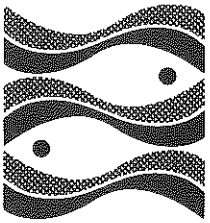
SERIES A (Freshwater) No. 29 1987



IRISH FISHERIES INVESTIGATIONS

J. Lucey and M. L. McGarrigle

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Roinn na Mara
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The distribution of the crayfish *Austropotamobius pallipes* (Lereboullet) in Ireland

by

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ABSTRACT

The distribution of *Austropotamobius pallipes*, the only freshwater crayfish recorded from Ireland and presumed to be an old native, is described using some 300 records collected since 1976: the positive and negative loci from regularly sampled rivers and streams are used to provide a baseline from which any future changes in distribution can be monitored. Although absent from some regions, most notably the south-west (south of the Dingle-Dungarvan line) and north-west (County Donegal), crayfish are widely spread in the country principally in Carboniferous Limestone areas. The natural chemistry characteristics of the river and stream sites supporting crayfish had the following ranges: pH 7.2 - 8.4, alkalinity 34 - 356 mgl^{-1} and hardness 47 - 402 mgl^{-1}. Factors which might be important in influencing distribution of *A. pallipes* in Ireland, including pollution, predation and disease, are discussed.

INTRODUCTION

The freshwater crayfish found in Ireland has been recorded as *Cancer astacus* (Tighe, 1802), *Astacus fluviatilis* (e.g. Rutty, 1772; Templeton, 1836; Fairley, 1972), *Potamobius pallipes* (Scharff, 1907; Kennedy & Fitzmaurice, 1971), *Astacus pallipes* (Frost, 1942) and *Austropotamobius pallipes* (e.g. Moriarty, 1973; Reynolds, 1982). In the Gaelic language many synonyms have also been used to describe the crayfish (Lucey, in preparation). *Austropotamobius pallipes* (Lereboullet) is apparently the only species occurring – reports of the presence of the European crayfish *Astacus astacus* (Linnaeus) in one lake have not been authenticated (C. Moriarty, personal communication) – and although presumed to be native the possibility of introduction by human agency cannot be ruled out (Lucey, in preparation).

The known occurrence of the crayfish was summarised in the mid-nineteenth century (Thompson, 1843a; 1843b) and in the early part of this century some brief chorologies appeared recording their presence in various parts of the country (e.g. Phillips, 1908; Delap, 1909). More recently Reynolds (1982) has compiled notes on distribution of *A. pallipes* in lakes, rivers and streams which included some 50 modern (1977-82) records.

In Britain an updated distribution of *A. pallipes* has been presented (Jay & Holdich, 1981) to allay fears that stocks were declining. That study was prompted by reports that disease, including crayfish plague in which the fungus *Aphanomyces astaci* (Schikora) is the aetiological agent, and pollution were eliminating the indigenous crayfish. The introduction of exotic species such as the signal crayfish *Pacifastacus leniusculus* (Dana) for aquaculture projects has led to warnings from some workers (e.g. Holdich, Jay & Goddard, 1978; Pratten, 1980; Jay & Holdich, 1981) that their escape from captivity and subsequent establishment in British waters could pose a threat to *A. pallipes*.

No alien crayfish have been introduced to Ireland for aquaculture purposes (J. Doyle, personal communication). Reynolds (1979) advised against the importation of exotic species to Ireland fearing the displacement of *A. pallipes* through competition as well as the possibility of plague introduction and advocated rather feasibility studies on harvesting and farming the native form. In a report on aquaculture development, the National Board for Science and Technology (1982) proposed that crayfish farming could offer good potential in Ireland and included among pre-requisites the establishment of more detailed knowledge on distribution of natural stocks. Moriarty (1973) has referred to the disappearance of crayfish from a lake in the midlands and Faris (1936) noted that they vanished from and subsequently returned to the upper reaches of the River Erne. Reynolds (1978) found indications of a reduction in range in some areas which may have been attributable to such factors as habitat alteration, predation or disease.

It would appear that the publication of a detailed distribution of one of Ireland's largest freshwater invertebrates (only full-grown specimens of the mussels *Anodonta cygnaea* and *Margaritifera margaritifera* can attain a larger size) is desirable. The information will provide a baseline for the status of *A. pallipes* in the country from which any future changes can be monitored. In addition, together with the data on the species in Britain (Jay and Holdich, 1981) it will complete the distribution pattern for these islands.

METHODS

The data are based on records collected since 1976 from surveys of rivers and streams in Ireland (Republic) undertaken by the Water Resources Division of An Foras Forbartha (The National Institute for Physical Planning and Construction Research) supplemented by the recent recordings of Reynolds (1982) and others. The authors' distribution information was obtained during surveys carried out to monitor biological water quality. The surveys were undertaken chiefly in the June-September period of each year but additional special investigations were also carried out at other times and in some cases rivers were examined faunistically on a monthly basis for seasonal distribution study purposes.

