Dace (*Leuciscus leuciscus L.*): an Invasive Fish Species in Ireland

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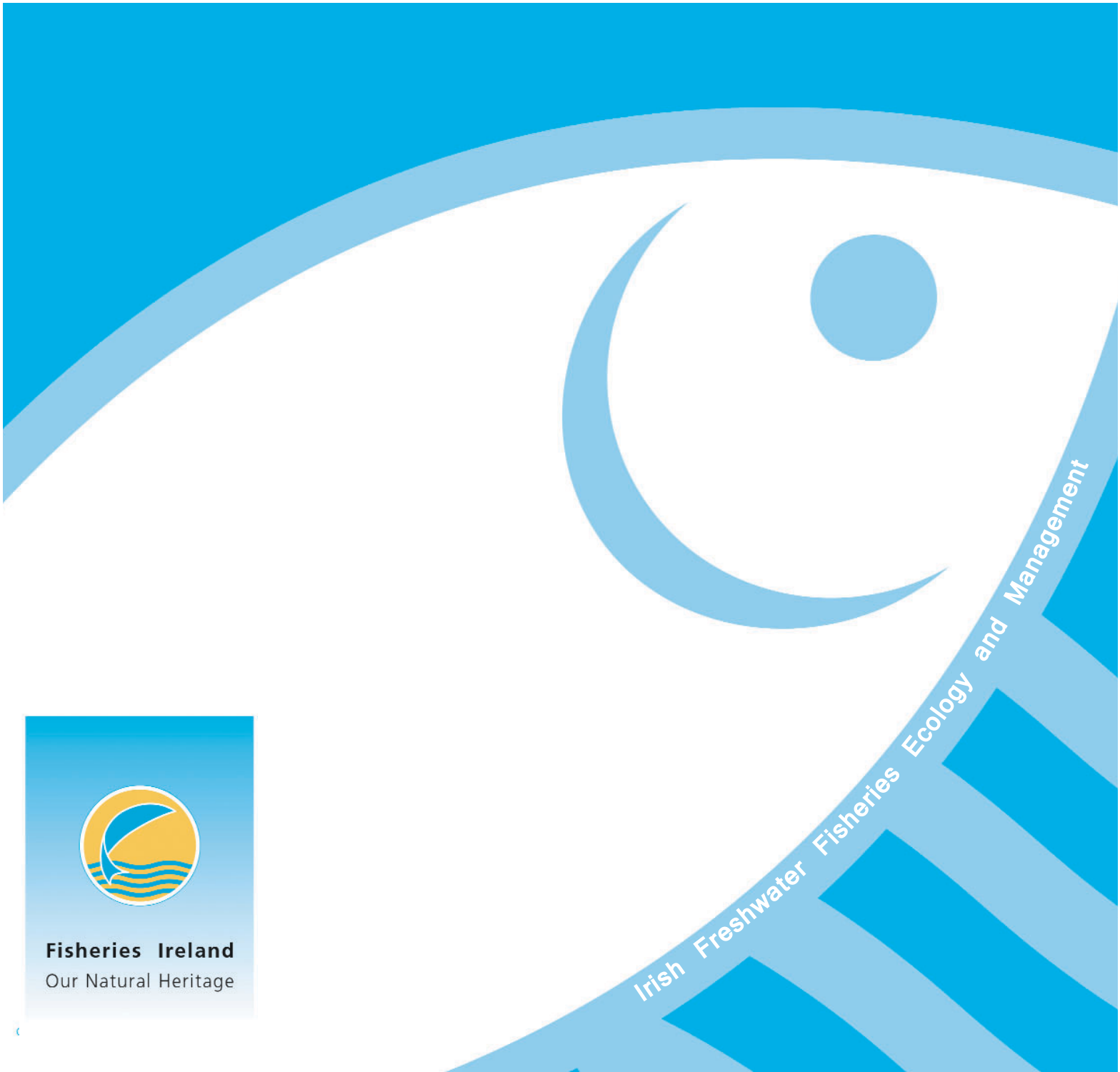

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Contents

Abstract

The dace (*Leuciscus leuciscus (L.)*) was first introduced from Britain to the Munster Blackwater in 1889. Until the early 1990s dace was restricted to this catchment. It has since been recorded in the lower reaches of the River Shannon, in Doon Lake (Co. Clare) and in the Rivers Barrow and Nore. In the River Barrow, where dace was first reported in 1994, it rapidly spread upstream and large populations now occupy the river from below St Mullins to Athy, a channel length of 69 km. Dace now represents an important angling species in the river, with individual angling catches regularly in excess of 15kg. This paper describes the rapid spread of dace within the River Barrow and compares the growth rates of dace from the River Blackwater, a stable population, with the invasive population in the River Barrow. While all the populations studied exhibited similar growth patterns, the growth rate for the invasive population in the River Barrow was significantly different, in each year class, from that recorded in the stable population. The potential impacts of the invasion on fish communities and on angling in Ireland are discussed.

