. astaci the only disease causing a decline in crayfish populations (Dunn et al, 2008; Tobia et al 2018). Hudina et al (2016) suggest that disease is not the primary explanatory variable for rise of P. leniusculus but has been heavily studied and therefore perceived as an important variable. The presence of A. pallipes could be having a more significant impact through interference competition or exploitation competition, gaining more food and shelter over native crayfish populations which therefore can have a negative impact on behaviour and fecundity (Dunn et al, 2009; Soderback 1991; Usio et al, 2001; Jackson et al, 2016). The combination of competition and disease has been witnessed before in other invasive-native species conflicts, red squirrel (Sciurus vulgaris L.) populations have not ceased to decline since the growth of North American grey squirrels (S. carolinensis Gmelin) in the U. K. which spread a poxvirus and have higher fecundity than red squirrels (Gurnell et al, 2004; Tompkin et al, 2002)

Monitoring native crayfish populations has proven difficult, methodology and timing of monitoring offer different results, suggestions have been made that

trapping has a higher yield than other survey methods (Peay 2006). However, Holdrich et al (2006) describes the variability in the results depending on trapping method when monitoring white clawed crayfish populations in a Huddersfield canal. 48 crayfish were marked and recaptured over a six-day period, yet when the canal was drained post trapping 549 crayfish were removed. Alternative methods have been used in an attempt to detect all aquatic species through DNA, water can be scanned using molecular techniques looking for environmental DNA (eDNA) of species or targeted DNA. This method has been used to detect white clawed crayfish, signal crayfish and also been developed to scan for T. contejeani (Harper et al, 2018; Robinson et al, 2018; Larson et al 2017). eDNA has already been effective in other native declining species, used for detection and evidence to support protection and conservation in ponds (___). As these techniques advance with further research and technology, they could become a useful and accurate tool to monitor and quantitate both native and invasive crayfish populations in rivers and other moving water environments (Jerde et al, 2011; Thompsen et al 2015). Equally, at the present there are a number of considerations when using eDNA in rivers, such as where the DNA signal has originated from, and if the DNA collected is accurate enough to estimate abundance (Goldberg et al, 2016; Grey et al 2018).

Moreover, once crayfish are detected, eradication methods take place. Similar to monitoring, there have been a range of methods used to reduce populations. The use of chemicals and insecticides have been suggested for eradication, but nothing has been developed and implemented commercially (Holdrich et al, 1999; Peay et al, 2006; Sandodden et al 2010). Whereas

other novel methods such as electrofishing and infrared detection of heartbeats could be used to manually removed signal crayfish from the water but have only been used within research (Peay et al, 2015: Cisar et al, 2018). The most widespread method of removal of P. leniusculus has been trapping, nonetheless, populations appear to recover and increase their range post removal (Freeman et al 2010). Gherardi et al (2011) suggests that more long term approaches should be considered such as integrated pest management approaches (IPM) and trapping alone is not enough.

Until signal crayfish have decreased to stable numbers, and native populations recover inhabiting wider regions of the U. K., better understanding of P. leniusculus dietary preferences needs to take place: Crawford et al, (2006) research on the Clyde river system in Scotland shows the potential decline of benthic invertebrates groups where P. leniusculus is present. These potential declines could be having wider impacts, as aquatic invertebrates in streams and rivers are used to score the quality of the water system (Mathers et al, 2016). Aquatic invertebrates can be used as part of river assessments because of their extensively studied communities, and how they respond to stressors (Lancaster and Briers 2008; Parmar et al, 2016). The Biological Monitoring Working Party (BMWP) 1980 scoring system is one of many systems which assesses river quality based on surveying invertebrate communities, commonly used by the environment agency in Britain and other agencies in the U. K. (Chad 2010). Other scoring systems which have been designed around scoring invertebrate families include the Lincoln Quality Index (LQI) and the Lotic-invertebrate Index for Flow Evaluation (LIFE) (Extence 1987; Extence et al, 1999). The BMWP scoring

system has been proven to be a useful tool and has been adapted for a range of global countries including Thailand, Brazil and Australia (Paisley et al 2014), if invasive species such as P. leniusculus are having a negative impact on aquatic invertebrate families, this information needs to be considered in future U. K. BMWP surveys where signals are present.