The crayfish were collected by handnet sampling using a standard net with a mesh of 12 threads per centimetre. Pratten (1980), when discussing methods of crayfish capture, reported that trapping is selective since only mature active specimens are caught and found that a handnet must be employed if the small (0 + age class) individuals are also to be taken; Thomas & Ingle (1971) also found handnetting to be the only satisfactory method for collecting *A. pallipes* in a river survey. Crayfish captured during the present study were generally returned to the waters from which they had been taken but representative specimens were sometimes retained for positive species identification using the keys and characters of Gledhill, Sutcliffe & Williams (1976).

The water chemistry values contained in the paper are expressed as follows: pH as pH units, alkalinity and hardness (total) as mgl^{-1} $CaCo_3$.

The distribution data have been plotted on the 10 km squares of the Ordnance Survey National Grid and are presented in two ways: the river and stream sites regularly sampled by An Foras Forbartha are used to display positive and negative loci for *A. pallipes* within the 10 km squares (densities of sites are included so that centres of distribution can be discerned); the positive records from that study are combined with those of other workers to provide an overall distribution of crayfish in lakes, rivers and streams throughout Ireland based on presence or absence in the 10 km squares. The Ordnance Survey grid references for the authors' records are listed in the Appendix, those for Reynolds' (1982) records have not been repeated here and those for records personally communicated are contained in the text.

DISTRIBUTION

That the ionic concentration of rivers and streams is influenced by local geology is well established (e.g. Shoup, 1947; Gorham, 1961; Egglishaw & Morgan, 1965; Hynes, 1970; Hutchinson, 1975) and Conway (1942) using the data of Clarke (1924) has tabulated the average ionic composition of various rock types showing the high calcium (Ca) and carbonate (Co_3) content of limestone compared with other sedimentary and igneous rocks. The waters draining different surface formations will vary in the amount of these ions according to, among other factors, the lithology of the bedrock and its resistance to weathering. Because crayfish, in common with many other Malacostraca, secrete exoskeletons of calcium carbonate they are most often found in harder water where these two ions are more readily available

(Hynes, 1970). It is to be expected therefore that *A. pallipes* should be more common where waters are influenced by easily weathered substrata rich in $CaCo_3$, such as limestone, than in areas of resistant acidic bedrock. Based on this premise the occurrence of crayfish is traced with the solid geological structure of the sites as background to establish whether such a relationship exists.

In the Boyne catchment, where the geology is predominantly Carboniferous Limestone, *A. pallipes* was found in the main river as well as at sites on the Athboy, Blackwater, Blackwater (Kells), Castlejordan, Deel, Knightsbrook and Moynalty: Reynolds (1982) listed it as abundant in Loughs Bane and Lene in this catchment also. The two tributaries (Devlin and Mattock) which join the main river upstream of Drogheda having travelled over Silurian grits and slates were negative when sampled.

No crayfish were recorded from the rivers surveyed in County Louth where the bedrock is mainly Silurian. Nor were they present in the rivers sampled in north County Dublin where Carboniferous Limestone is the dominant rock type but the area has a sizeable proportion of rivers affected to some degree by pollution.

The Liffey passes over granite, Ordovician grits and slates and then limestone; *A. pallipes* was recorded in the main river and two of its tributaries (Morrell and Rye Water) at sites which overlie limestone strata. Frost (1942) in a fauna survey of the Liffey listed crayfish as occurring at Straffan ("pH 8.4 and hardness 155 ppm") while upstream at Ballysmuttan ("pH 6.8 and hardness 6.7 ppm") they were absent. During the present study the authors have also found populations at the former site which is on limestone but not at the latter where the bedrock is granite. The three tributaries examined which proved negative pass over limestone but had polluted stretches.

In the rivers surveyed in County Wicklow, where granite and shales of Ordovician age preponderate, crayfish were for the most part absent e.g. in the Avonmore-Avoca system where pH and alkalinity were low. *A. pallipes* has however been recorded from a part of the county in waters of medium hardness; in Poulaphouca Reservoir (Moriarty, 1963) and from the Brittas river (O'Keeffe & Reynolds, 1982) where glacial limestone gravel overlies the granite and Ordovician slate and schist (Farrington, 1942). The Brittas River crosses the county border and Moriarty (personal communication) has found specimens in County Dublin (0 02 21).

The Slaney rises in and traverses areas of intrusive bedrock type including granite and felsite and then runs over Ordovician grits and slates. No specimens were obtained from the Slaney or the ten tributaries surveyed – reports of crayfish sightings in one tributary, the Bann, were not verified by subsequent sampling. The rivers to the east of the Slaney catchment flowing to the Irish Sea over Ordovician strata were also apparently without crayfish when sampled. Crayfish were collected at eight locations on the Barrow – seven on limestone the eighth on granite – and from six of the eighteen tributaries examined. The Nore for a large part of its course traverses limestone plains and then Old Red Sandstone below Thomastown. Before joining the Barrow it runs over Ordovician strata. The upper reaches supported populations of crayfish. The sites on the nine tributaries where crayfish were found were largely limestone regions but they occurred on other Carboniferous rocks also e.g. the Castlecomer Stream site is in an area of Coal Measures while the positive site on the Dinin overlies Millstone Grit and flagstone. In this area also the Muckalee contained crayfish at the site overlying limestone but not at the other location examined which is on Upper Avonian shales and sandstone. The Suir travels over limestone on its course until it crosses Old Red Sandstone at Newcastle and *A. pallipes* was present at four of the sites examined as well as at twenty-one sites on eleven of its tributaries. The vast majority of the positive sites in the catchment were from limestone regions, the two exceptions being the sites overlying Silurian sediments on the Clodiagh (Waterford).

