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THE PRESENT STATUS OF FRESHWATER CRAYFISH IN IRELAND.

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ABSTRACT

Austropotamobius pallipes is the sole crayfish species in Ireland, where it is wide-spread in both lakes and rivers. Growth rates in lake populations are the highest recorded for this species. There are no records of any introduction of alien crayfish, but *A. pallipes* is known to have been moved around by human intervention. There is, however, no tradition of its use as food, and biogeographic considerations may suggest that the crayfish is not indigenous. This paper examines the current status of *A. pallipes* in Ireland, in the light of recent events : the verification of plague outbreaks despite the absence of American crayfish species, and the recent imposition of protected status.

Key-words : *A. pallipes*, ecology, lakes, Ireland, introductions.

LA SITUATION ACTUELLE DE L'ÉCREVISSE PRÉSENTE EN IRLANDE.

RÉSUMÉ

Austropotamobius pallipes est la seule espèce d'écrevisse présente en Irlande, où elle est largement répandue dans les lacs comme dans les rivières. La croissance des peuplements lacustres est la plus élevée. Aucune introduction d'écrevisses exotiques n'a été signalée, mais *A. pallipes* est considérée comme ayant été transplantée délibérément. En tout cas, il n'existe pas de tradition gastronomique, et sa répartition biogéographique suggère qu'elle n'est pas indigène. Cet article fait le point sur le statut actuel d'*A. pallipes* en Irlande, du fait d'événements récents : d'une part, la peste de l'écrevisse a été vérifiée en l'absence d'introductions d'écrevisses américaines ; d'autre part, *A. pallipes* a maintenant en Irlande le statut d'espèce protégée.

Mots-clés : *A. pallipes,* écologie, lacs, Irlande, introductions.

INTRODUCTION

Throughout its natural range across western Europe, the distribution and abundance of *Austropotamobius pallipes* (Lereboullet) has undergone dramatic reduction due to habitat destruction, pollution, the introduction of foreign crayfish species and the resultant spread of the lethal plague fungus, *Aphanomyces astaci* Schikora (HOLDICH and LOWERY, 1988).

A. pallipes is the only species of crayfish found in Ireland, and Ireland is now thought to hold some of the best stocks of this species, under least threat from external factors. It is thus believed to be of substantial conservation importance. This paper evaluates research on the current status and importance of Irish stocks, examines their distribution in Ireland and their ecology in streams and lakes, summarises their biological parameters, and assesses their status - native or introduced - before coming to a conclusion on their importance for conservation and the appropriateness or otherwise of current conservation strategies.

BIOLOGICAL INFORMATION ON IRISH CRAYFISH STOCKS

Current distribution in Ireland

A. pallipes occurs in both lakes and streams across Ireland, wherever calcium levels are appropriate (REYNOLDS, 1982). Stocks are widely distributed in lowland limestone regions of Ireland (LUCEY and McGARRIGLE, 1987 ; LOWERY and HOLDICH, 1988 ; HOLDICH and REEVE, 1991), although absent from some apparently suitable western habitats (REYNOLDS, 1989). Ireland's largest lakes (over 2000 ha) contain crayfish stocks only near mouths of inflowing rivers (REYNOLDS, 1982). Their scarcity may be owing to the abundance of eels, known to be voracious predators on crayfish (MORIARTY, 1973 ; REYNOLDS, 1979b). Prolific crayfish populations are situated in the lime-rich waters of the smaller midland lakes, though elsewhere in Europe *A. pallipes* is chiefly a stream-dweller, especially where its range overlaps with that of *Astacus astacus*. The Irish ecological situation is thus unique in Europe ; the species can express its maximum habitat range free from competition, from exploitation, and from disease problems associated with introduced species. However, since the first confirmed outbreak of the plague fungus in Lough Lene, Co. Westmeath in 1987 and its suspected recurrence elsewhere (REYNOLDS, 1988b ; MATTHEWS and REYNOLDS, 1990), repeated surveys have indicated the loss of stocks from several midland lakes (MATTHEWS and REYNOLDS, 1992 ; MATTHEWS *et al.*, 1993).