Introduction

The Biology of Dace

The dace (*Leuciscus leuciscus* L.) has a European-wide distribution ranging from Scandanavia to the South of France and eastwards into the former Soviet Union (Wheeler, 1969). Ireland currently represents the world-wide western limit of this species.

Dace is a cyprinid fish, generally not living more than ten years (Cragg-Hine and Jones, 1969). It is relatively small, the current Irish rod-caught record standing at 0.509kg (Irish Specimen Fish Committee, 2003). The dace has a dorso-ventrally flattened symmetry, which makes it suited to fast flowing water. The mouth is inferior and the tail is deeply forked. The flanks are silver, darkening to a bluish green along the back. The eye is yellow.

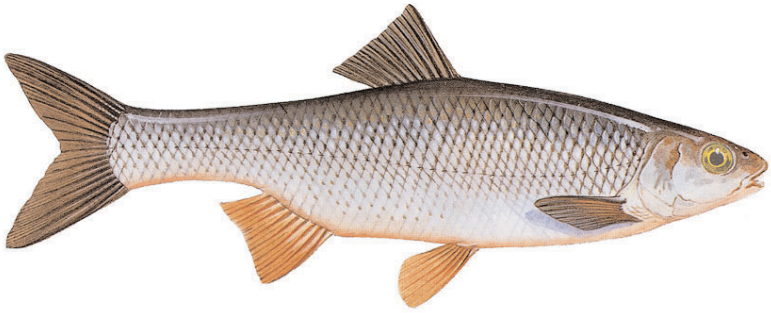

Figure 1. Artist's impression of a typical dace.

Dace primarily inhabits fast flowing water systems, although it is also found in lowland rivers and lakes (Millere and Jones, 1997). It feeds all year round, with a peak in feeding activity during the summer. Feeding slows considerably during the winter as water temperatures decrease, although there is no winter fast (Hartley, 1947). Dace is omnivorous, with a highly varied diet (Cowx, 2001). Prey selection is seasonal. During the summer, insects, such as ephemeroptera and chironomid larvae, are common prey with algae also making up a large proportion of the diet. In winter, the algal content of the diet is much lower and detritus becomes more important, with

trichopterans and molluscs being the most common animal prey (Mann, 1974; Hellawell, 1974). The dace feeds low down in the water column during winter months, but during the summer it feeds extensively off the surface. Like most small fish species, the dace resides in large, often dense, shoals and, when present in large numbers, it can seriously reduce the amount of food available to other fish species (Kennedy and McCarthy, 1965).

Bourgeois (1963) reported dace hybridisation with chub (*Leuciscus cephalus* L.) in mainland Europe and hybridisation with bleak (*Alburnus alburnus* L.) has also been recorded (Kennedy and McCarthy, 1965). In Ireland, dace spawn earlier in the year than any other cyprinid, usually between February and March when water temperature reaches 10^{O}C (Kennedy, 1969). As a consequence, hybridisation is unrecorded in Irish waters.

Spawning usually occurs after a short upstream migration, with a sand or gravel substrate being preferred (Penczak, 1967). Eggs are negatively buoyant and when discharged into the water they quickly attach to the substrate where they can survive extremely heavy spate conditions. Dace eggs hatch approximately one month after spawning (Mills, 1981). Fecundity is estimated at between 6,550 and 9,500 eggs for a 20cm female (Cowx, 2001).

Where present in Ireland, dace populations have become an important recreational angling species. Catches in excess of 15kg, often consisting of 50 to 100 fish, are commonplace in these waters. In spite of this, and the possible threat posed by this invasive species, little research has been conducted on Irish dace populations.

This study details the current distribution of dace in Ireland. In addition, the growth rates of established (>100 years) and newly invasive populations (<25 years) are compared. The possible effect of the invasion of dace on other resident fish species is discussed.