South of the 'Thrust Fault' running from Dungarvan in the south-east to Dingle in the south-west (Charlesworth, 1963; Whittow, 1978) where the older rocks (Old Red Sandstone) have been deposited on the newer rocks (Carboniferous) no crayfish were obtained. The River Lee and its tributaries are below this plane of rock dislocation while the Blackwater runs close to it as it flows in a west-east direction. Toner & O'Connell (1970) examined the Blackwater and Martin rivers and did not record *A. pallipes* among the fauna. One tributary of the Blackwater, the Awbeg, flowing over limestone strata did have crayfish at six sites but the other tributaries above the folded zone such as the Allow running over Millstone Grit series and the Araglin passing through Old Red Sandstone country did not contain crayfish. *A. pallipes* was not recorded from the Caragh, a soft, slightly acidic river system flowing over Old Red Sandstone in County Kerry (Dowling, O'Connor & O'Grady, 1981).

The River Feale, lying between the Blackwater to the south and the Shannon Estuary to the north, which flows over Millstone Grit and flagstone did not harbour populations of crayfish. The Deel passing through limestone countryside did not yield any crayfish but the river is excessively eutrophic over most of its course (Lennox & Toner, 1980; Clabby 1981). *A. pallipes* was found in two rivers in this region, the Loobagh and Morningstar, where the strata are mainly limestone. Across the Shannon Estuary in County Clare where the bedrock is chiefly Millstone Grit and flagstone , crayfish were not recorded e.g. River Inagh. The apparent absence of *A. pallipes* from the north Clare limestone plateau, known as the Burren, may be explained by the lack of surface rivers where due to the porous nature of the rock the Karst topography is characterised by underground drainage.

In the west the Corrib system includes Loughs Carra, Corrib and Mask and crayfish were found in the first two of these lakes (Reynolds, 1982) and in the feeder rivers, Abbert, Clare, Dalgan, Grange, Robe and Sinking flowing from the east over Carboniferous Limestone. West of the lakes the bedrock includes shales and sandstone of Ordovician age, schist and gneiss as well as granite and the rivers influenced by these rocks of minimal carbonate content did not support crayfish. *A. pallipes* was present at one of the four sites examined on the Westport river. The river flows from an area of Carboniferous Limestone through Avonian shales and sandstones to schist and gneiss strata before its ingress to Clew Bay. With a longitude of 9° 32'W this site is further west than the Atlantic coasts of Portugal and northern Spain and these crayfish are among the most westerly populations in Europe.

A. pallipes was not found in the Moy but five of its tributaries (Glore, Owengarve, Sonnagh, Swinford and Yellow) and two of the feeder rivers to Lough Cullin (Castlebar and Manulla rivers) and one to Lough Conn (the R. Deel) within the catchment did yield records. The Moy and its tributaries cross the granite and schist of the Ox Mountains having first traversed limestone strata. To the west the Carboniferous series give way to quartzite, schist and gneiss and the rivers in this area apparently did not hold crayfish.

A. pallipes was recorded from the Owenbeg, the Bonet and its tributary the Owenmore where four of the five positive sites overlie Carboniferous strata (Carboniferous Limestone and Avonian shales and sandstones). Large numbers occur also in a small lake, Lough na Leibe (G 72 12), near Ballymote (J. Caffrey, personal communication).

Crayfish did not occur in the rivers surveyed in the extreme north-west (County Donegal) of the country where the strata are predominantly schist-gneiss, granite and quartzite.

The Erne system includes Upper and Lower Lough Erne, Loughs Gowna and Oughter. South of the border with Northern Ireland *A. pallipes* was collected from the main river and six of its tributaries at eighteen sites and Reynolds (1982) reports its occurrence in L. Gowna. In Northern Ireland apart from some lakes of the Erne system in the Fermanagh area Reynolds lists recent records of crayfish from only one river, the Ballinderry, a tributary of the R. Bann (L. Neagh).

The Shannon with its tributaries drains about one-sixth of Ireland flowing over Carboniferous strata until the main river reaches Killaloe where it meets the hard Silurian barrier in the lower part of its freshwater course. Crayfish were found to occur in the upper reaches and in twenty two of its tributaries. Some tributaries from east Clare, north-east Limerick and north Tipperary emptying into the lower mainstream and Lough Derg cross Silurian strata rimmed by Old Red Sandstone and these rivers apparently did not have *A. pallipes* among their fauna. Crayfish are known to occur in many of the lakes in the Shannon system e.g. Carrigaport Lake and Lough Ree (Reynolds, 1982) as well as Loughs Glore (N49 72), Owel (N40 56) and White Lake (N51 72) (J. Caffrey, personal communication).