Growth and maturity in Irish crayfish

The biology of Irish *A. pallipes* stocks has been well studied (*e.g.* LAURENT, 1988 ; REYNOLDS *et al.*, 1992 ; MATTHEWS and REYNOLDS, 1995). *A. pallipes* breeds at a smaller size than the main commercial astacids such as *Astacus astacus, A. leptodactylus* and *Pacifastacus leniusculus*, normally maturing at 22-25 mm carapace length (about 5 cm total length) when 3-4 years old (REYNOLDS *et al.*, 1992). By comparison with other astacids, it is rather slow growing, reaching 9 cm total length and 40 g in 5 or more years, and an ultimate size of perhaps 12 cm (REYNOLDS *et al.*, 1992). Some data for Irish crayfish stocks are given in Table I.

Table I

Some biological data for Irish crayfish stocks (R = River ; L = Lake). All measurements are in mm. m = male ; f = female ; CL = carapace length ; TL = total length (90 mm TL is usual minimum capture size) ; % MI = per cent moult increment in length ; Fec = pleopodal fecundity counts.

Tableau I

Quelques données biologiques sur les stocks d'écrevisses en Irlande (R =Rivière ; L = Lac). Toutes les mesures sont en mm. m = mâle ; f = femelle ; CL = longueur de la carapace ; TL = longueur totale (90 mm est la taille légale de capture) ; % MI = pourcentage de l'augmentation de taille à la mue ; Fec = fécondité.

Site	modal sizes (CL)	max size	% MI	Fec : Mean(max)	Ref.
White L	f : 13, 20, 32, 35, 37		5.7m, 5.1f	55.5 (80)	
	m : 13, 21, 34, 39, 42, 44, 49	max 55.0			(1)
White L	f : 10.8, 23.5, 30.7, 35.5, 40	max 50.0			
	m : 10.8, 23.7, 30.7, 38.6, 45	max 58.5 (62.8 g)	%MI 2.6-21.7		(2)
White L				62.7 (112)	(3)
Lene L	f : 14-20, 30-31				
	m : 14-20, 39, 50	max 50	%MI 21%		(4)
Blessington L		max 52	%MI 6-9%		(5)
Lisheens R	f : 7.6, 13.2, 22.0	max 41			
	m : 7.6, 14.2, 20.8, 28.0	max 46			(2)

(1) MORIARTY, 1973
(2) O'KEEFFE, 1986
(3) WOODLOCK and REYNOLDS, 1988
(4) REYNOLDS and MATTHEWS,1997
(5) MATTHEWS and REYNOLDS, 1995

Ecology in Irish streams

Crayfish are well known in many Irish streams (REYNOLDS, 1982 ; LUCEY and McGARRIGLE, 1987), and their ecology has been studied in head-waters of the R. Liffey at 217 m elevation (O'KEEFFE, 1986), and at 100 m in the Clare River (McFADDEN and FAIRLEY, 1984) and Nore (O'BYRNE, pers. comm.). White-clawed crayfish have rather similar living requirements to those of brown trout *Salmo trutta*, both thriving in Irish streams with good water quality and moderate summer water temperatures ; however, juveniles are eaten by trout and eels. Crayfish are important in the diet of otter (McFADDEN and FAIRLEY, 1984). Juvenile crayfish feed on small invertebrates, particularly insect larvae and amphipods, while adults have a more varied diet including oligochaetes, fish and vegetation (O'KEEFFE, 1986). In the Liffey head-waters, the volume ratio of animal to plant matter in stomachs fell from over 5 : 1 in subyearlings to 1 : 1 in mature crayfish (O'KEEFFE, 1986).

Ecology in Irish lakes

A. pallipes occurs in many smaller lakes across Ireland, chiefly in areas containing Carboniferous Limestone (REYNOLDS, 1982 ; LUCEY and McGARRIGLE, 1987). Irish lake populations have been studied in Co. Westmeath at an elevation of 107 m, at White Lake (MORIARTY, 1973 ; O'KEEFFE, 1986 ; WOODLOCK and REYNOLDS, 1988b) and Lough Lene (MATTHEWS and REYNOLDS, 1992 ; REYNOLDS and MATTHEWS, 1993 ; MATTHEWS *et al.*, 1993) and at 200 m in Blessington Reservoir, Co. Wicklow (MATTHEWS and REYNOLDS, 1995).