A History of Dace in Ireland

In 1889 British anglers river fishing on the Munster Blackwater accidentally released a number of dace and roach (*Rutilus rutilus* L.), which were being held as live baits. This was the first introduction of both species to the country. While roach rapidly spread to colonise most catchments in the country (Fitzmaurice, 1984), dace became

a naturalised part of the fish fauna of the Munster Blackwater and, for almost 100 years after their initial introduction, remained confined to this river. In 1980, however, anglers in county Clare reported catching dace downstream of Doon Lough in the Ahaclare River. Ten years later the first dace were reported from the Maigue River, which enters the Shannon Estuary almost directly opposite the Ahaclare River. By 1994 dace were also present in the River Shannon, from Limerick to Ardnacrusha Dam, and in the Mulkaer River, which joins the River Shannon between these two sites. The first dace on the eastern side of the country were recorded from the River Nore in 1990. Soon after, dace were reported from the River Barrow, which joins with the River Nore before discharging into the sea at New Ross, Co. Wexford (Figure 3).

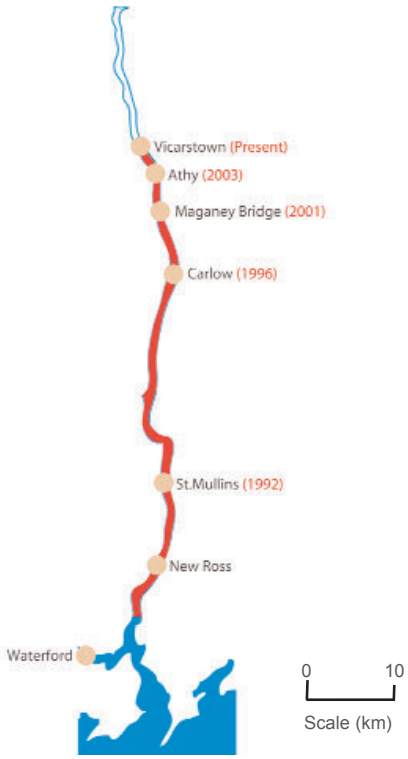

Figure 2. Map of the River Barrow charting the upstream spread of dace from their initial discovery at St.Mullins in 1992.

The results of fish stock surveys of the River Barrow carried out by the Central Fisheries Board in the last 15 years have charted the spread of dace through this river system (Figure 2). From their first discovery in the tidal waters at St. Mullins in 1992 dace spread upstream and are now established as an important angling species throughout the river. They have covered a distance of over 70km in fourteen years. Anglers have also reported catching dace in the Boyne, Suir and Liffey Rivers. However, no specimens have been recovered in surveys of these waters.

Methods

Questionnaires seeking information on the current distribution of dace in Ireland were sent to each of the seven Regional Fisheries Boards and to prominent angling clubs throughout the country. Based on responses obtained and on experience within the Fisheries Boards, a comprehensive list of waters containing dace was formulated. To validate these records, a numbers of these waters were surveyed in 2004. Data collected in these surveys was supplemented with archive data from within the Central Fisheries Board.

Surveys were carried out either by electro-fishing, fyke netting or by angling (Table 1.). These waters were examined either qualitatively, to confirm the presence/absence of the fish, or quantitatively, to gather a large enough sample size to determine a growth rate for the population.

Table 1. Irish waters from which dace have been recorded. The date that the dace were first recorded and the survey method employed to validate the records are presented.

River	Survey Site	Survey Method	Date of Survey
Munster Blackwater	Cappoquinn	Electrofishing	1973
Munster Blackwater	Mallow	Electrofishing	2002
R. Barrow	St Mullins	Angling	2004
R. Nore	Inistigue	Fyke netting	2003
Ahaclare R.	d/s Doon L.	Electrofishing	2004
R. Shannon/ Mulkaer	R.Annacotty	Angling	2004
R. Maigue	Adare Manor	Electrofishing	2004