DISCUSSION

The prime objective of the study has been to determine the distribution of crayfish in Ireland and from this to deduce whether the distribution pattern corresponds with calcareous areas. The aspect of geology and natural chemistry of sites together with other factors which might be important in regulating distribution will form the basis for discussion.

From the results presented it is apparent that *A. pallipes* is widely spread in the country inhabiting lakes, rivers and streams. Some 1800 sites on rivers and streams throughout the country were examined of which 243 contained crayfish (Fig. 1). These records together with those of other workers give a total of 300 loci for *A. pallipes* from which the distribution pattern for the species is constructed (Fig. 2).

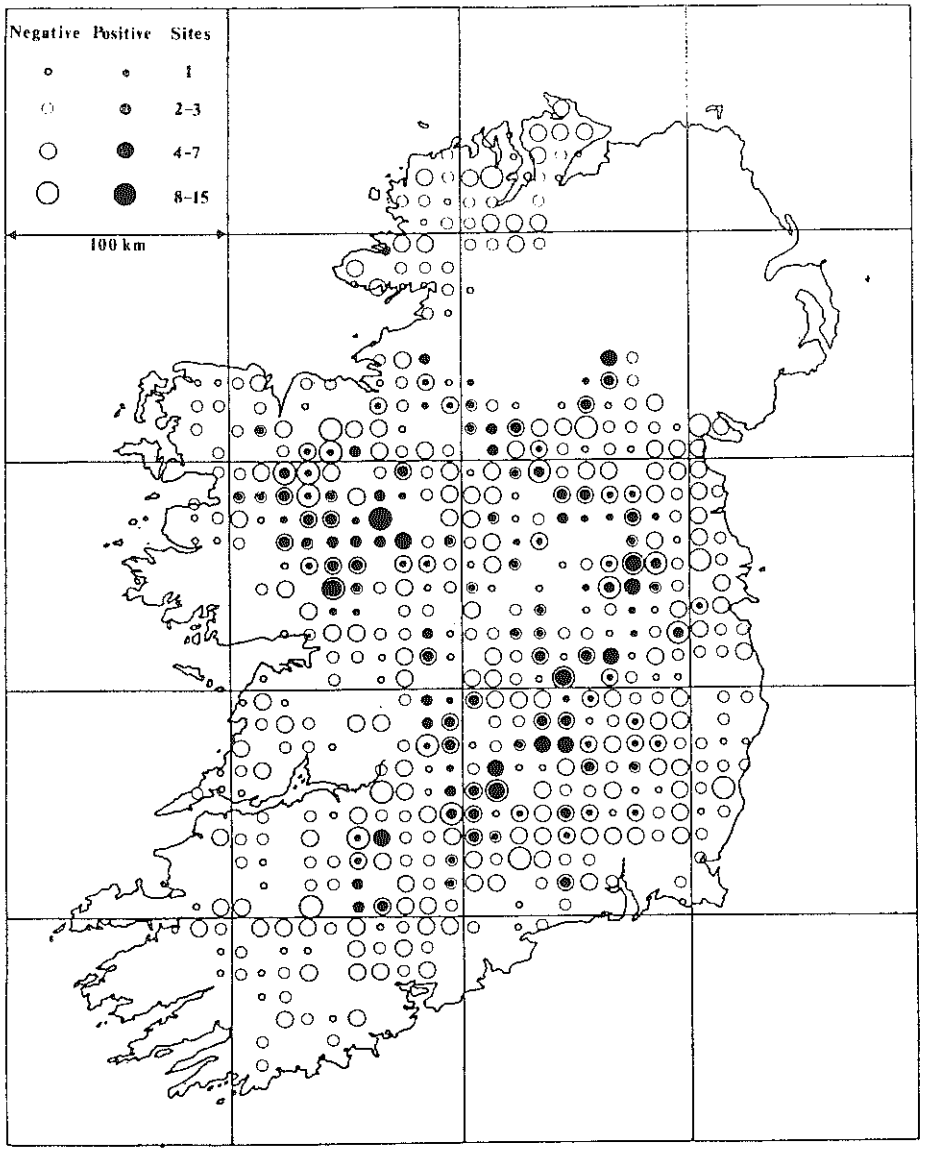

FIG. 1. The distribution of *Austropotamobius pallipes* in regularly sampled rivers and streams in Ireland (Republic) from records collected since 1976 and based on 10 km^2. Open circles represent the sites sampled which were negative and the solid black circles are the sites where the species has been found; the size of the circle indicates the number of sites in that 10 km square.