The presence of P. leniusculus is thought to causes direct and indirect effects on an ecosystem. When signal crayfish are present in a pond or lake environment, benthic invertebrates and macrophytes are restricted from escaping predation from a keystone consumer, these predation rates can then alter natural food webs (Nystrom et al, 1996; Nystrom et al 2001). Their diet has been replicated in a laboratory setting, specific species are thought to be highly predated on, such as the common pond snail (Lymnaea stagnalis) (Nystrom & Strand 1996; Nystrom & Perez 1997). Bondar et al (2005) compared a laboratory experiment which represented a pond environment, to a field study creek location on P. leniusculus using stable isotopic analysis to assess preference of diet through different crayfish life stages. They included, young of the year (YOY), juveniles, and adults as the different stages of growth as part of their investigation. Their results (Fig. 1) represent the differences in diet when present in different environments, both adults and juveniles have a preference of invertebrates (1. 6%) in an experiment environment, whereas only YOY where found to have presence of invertebrates (0. 7%) within their gut when sampled from the creek.

Other researchers have also tried to understand diet preference within a laboratory setting: Rosewarne et al (2016) provided four different prey items

simultaneously to assess preference (Gammarus, chironomidae larvae, an isopod and gastropod), they found chironomidae larvae to be most preferential, while gastropods where least preferred suggesting having a range of choices may change dietary preference. They conclude that when given wider choices including macrophytes that P. leniusculus can be described as a ' generalist omnivore' which is similar with other studies results (Gaun & Wiles 1998). Crawford et al (2006) study on the Clyde river in Scotland found mean abundance of certain invertebrate families to be lower in parts of the river where signals were present. Chironomidae were significantly lower, along with a range of other taxa including, plecoptera, hydracarina, hirudinea, and tricladida. Moreover, not only are invertebrates thought to be predated on in river systems but also fish eggs, and the presence of signal crayfish can alter fish behaviour, subsequently causing reductions in growth rates in later periods (Light 2005). These findings are similar to those of Wood et al (2017) who found that growth rates could be reduced through change in behaviour of larva Chubb fish, but also that there is a negative impact on predation of Chubb eggs. Equally, they also found that older Chubb had an increased rate of development if at a specific ages post signal crayfish invasion through predation of crayfish. This observation has been documented by other researchers who have concluded that some conservation issue fish species may benefit from predation of crayfish if fish populations can reproduce and develop without being negatively affected by crayfish egg predation (King et al 2006).

This investigation wanted to better understand the impact of ' presence' and ' absence' of signal crayfish on benthic invertebrate groups in rivers across

the U. K., and how their presence could be having a negative impact on river condition monitoring systems. Previous studies have only focused on one region or river system (Crawford et al, 2006; Mathers et al, 2016; Bondar et al 2005), this study would focus on 6 river systems ranging from Stirling in Scotland, to Winchester in the south of England to try and understand if diet differences are similar across different regions of the U. K.

Method

Study area

Chosen sites, how liaising with the Fishmongers guild? RT, where, coordinates, travel.

Field and identification methods

Chadd 2010 – Kick sampling, selecting families <30 minutes sort out, storage of inverts, water samples, GPS/altitude, sterilisation between sites following set protocols designed around environment agency recommendations.

Data analysis

All invertebrates were identified in a laboratory setting using the FBA aquatic guide (____) and a compound microscope. Any families which were difficult to identify were checked with an expert using microscope imagery. Each family was added to a database of sites (River Carron1, River Carron2, etc) which could be then scored using original BMWP scores documented in Paisley et al (2014) methodology. A selection of environmental information was then

added to this database, including; site altitude, river name, and presence or absence of crayfish. _____ (ASPT) scores where then added to show any obvious trends of site condition between sites when only considering totals of families and BMWP scores alone (__). Two hypotheses were analysed, the first (1) There is a (negative) difference in the total number of benthic invertebrate families in rivers which have a ' presence' of P. leniusculus. And second, (2) there a difference in mean BMWP scores of ' presence' and ' absence' of P. leniusculus. To analyse these hypotheses, R- (____) was used for its range of functions and packages to analyse community data. Basic functions of R were used (Student T-test, mixed model effects, ANOVA) for initial analyses, while other packaged were installed for more complex analyse such as the ' Vegan' package and ' Lmne4' package (___).

R- Two sample t-test , mixed model effects, Vegan package, ordination plots, dendrograms

Aims objectives

- The main objective of this investigation was to identify negative trends of aquatic invertebrate families in rivers which have a ' presence' of signal crayfish.
- Invertebrates which were collected from each site would be scored using the BMWP index, river scores could then be compared and analysed for differences between ' presence' and ' absence'.
- Invertebrate families which are significantly different between sites will be investigated to why these families may be lower based on research literature available.