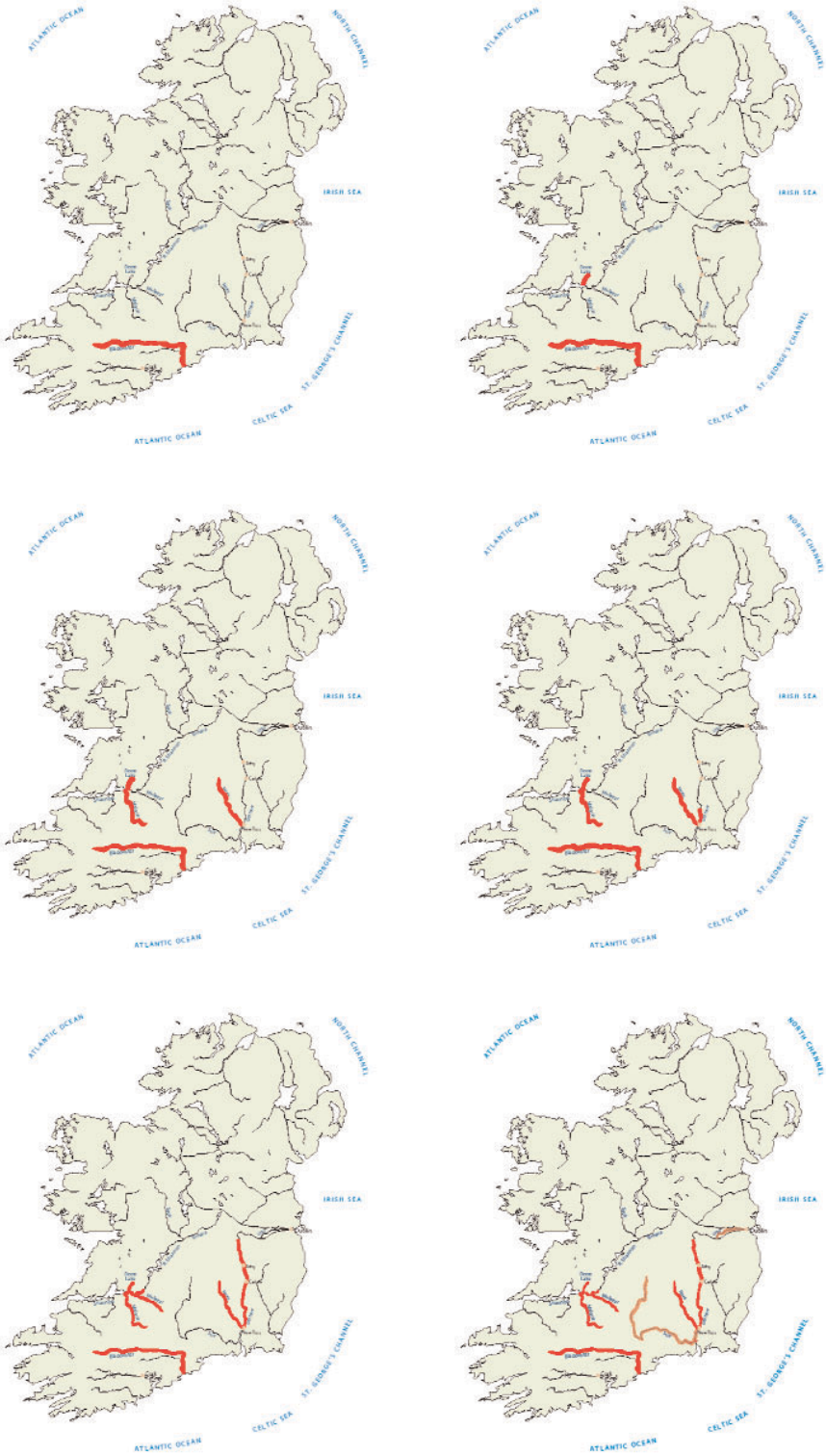

Figure 3. Spread of dace in Ireland. a)1889 – initial introduction into Munster Blackwater; b) 1980 – dace recorded from Doon Lake and the Ahaclare River; c)1990 – dace recorded from the Nore and Maigue Rivers; d)1992 – first report of dace in the River Barrow; e)1994 – dace present on the Lower Shannon and Mulkaer Rivers. f)Situation at present, unconfirmed reports of dace from the River Liffey and River Suir.

Fish caught were measured for fork length (cm) and weight (g), and a number of scales were removed from between the lateral line and the insertion point of the dorsal fin for age and growth analysis. Archive data on the growth rates of dace from the Munster Blackwater in 1973 was used to represent the established population, as dace have been resident in this river for over 100 years. Growth rates were developed by back-calculation of length-at-age using scale reading techniques.