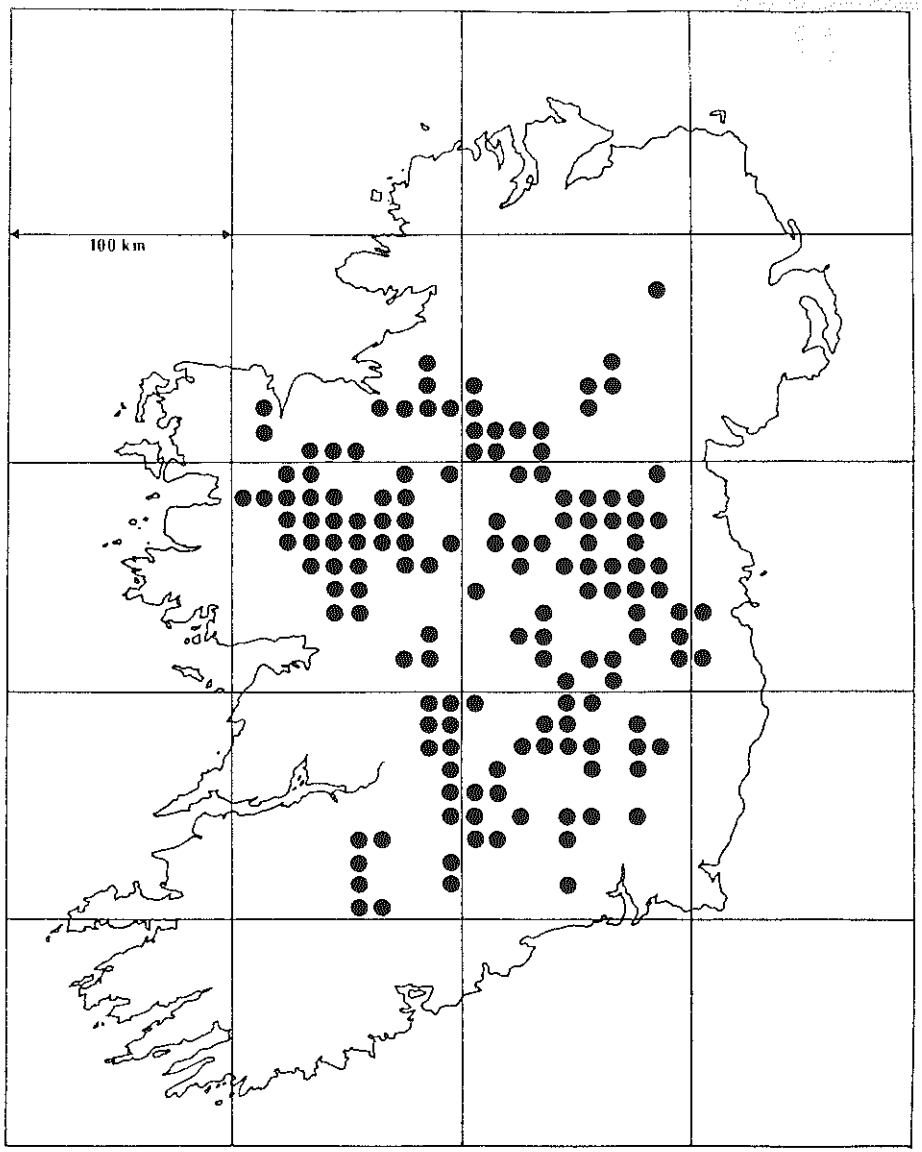

FIG. 2. The distribution of *Austropotamobius pallipes* in Ireland from records collected since 1976, based on presence in 10 km squares.

The sites on the regularly sampled rivers and streams from which crayfish were recorded had the following natural chemistry characteristics: pH 7.2 - 8.4, alkalinity 34 - 356 mgl^{-1} and hardness 47 - 402 mgl^{-1}. The occurrence in respect to solid geology and chemistry of the sites is summarised in Table 1 and this shows that the majority of collections (89%) were from Carboniferous strata with the bulk (83%) on Carboniferous Limestone.

TABLE 1 Occurrence of *Austropotamobious pallipes* with respect to solid geology and water chemistry (median values) at sites on regularly sampled rivers and streams. Figures in parentheses are the sites which were examined on each particular rock type : 4.4 per cent of the sites examined were on rock types other than those represented in the table.

Solid Geology	Occurrence (%)	pH	Alkalinity (mgl^{-1})	Hardness (mgl^{-1})
Coal Measures	0.4 (0.3)	8.1	96	107
Millstone Grit and Flagstone	0.8 (2.6)	8.0—8.1	51—150	66—181
Avonian Shales and Sandstone	4.5 (7.6)	7.7—8.4	45—219	83—250
Carboniferous Limestone	83.1 (56.4)	7.7—8.4	52—356	64—402
Old Red Sandstone	2.9 (3.9)	7.8—8.3	89—189	90—200
Silurian Grits and Slates	4.1 (7.5)	7.7—7.9	34—89	53—103
Ordovician Grits and Slates	2.1 (7.9)	7.2—7.4	35—45	47—61
Schist and Gneiss	0.4 (4.9)	8.2	105	127
Granite and Felsite	1.6 (4.5)	7.9—8.2	126—258	150—304

The distribution of crayfish in Britain shows a similar pattern with the great majority of occurrences from chalk- and limestone-bearing substrata with a few sites in Wales and Devon on Old Red Sandstone and more permeable sandstone (Jay & Holdich, 1981). It would appear that the distribution of *A. pallipes* in Ireland is correlated with easily weathered substrata rich in calcium carbonate even when allowance is made for the relatively high proportion of sites examined on Carboniferous Limestone.