In lakes, freshwater crayfish are recognised as keystone species with measurable impacts on benthic fauna and macrophytes, and thus on water quality. *A. pallipes* in Irish lakes crops aquatic macrophytes, particularly charophytes, checking increased primary productivity and stimulating regrowth (MATTHEWS *et al.*, 1993). Sharp lower boundaries are observed below the *Chara* zone, but it is unclear if these relate to depth, and hence to temperature and light penetration, or are a direct result of crayfish cropping. Healthy crayfish are rarely observed below the littoral zone ; those occurring lower are often infected with Thelohania (O'KEEFFE and REYNOLDS, 1983).

As important predators on the zoobenthos, crayfish may regulate the passage of benthic productivity to fish such as salmonids and perch (MORIARTY, 1963). In White Lake, subyearlings fed chiefly on entomostracans, also on small insect larvae while larger crayfish fed predominantly on charophytes, and the largest included a significant proportion of dead terrestrial vegetation (deciduous leaves) and juvenile crayfish. Animal to plant volume ratios fell from 6 : 1 for 0+ to 0.7 : 1 for large crayfish (O'KEEFFE, 1986). Larger crayfish prey on a wide variety of benthic invertebrates including snails, crustaceans and insect larvae (O'KEEFFE, 1986 ; MATTHEWS *et al.*, 1993), controlling abundance of some species ; gammarids, while important in the diet, coexist with crayfish, but burrowing caenid may-flies are reduced (MATTHEWS and REYNOLDS, 1992 ; MATTHEWS *et al.*, 1993). As well as fish, dragon-fly nymphs and large crayfish may be important invertebrate predators on juvenile crayfish in Ireland (O'KEEFFE, 1986).

DISCUSSION

Assessment of status

A. pallipes is presumed native in Ireland, but without definitive evidence (REYNOLDS, 1979a, 1979b, 1989). Early records of crayfish in Ireland are given in RUTTY (1772) ; a later writer suggested that it may have been introduced (THOMPSON, 1843).

Because Ireland was cut off from the continent by rising seas early after the last glaciation, only freshwater forms with an arctic-alpine tendency can have persisted to recolonise from periglacial *refugia*. Even amongst insects with a winged terrestrial phase, numbers of Irish species are around 70 % of British or continental species numbers. Most Irish freshwater fishes are either euryhaline (*e.g. Gasterosteus),* diadromous (*e.g. Salmo, Salvelinus)* or are recognised to have been introduced. In some, the evidence for introduction is clear, *e.g. Esox* (17th century) and

Rutilus (19th century) ; in others (*e.g. Phoxinus, Tinca),* it is strongly suspected. Some fishes were introduced in the Middle Ages, perhaps by the large continental religious orders with their centralised economies ; other fish and invertebrates were more recent introductions. *A. pallipes*, intolerant of salt water, may have been one of these (REYNOLDS, 1989). Its genetic similarity to Belgian, French and Corsican stocks is notable (ATTARD and PASTEUR, 1984) and indeed, the British and northern French stocks are also closely similar (GRANDJEAN *et al.*, 1997).

Whatever their origins, crayfish are now an integral part of many Irish freshwater ecosystems, where they have a fast growth rate and occupy a wide range of habitats (lakes and streams) generally free from competition, from exploitation, and from disease problems associated with recently introduced species. Historical reports suggest human-mediated movement of crayfish stocks between catchments within Ireland (REYNOLDS, 1982) ; however, there is no tradition of crayfish fishing. There are also no recently introduced crayfish species, such as are present in Britain and elsewhere in Europe.