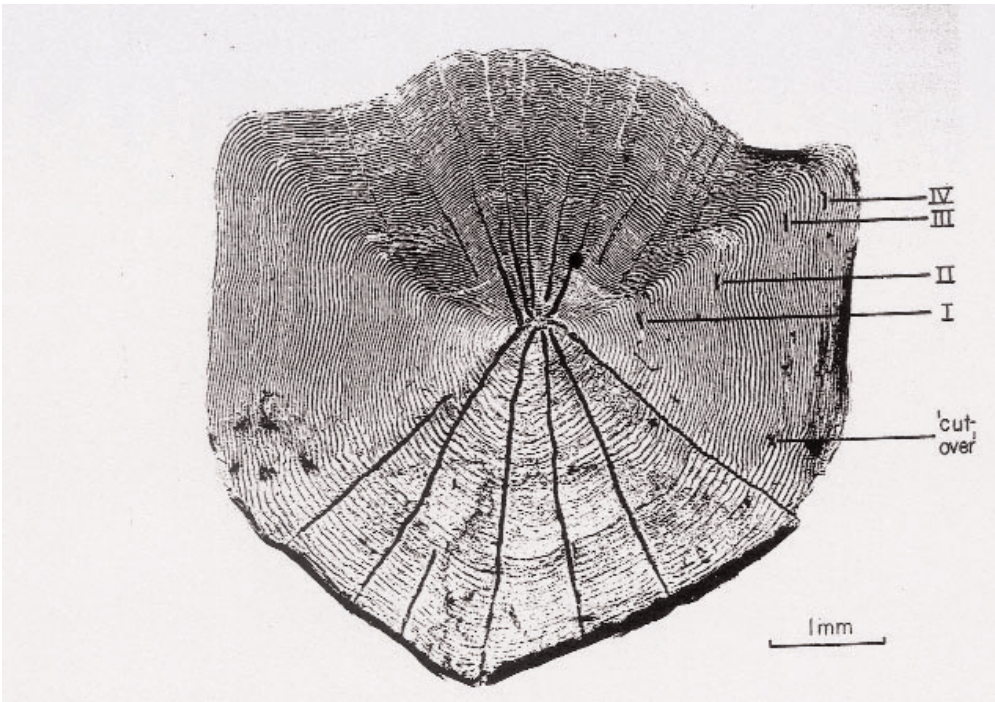

Figure 4. Scale of a dace in its 5th year. The 'cut over' gives a clear indication of a new year's growth (from Kennedy and McCarthy, 1965).

MS Excel was used to prepare growth curves for all samples and for statistical comparison. ANOVAs were used to compare length at age. Mean growth rates for river dace from the U.K. were extracted from Cowx (2001). Length frequency histograms were derived for all sites where more than 30 specimens were captured. For comparative purposes frequency is given as a percentage of the total population.

Results

The largest fish recorded in this study measured 29.5cm and was captured during the 1973 survey of the Munster Blackwater. Fish from the River Nore were, on average, the oldest and largest. However, a fish in its tenth year was recorded from the Munster Blackwater in 1973. The Mulkaer River contained the smallest and youngest fish (Table 2).

Table 2. Length, weight and mean age of dace from rivers where the species is known to be resident.

River	n	Length (cm)			Weight (g)			mean age
		mean	min	max	mean	min	max	
B'water '73	531	17.70	8.6	29.5	80.27	3.7	339.5	4+
B'water '02	43	20.82	15.4	25	121.76	39	206	5+
Barrow '04	34	17.82	10	24	87.85	15	175	4+
Maigue	64	15.74	9.3	26.5	81.23	26	250	3+
Nore	15	23.43	19.2	25.6	166.94	86.2	205.6	5+
Mulkaer	49	12.97	8.5	17.8				2+

Both length-frequency histograms for the Munster Blackwater showed one old cohort of large fish. The invasive populations, i.e. the Barrow, Mulkaer and Maigue rivers, contained two or three cohorts distributed over a greater size range (Figure 5).

Table 3. Mean length at age of dace from Irish rivers.

	n	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
B'water '73	93	5.28	11.51	16.37	19.67	21.74	23.40
B'water '02	38	5.64	10.09	14.37	17.26	19.47	21.08
Maigue '04	63	5.67	11.50	17.41	20.77	21.65	23.77
Nore '04	14	6.36	11.80	16.58	19.61	21.40	22.84
Barrow '04	34	5.86	10.24	14.90	18.03	20.72	20.79
Mulkaer '04	49	4.24	8.40	10.81	14.03	15.25	