The percentage occurrence (11%) on non-Carboniferous, less easily weathered rock types showing higher than expected natural chemical characteristics may at first glance seem surprising but many of these river and stream sites (e.g. lower R. Barrow on granite and R. Bonet on schist – gneiss) are influenced by limestone further upstream while others have coverings of calcareous glacial drift material influencing the waters where the rivers have not as yet reached the underlying rock floor (Freeman, 1950; Charlesworth, 1966). The two sites on the Clodiagh in Waterford are Silurian sediments but the river flows through a plateau where the exposure of grey slates and greenish grits has created a comparatively fertile tract of soils in an area of otherwise barren heathery hills (Whittow, 1978). An examination of the glacial drift deposit map (Royal Irish Academy, 1979) shows that almost all the 27 sites from the non-Carboniferous areas which supported crayfish populations have some covering with till.

No direct relationship between distribution of *A. pallipes* generally and occurrence of particular drift material or soil type was discernible. The distribution does however show correspondence with lowland areas – the island is rather flat having a saucer shape due to the marginal mountain ranges with the topographically high areas mostly composed of the more weather resistant rock types. Although crayfish appear to be rare at heights above about 150 m they have been recorded at higher altitudes e.g. Dorrity (1945) and Moriarty (1963). The absence of marked watersheds in the Central Plain has doubtless aided the dispersal of many aquatic organisms (Praeger, 1950) including *A. pallipes* (Reynolds, 1978).

The values for alkalinity and hardness of waters containing crayfish show a wide range but the majority of the sites were greater than 100 mgl^{-1} for both parameters. The rivers at the lower end of the range such as the Clodiagh (Waterford) and Dinin apparently support low numbers of *A. pallipes* as evidenced by the very few specimens captured on each sampling occasion. The hydrogen ion concentration is related to alkalinity and hardness and may affect the normal uptake of other ions by *A. pallipes* (Shaw, 1960) as well as acting indirectly through limiting food supply of benthic invertebrates generally (Sutcliffe & Carrick, 1973). The pH range (7.2 - 8.4) recorded for crayfish sites in the present study is narrower than that (6.0 - 9.2) reported by Jay & Holdich for British waters but with few exceptions Irish river values lie between 5 and 8.5 and most fall within the range 7.5 - 8.5 (Flanagan & Toner, 1972).

In the course of the study *A. pallipes* was apparently absent from rivers sampled in some areas viz. Clare, Donegal, Dublin, Kerry, Louth, Wexford and the greater part of Wicklow. In Dublin crayfish are present in the Brittas River. They were recorded from the R. Tolka by Rutty in the eighteenth century but in recent times the river has been seriously polluted over most of its length (Flanagan, 1974; Lennox & Toner, 1980) and *A. pallipes* has not been found by the authors nor by others (O'Connor & Bracken, 1980) during faunal surveys. Crayfish holdings in the British Museum of Natural History evince that they were also present in the R. Dodder in 1905 (R. Ingle, personal communication). Crayfish were reported from two rivers in the limestone south of Donegal in the early part of this century (Allingham, 1909; Crawford, 1909) but no recent records exist for that county. They were found in only one river in Cork, the Awbeg, a tributary of the Blackwater which is on limestone strata; crayfish were listed as occurring in the county in the nineteenth century (Humphreys, 1845) but no specific location was given. *A. pallipes* is evidently restricted to a small part of Wicklow where limestone drift material influences the waters – the absence of other malacostracans from many streams and rivers in this county has been noted by Kennedy & Fitzmaurice (1971). The absence of crayfish from Donegal, Kerry, Louth, Wexford and the larger parts of Cork and Wicklow may thus be associated with the paucity of ions in rivers and streams draining such base-poor, weather resistant surface formations.

Timing of sampling is an important aspect in distribution studies where species are quiescent during some seasons. Brewis & Bowler (1983) found that a crayfish population in Northumberland remained torpid for a long overwintering period lasting some 30 weeks; Thomas & Ingle (1971) noted that specimens migrated to deeper waters of a Kent river during December and similar behaviour has been observed in a river in Northern Ireland (Praeger, 1950). In the course of the present study crayfish were absent from the site in the R. Triogue between December and April – the largest catch recorded was in September which coincides with the reported mating period (September-October) for *A. pallipes* in these islands (Thomas & Ingle, 1971; Moriarty, 1973; Holdich, Jay & Goddard, 1978; Reynolds, 1979). Crayfish appear to be most active between June and October (Moriarty, 1973; Brewis & Bowler, 1982) and from limited seasonal distribution studies carried out on some rivers in south-east Ireland during the present study the indications are that this period would be most productive for sampling.