Non-native crayfish species are prohibited entry to Ireland under the Fisheries Acts ; a measure which has so far been successful in preventing the spread of exotic crayfishes to this country. Protected under the Irish Wildlife Act (1975), Irish stocks of *A. pallipes* remain wide-spread and abundant, whereas the decline in numbers throughout the rest of its European range has resulted in its inclusion as a threatened species under the EU Habitats Directive. Ireland's crayfish populations are thus today considered of European importance and are protected under international and national legislation. Several options are thus open for its conservation - restoration of recently lost lentic stocks, range extension through establishment of new lake stocks, and introduction to man-made habitats (REYNOLDS, 1988a).

Restoration of lentic stocks

In mainland Europe, restocking of plague-susceptible native crayfish may be hampered by reinfection from exotic species which carry the plague fungus. There are no alien crayfish in Ireland, which enhances the possibilities for stock restoration or introduction to suitable new habitats. However, restocking is seldom done in Ireland, particularly since the crayfish has received protected status.

Natural stocking must have occurred in instances where a stock was eliminated or a new habitat created. Blessington Lake came into existence through the construction of a dam on the upper Liffey River in 1941. Fish traps set in 1958 and stomach samples of resident trout (*Salmo trutta* L.) and perch (*Perca fluviatilis* L.) provided early evidence of lake stocks of crayfish (MORIARTY, 1963). More recent reports for crayfish in Blessington Lake are given by REYNOLDS (1982), who also recorded two populations upstream of the lake, one of which was studied by O'KEEFFE (1986). A Blessington Lake study between 1989 and 1993 indicated about 5 trappable (adult) crayfish per m2 of suitable shoreline (MATTHEWS and REYNOLDS, 1995). This lake population has developed within the 50 years' life of this reservoir. The findings suggest a sparse, patchily distributed population limited by its environment and unlikely to sustain commercial harvesting.

Certain of the smaller midland lakes (*e.g.* L. Lene, Pallas Lake) have recently lost their crayfish stocks, through pollution, or through disease (REYNOLDS, 1988b). Crayfish populations in Lough Lene received brief study in 1987, just before they were eradicated by crayfish plague (REYNOLDS and MATTHEWS, 1993). Crayfish were experimentally reintroduced in 1989 and 1991, and in July 1996, a search by SCUBA and shallow-water netting yielded evidence of successful crayfish reproduction in most years (REYNOLDS and MATTHEWS, 1997). One immature female found in association with its 14 mm CL *exuvium* had a 3 mm (21 %) growth increment, about twice the average for White Lake crayfish of this size.

We have thus demonstrated that stocks can be re-established, particularly as there are no exotic species which would carry the crayfish plague fungus *Aphanomyces astaci* (MATTHEWS and REYNOLDS, 1992). This is important in stock management in a European context as *A. pallipes* is highly endangered elsewhere in Europe. Comparable restocking efforts elsewhere in

Europe have met with limited success owing to reinoculation of plague-susceptible native crayfish from disease resistant exotic species which carry the plague fungus. This greatly enhances the possibilities for stock restoration in Ireland, or introduction to suitable new habitats.

Certain lakes, apparently suitable for crayfish, have never held stocks for geographic reasons such as the absence of outflowing streams. One such lake is Ballinlough, Co. Mayo, managed as a sports fishery by the Salmon Research Agency of Ireland. Ballinlough is an alkaline, spring-fed lake, somewhat similar to the lime-rich crayfish lakes of the Irish midlands. Local information suggests crayfish were formerly present in the lake (GILL, pers. comm.) and they may still be found within 10 km of it (LUCEY and McGARRIGLE, 1987). It is hoped that a new population of *A. pallipes* may be established in this lake using local stocks, and their impact on the ecosystem carefully monitored (MATTHEWS, pers. comm.). Finally, the suitability of new water-bodies developed on cutaway peatlands is under investigation for crayfish.

Conservation implications of crayfish introductions into lakes

A. pallipes is wide-spread and well established in Ireland, even if not unequivocally native. The present distribution of white-clawed crayfish undoubtedly reflects their having been moved around Ireland in the past (REYNOLDS, 1982). Fundamental objections to further altering this distribution in a controlled and recorded manner are therefore difficult to sustain.