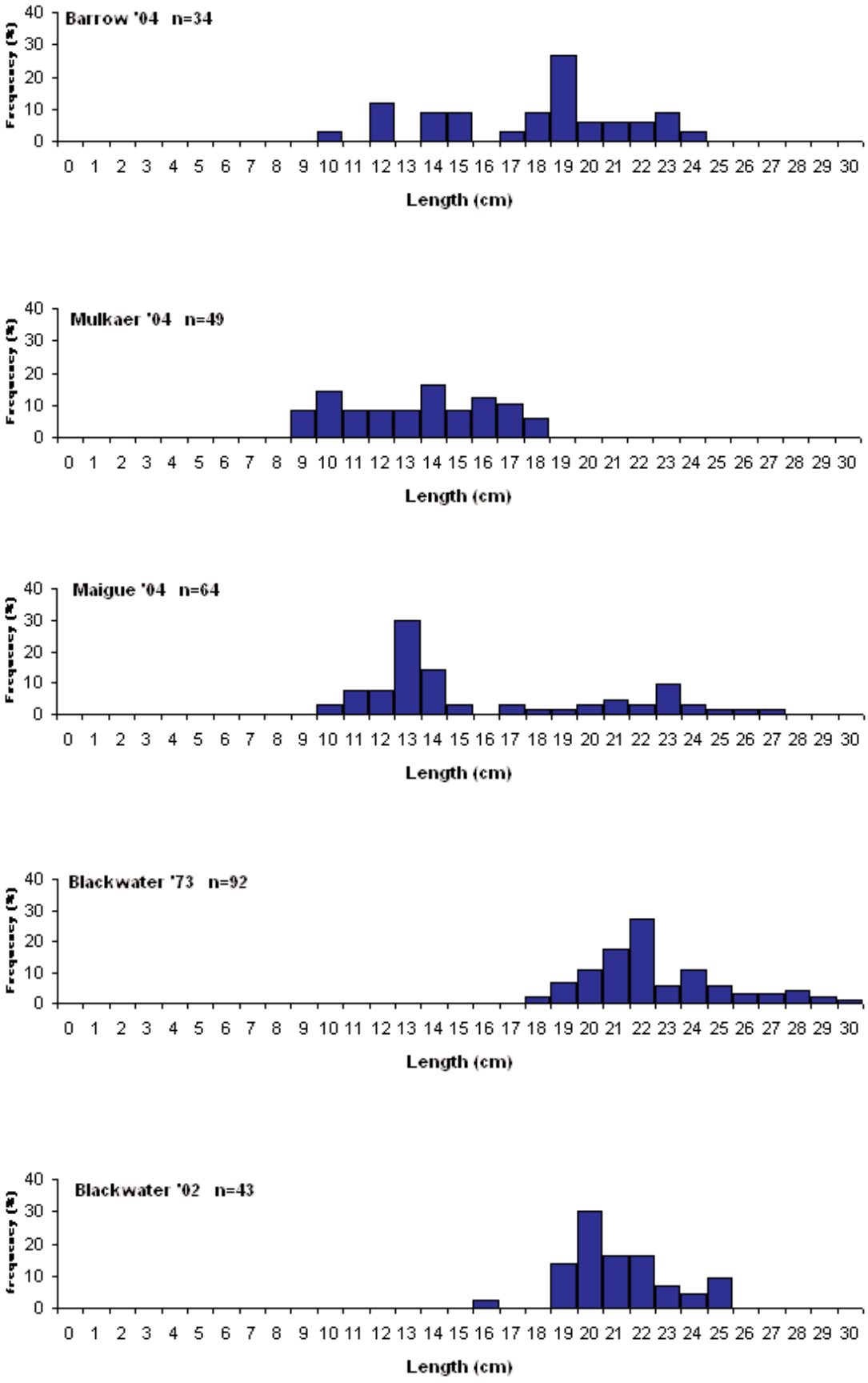

Figure 5. Length-frequnecy histograms for sites studied where n>30. Frequency is given as a percentage of the total population.

Table 3 and Figure 6 show the growth data from six of the rivers surveyed in Ireland. The slowest growth rate was recorded from the Mulkaer River, where fish at four years old measured 14.03cm. By contrast, the fastest growth was recorded from the invasive dace population on the River Maigue. Here, four year old fish measured 20.77cm. Four year old fish from the established population in the Munster Blackwater measured 19.67cm in the 1973 survey and 17.26cm in the 2002 survey (Table 3). The other invasive populations (i.e. River Barrow - 18.03cm and River Nore - 19.61cm) exhibited growth rates between these two values. Four dace, only, were collected from the Ahaclare River (Doon Lake system). It was, therefore, not possible to develop a reliable growth rate for this catchment. Dace from the River Nore were quite old, with all the fish examined being greater than six years of age. Analysis of scales from these fish provided sufficient data to derive a growth rate despite the relatively small sample size (n=15). Statistical analysis for length at age (Table 4) showed the Mulkaer population differed significantly ($p<0.001$) from all the other river populations at each age class.

Table 4. Comparison of length at age for each population studied; results of ANOVA's with Tukey post-hoc tests at year 4. ($F_{5,169}$= 45.75, p = 0.000, sig.)