Fluctuations in crayfish numbers between years have been reported in rivers in England by Duffield (1933) who suggested that the evidence for the cyclic decline, occurring at 13 to 14 year intervals, pointed to disease possibly interacting with other factors such as climate, food supply and enemies as the main causative agency. During periods of crayfish abundance in the rivers Duffield recorded that "sackfulls" and "more than could be wheeled in a barrow" were taken by the inhabitants of the localities in an evening's fishing but chose to ignore this factor as contributing to the collapse of populations. More recently, disappearances and deaths of large numbers of crayfish have occurred in rivers in southern England which have not been satisfactorily explained (Lowery, Hogger & Aldeman, 1983). Reference has already been made to the disappearance of crayfish from a river in the 1930s and a lake (Pallas) during the 1960s in Ireland and while the river became repopulated in subsequent years the lake apparently did not and some form of disease was implicated. The lake, however, was treated with the piscicide rotenone in 1963 to remove coarse fish prior to being established as a trout fishery and the abrupt decline in crayfish numbers occurred shortly afterwards – the last record for the lake is 1967 when two specimens were taken in a perch trap (K. Whelan, personal communication). The lake is fed by groundwater and its outflow takes a subterranean course through the fissured limestone a short distance away (Kennedy & Fitzmaurice, 1971) and this could be one factor which has prevented successful recolonisation.

O'Keefe & Reynolds (1983) reported that two diseases which affect crayfish have been isolated in Ireland: porcelain disease caused by the microsporidian *Thelohania contejeani* was found to occur at low levels in some lake and river populations, while a condition caused by a fungus and called "burn spot disease" occurred in specimens from one lake. These workers found no evidence of the fungus *A. astaci* in the rivers or lakes examined and concluded that crayfish disease was not a serious problem in Ireland.

The regulation of crayfish populations by predators has been considered unimportant by some workers (e.g. Momot & Gowing, 1977; Brewis & Bowler, 1983). Trout (*Salmo trutta*) and perch (*Perca fluviatilis*) are known to consume *A. pallipes* in Irish waters (Moriarty, 1963; Kennedy & Fitzmaurice, 1971) and Reynolds (1978; 1979) has suggested that the restriction of crayfish to a single tributary of the extensive Bann system in Northern Ireland may be the result of eel (*Anguilla anquilla*) predation. In Sweden eels have apparently been responsible for the demise of crayfish populations in some areas (Svardson, 1972). Pike (*Esox lucius*) may be significant in controlling crayfish numbers e.g. in a section of the Island River (M 790 718): gut analysis of specimens over 30 cm length revealed that 68% contained large numbers of crayfish (J. Caffrey, personal communication).

The otter (*Lutra lutra*) is widespread and common in Ireland (Chapman & Chapman, 1982) and in a study of 781 spraints collected from one river system *A. pallipes* occurred in 80%, forming around 76% of their total bulk, at eight of nine sites examined – the one site where crayfish were scarce in scats (only 13% contained them) was the only place on the system where eels were numerous (McFadden & Fairley, 1984). That study of the food of otters in the Clare River system in County Galway also showed that berried females were regularly taken in winter. The feral mink (*Mustela vision*) which apparently has a scattered distribution in Ireland (Ní Lamhna, 1979) is known to take crayfish regularly (Fairley, 1980) and indeed has been considered to discriminately catch *A. pallipes* in a tributary of the R. Boyne (J. Caffrey, personal communication).

The freedom of competition from other crayfish species in Ireland and Britain allows a wider ecological range for *A. pallipes* than in continental Europe where it is confined to small streams with other species occupying the larger streams and rivers (Hynes, 1970). The relatively low proportion of seriously polluted waters – 84% of the length of the regularly sampled rivers and streams considered in the present study has been found to be unpolluted (Water Pollution Advisory Council, 1983) — must also be a factor contributing to the widespread distribution of the species in Ireland.

Agricultural and industrial development could pose a threat to crayfish – the restricted distribution of *Orconectes neglectus* in some American states is believed to have resulted from an increase in agricultural practices (Williams, 1954). In Ireland many rivers are dredged, under the Arterial Drainage Act 1945, to alleviate flooding effects and such operations can, as well as removing large numbers of crayfish (Hogger & Lowery, 1982), destroy or alter the habitat. Some indications that dredging may have indirect effects on crayfish populations have been noted during the course of this study e.g. at a site upstream and downstream of where a river was being excavated in 1980 27 specimens, 9 of which had fungal excrescence, were captured but a re-examination of the site two years later at the same time of year yielded only a single individual for the same sampling effort.

Crayfish are regarded as important relatively sensitive indicators of pollution and the Astacidae receive a high rating in the score system used for monitoring biological water quality in England and Wales (Department of the Environment, 1979; National Water Council 1981). There are indications that the effects of pollution may have caused localised demise of crayfish populations in some areas in Ireland e.g. the Dodder and Tolka rivers in the Dublin area. Jay & Holdich (1981) point out that because acidity has a direct bearing on *A. pallipes* survival, any lowering in pH of waters might affect its distribution. Although some increases in acidity of rainwater have been recorded in Ireland (Mathews, McCaffrey & Hart, 1981) the threat from this source to waters supporting crayfish is likely to be minimal as the natural chemistry characteristics show these to be, for the most part, well buffered systems.

It has not been possible to gauge if any major changes in distribution of *A. pallipes* have occurred with time due to the lack of a previous baseline for the species in the country. The authors believe that the present study establishes the status of *A. pallipes* in Ireland and that the distribution data have been presented in a manner which will allow any future changes to be readily discerned.

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APPENDIX

The authors' records for the occurrence of A. pallipes in rivers and streams in Ireland collected 1976-1985.