A. pallipes has recently been protected in Ireland under the Wildlife Act, and because of its rare and declining status elsewhere in its European range is now listed under the EU Habitats Directive. Any translocation or exploitation will require licensing. As populations are threatened, particularly in Britain and continental Europe, establishment of new populations without danger to existing stocks should be welcomed (REYNOLDS and MATTHEWS, 1995). Similar research and management objectives are recognised by crayfish researchers in France, Spain, Portugal, Germany and U.K. (WESTMAN and MANNINEN, 1996).

As they may feed on dead or dying fish, astacid crayfish have been suspected on the continent to act as mechanical carriers of diseases such as IPN virus, originating in America. The prohibition under Fisheries legislation of exotic crayfish imports into Ireland is designed to protect our salmonid fisheries, but this import ban has also been used to provide protection for native crayfish from exotic species proposed for farming, particularly *Pacifastacus* which carries crayfish plague. There has been, however, no study of viral presence in the native crayfish, which coexists with salmonids in much of the country.

Potential for exploitation of Irish crayfish

While elsewhere in Europe *A. pallipes* is regarded as a delicacy, Irish crayfish stocks, like those of Great Britain, are unusual in being both wide-spread and almost unexploited. They thus provide valuable data on the dynamics of undisturbed decapod populations. The slow growth and relatively small final size of *Austropotamobius pallipes* make it uneconomic today in a commercial fishery, but the resource could sustain small scale recreational fisheries. Capture data from Blessington Reservoir (MATTHEWS and REYNOLDS, 1995) and Lough Lene (REYNOLDS and MATTHEWS, 1993) indicate a potential mean CPUE of around one crayfish of edible size per trapnight. Irish river sites have yielded much higher catches (O'KEEFFE, 1986).

Impacts of a recreational fishery are likely to be minor to the species. *A. pallipes* breeds at 50 mm total length, but is not ready for the table for at least two years thereafter ; also, very large females have unpredictable egg numbers and sizes (WOODLOCK and REYNOLDS, 1988a, 1988b ; REYNOLDS *et al.*, 1992). Despite a rather low reproductive rate (an average of 60-80 eggs per year), under good conditions a population in excess of 1 million crayfish could be produced from a single pair inside 10 years. It is thus not likely that any fishery would affect stocks.

The establishment of selected crayfish recreational fisheries could have beneficial results. Ireland is known as an angling country, and as with salmonids, the economic potential of crayfishing is almost unrelated to their market value. Controlled exploitation of crayfish stocks could also increase fundamental scientific knowledge : the fishery could be regulated by scientific management, using size, sex and/or numerical controls on catches, in order to answer fundamental questions such as the impact of large males on population structure. At the same time, suitable publicity could enhance our awareness of the importance of this invertebrate within the aquatic food-web.

There is, however, a threat of crayfish plague from traps brought in by visiting anglers, which may be infected with *Aphanomyces* zoospores. Any exploitation should therefore be controlled, perhaps in relation to a recreational fishery with gear supplied. The danger to established stocks that visiting fishermen may introduce either exotic species or disease is minimised if only new stocks are fished, while the conservation status of the species may be enhanced.

Ultimately, increased public knowledge and awareness of this valuable, but hitherto neglected, fishery may represent the best long-term conservation strategy for this important freshwater species. By analogy with salmonids, whose successful conservation has been fostered through such measures by angling interests, carefully regulated recreational fisheries could provide commercial returns without endangering native stocks (REYNOLDS and MATTHEWS, 1995).

CONCLUSION

The information suggests that the white-clawed crayfish is doubtfully native in Ireland - only genetic studies will make this status clear. Irish stocks are nevertheless of European importance for conservation of the species, and lake habitats may provide a safe haven and ultimately a source for reintroduction.

While encouraging the conservation of Irish crayfish in a European context, we have advocated permitting establishment of new crayfish stocks in Irish waters and some exploitation of selected stocks, rather than enforcing total protection. Regulated exploitation of certain stocks would have benefits in providing fundamental information on the impacts of varying exploitation rates on population dynamics.

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