	B'water '73	B'water '02	Maigue '04	Nore '04	Barrow '04	Mulcair '04
B'water '73						
B'water '02	***					
Maigue '04	ns	***				
Nore '04	ns	***	ns			
Barrow '04	**	ns	**	ns		
Mulkaer '04	***	***	***	***	***	

* p < 0.05, significant
** p < 0.01, very significant
*** p < 0.001, highly significant

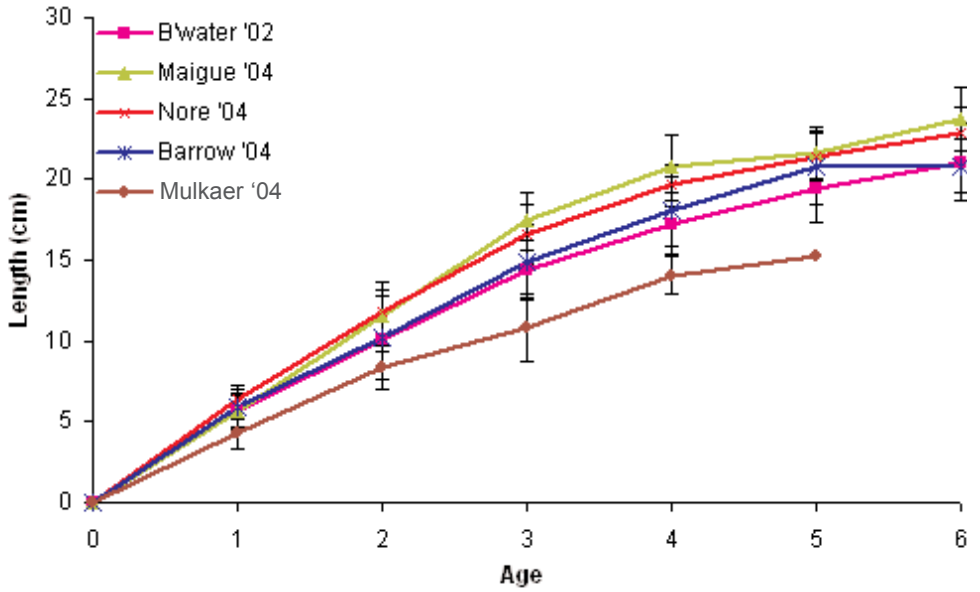

Figure 6. Growth rates for Irish populations of dace.

Discussion

Following their introduction to Ireland in 1889 dace remained confined to the Munster Blackwater for over 90 years. The last 25 years, however, has seen them spread into seven river systems in three different catchments. There are also unconfirmed reports of dace being caught from the River Liffey and the River Suir.

The rate of spread between different river systems appears to have slowed somewhat in the last five to ten years. Dace has expanded its range to such an extent that further spread will require it gaining access to new catchments. One exception to this is the River Shannon. At present the hydro-electrical power station at Ardnacrusha, approximately 10km upstream from Limerick, appears to represent an insurmountable barrier to the fish. Cragg-Hine and Jones (1969) refer to the difficulties dace have in passing man-made barriers. As no dace are present above the dam it appears they are unable to use the fish lifts installed for migrating salmonids. However, if the dace were to pass the dam, it would have the capacity to colonise the whole River Shannon catchment. The Shannon-Erne Waterway, towards the upper limit of the River

Shannon, represents a corridor to Northern Ireland, which the fish could use to access the River Erne catchment. The River Barrow, which holds an extensive stock of dace, is also connected, *via* the Grand Canal, to the River Shannon. It is, therefore, currently possible for fish to move between these two systems. However, as yet, no dace have been recorded from any Irish canal. Considering the substantial increase in range achieved by dace in the last twenty-five years, it seems inevitable that it will further expand its range.

Another mechanism of spread available to dace may be *via* estuaries. A number of Irish rivers containing dace join at their tidal reaches. The Barrow and Nore Rivers join at New Ross before entering the sea at Waterford, while the Shannon, Mulkaer, Maigue and Ahaclare Rivers all flow into the Shannon Estuary. Dace have the ability to osmoregulate in tidal waters (O'Hara, 1976) and fish have been recorded from the tidal reaches of all the rivers surveyed. It is possible that, in periods of flood, when the estuaries are less saline than normal, dace could move from the tidal reaches of one river to another. This could explain the presence of dace in waters linked by estuaries and their absence in other river systems in the locality. For example, dace are present in the Ahaclare and Maigue Rivers, which enter the top of the Shannon Estuary, near Limerick. No fish have been recorded in the Fergus or Deel Rivers, which enter further down the estuary. The fish may have been able to move from one river to another through the brackish water at the top of the estuary but not through the more saline waters closer to sea. Further study is needed in order to better evaluate this theory.