Meath. Athboy: N718 642, N771 567; Blackwater: N720 452, N719 463, N712 501; Blackwater (Kells): N678 780, N737 775, N794 740, N819 723; Boycetown: N832 560; Boyne: N710 499, N734 526, N767 539, N772 567, N825 564; Deel: N689 493; Inny: N551 792, N530 807, N494 812; Knightsbrook: N828 563; Moynalty: N719 833.
Kildare. Barrow: N621 109; Liffey: N923 291; Morrell: N926 289; Slate: N703 216, N667 191; Rye Water: O004 360.
Meath/Kildare. Blackwater: N766 399, N736 424; Boyne: N684 449.
Laois. Barrow: N454 091, N463 093; Clodiagh: N318 108; Erkina: S267 787, S316 777, S363 782; Goul: S364 772; Gully: S405 793; Nore: S363 899, S374 879, S411 840, S425 803; Owenass: N402 047, N441 064; Stradbally: S571 963; Triogue: S478 970.
Laois/Kildare. Barrow: N613 089, S703 882.
Offaly. Clodiagh: N340 170, N257 256; Figile: N595 179, N622 117; Little Brosna: S035 916, S045 913, S068 909; Slate: N613 166; Tullamore: N386 241.
Offaly/Meath. Castlejordan: N554 408.
Offaly/Laois. Barrow: N490 009, N513 106.
Carlow. Burren: S798 677, S809 713, S720 763.
Kilkenny. Castlecomer Stream: S532 732; Dinin: S532 699; Glory S484 398, S483 430; Goul: S306 702, S330 738; King's: S413 439, S525 438; Muckalee: S515 663; Nore: S424 762; Owveg: S473 796, S450 779, S441 757.
Carlow/Kilkenny. Barrow: S733 458.
Waterford. Clodiagh: S420 148, S446 155.
Tipperary. Aherlow: R993 293; Ballyfinboy: R938 917, R 897 938, R 862 959; Black: S191 579; Breagagh: S176 534; Clashawley: S198 362; Clodiagh: S037 563, S048 514; Drish: S190 620, S148 584, S138 571; Fidaghta: S007 315; King's: S294 477; Multeen: R999 543, R993 512, S001 490, R984 446, R989 413, R984 408; Nenagh: R963 695, R960 730, R915 740, R877 780, R861 822, R831 849; Ollatrim: R978 813, R914 803; Rossestown: S166 654, S146 632; Suir: S133 623, S051 457, S045 431, S011 342; Tar: R984 156.
Cork. Awbeg: R544 186, R522 151, R543 098, R567 083, R657 075, R678 055.
Limerick. Loobagh: R551 274; Morningstar: R687 304, R665 323, R653 353, R613 367, R589 364.
Galway. Abbert: M560 380, M558 428, M474 422, M437 448; Ballinure: M817 270, M840 268; Clare: M407 629, M393 613, M395 587, M410 562, M420 537, M428 434, M415 404, M417 364; Cloonlyon: M771 525; Dalgan: M431 643; Derryhippo: M756 612; Grange: M560 542, M547 524, M482 498; Island: M597 730, M625 719, M662 728, M695 717; Kilcrow: M806 172, M800 150; Sinking: M525 620, M502 640, M458 630; Springfield: M668 644, M655 664, M664 705.
Mayo. Castlebar: M101 895; Dalgan: M498 794, M478 719, M432 775; Deel: G157 192; Glore: M486 813, M350 918; Loughnaminoo Stream: M255 850; Manulla: M232 813, M214 825, M225 912, M220 934; Owengarve: G550 040; Robe: M381 746, M364 723, M339 710, M288 717, M261 687, M295 649, M283 649; Sonnagh: G447 010; Swinford: G350 015, Westport: M023 828; Yellow: M398 837.
Sligo. Owenbeg: G858 246, G607 254.
Monaghan. Blackwater: H593 372, H657 359; Finn: H545 284, H538 256, H518 246; Magherarney: H606 318; Mountain Water: H603 459, H627 439, H655 430, H672 434, H686 432.
Cavan. Ballinagh: N388 979; Blackwater: N600 890; Erne: N330 950, N356 974, H357 015; Nadreegeel Lough Stream: N591 882; Shannon: H048 323, H021 290; Woodford: H250 157.
Leitrim. Bonet: G840 448, G870 413; Owenmore: G895 394; Shannon: G992 267; Woodford: H202 120, H236 127; Yellow: H080 150, H124 119, H122 112, H133 089, H156 095, H164 110.
Roscommon. Breedoge: M754 927, M745 947; Derryhippo: M794 628; Frances: M668 840, M684 806, M677 798; Hind: M958 616; Owengarve: G588 021; Owennaforeesha: M750 875; Suck: M654 808, M671 780, M693 756, M790 649, M829 577.
Roscommon/Galway. Suck: M698 718, M757 672.
Longford. Camlin: N165 781; Cullies: N272 973; Inny: N403 816, N227 592.
Westmeath. Breensford Stream: N075 442; Brosna: N330 356; Deel: N600 530; Glore: N475 727, N443 743; Inny: N259 603; Riffey: N331 687.

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