While natural migration plays a large part in the spread of dace, the unregulated movement of fish by anglers may be more important. The initial introduction of dace to Ireland was carried out by British pike anglers and, more recently, coarse anglers have been known to move fish around the country. As dace feed all year round and reside in large shoals, they are highly prized by coarse anglers. Anglers often transfer fish in the hope of improving their local angling amenity. While this was not the intention of the initial introduction, it probably best explains the more recent movement of dace from one catchment to another.

The unregualted movement of fish by anglers from one water to another contravenes current Fisheries Board policy. While such movements are not illegal, as yet, they carry significant risk to resident fish populations in the receiving water. In addition the deliberate spreading of dace by human influence is not consistent with maintaining the

natural biodiversity of Irish waters.

Elevated growth rates are a feature of invasive populations. In this study, it was hypothesised that fish with the fastest growth rates would be recorded from waters that had recently been colonised. As a corollary, the growth rate among dace from established populations would be expected to be relatively slow. Fitzmaurice (1984) detailed this in relation to invasive populations of roach in Ireland, and it was predicted that Irish dace would exhibit similar characteristics. Scale reading proved otherwise, however. Dace from the Mulkaer River were the only population to show a significantly different growth rate to all other populations. In spite of its being one of the most recently colonised rivers, the population in the Mulkaer River exhibited the slowest growth rate (see Table 3). It also exhibited the lowest mean length and age of all the populations surveyed. It is, therefore, likely that natural factors in a river limit the growth of dace, repressing the elevated growth rate seen in invasive populations. The Munster Blackwater, site of the original introduction of dace to Ireland, was predicted to have a relatively slow growth rate, as it represented an old, established population. However, growth rates for both 1973 and 2002 populations were not significantly different to the other invasive populations, with the exception of the Mulkaer.

It appears that natural factors within individual waters, such as competition for food and habitat, has a greater bearing on growth rate of Irish dace than the length of time a population has been present. This theory needs to be tested further, however, as the only established population at present is in the Munster Blackwater. In time, current invasive populations will become established and dace will invade new systems. A larger dataset will be available and it will be possible to more thoroughly investigate the factors affecting growth rates of Irish dace. Further study is also necessary in the Munster Blackwater where dace exhibited slower growth in 2002 than in 1973. When compared with growth rates from the U. K. (Cowx, 2001) most Irish populations exhibited relatively fast growth, particularly after their third year.

As with all introductions of non-native species, there are a number of advantages and disadvantages to the invasion of dace in Irish waters. Dace add to the amenity value of the angling product for coarse anglers, providing added diversity and year-round sport. However, they will readily take a lure cast for a trout and are considered a nuisance by game anglers. The presence of dace in high densities also puts native species under increased pressure for food and space.

The most pressing of the threats posed by dace is the impact on native salmonids. Dace, trout and salmon have similar habitat preferences and all spawn over gravels in fast flowing water. Efforts to create and improve breeding grounds for salmonids in the Munster Blackwater have been hampered by dace moving onto the newly introduced gravels at spawning times (O'Grady M., pers. comm.). This not only limits the breeding grounds available to salmonids but also increases the number of dace present, through successful spawning of the latter. During the summer months the dace feeds heavily on the same aerial insects as juvenile salmon and trout (Weatherley, 1987). Due to the high densities in which dace are found, this can create a substantial drain on the food available to salmonids. Similarly, large shoals of dace will actively compete with the coarse fish already resident in the river.

The recent spread of dace bears a striking resemblance to that recorded for the roach. Although both species were introduced at the same time, roach expanded their range from the Munster Blackwater far earlier than dace, ultimately colonising practically the whole country by the mid-1980s. This expansion was facilitated by people moving them from the Munster Blackwater to different watercourses at the beginning of the twentieth century. This allowed roach to become established in different parts of the country, before further expanding through natural migration. Roach are now the most numerous fish in Ireland and have significantly impacted on species composition wherever they have been introduced (Caffrey and McLoone, 2003).

Any efforts to prevent the dace invasion following the same pattern must begin with educating anglers to the potential long-term impacts of introducing non-native species. Legislation is currently in place preventing the movement of live roach from one water to another (Bye-Law No. 561, 1973, Transfer of Live Roach) and it is recommended that this be expanded to include the dace.

Acknowledgements

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