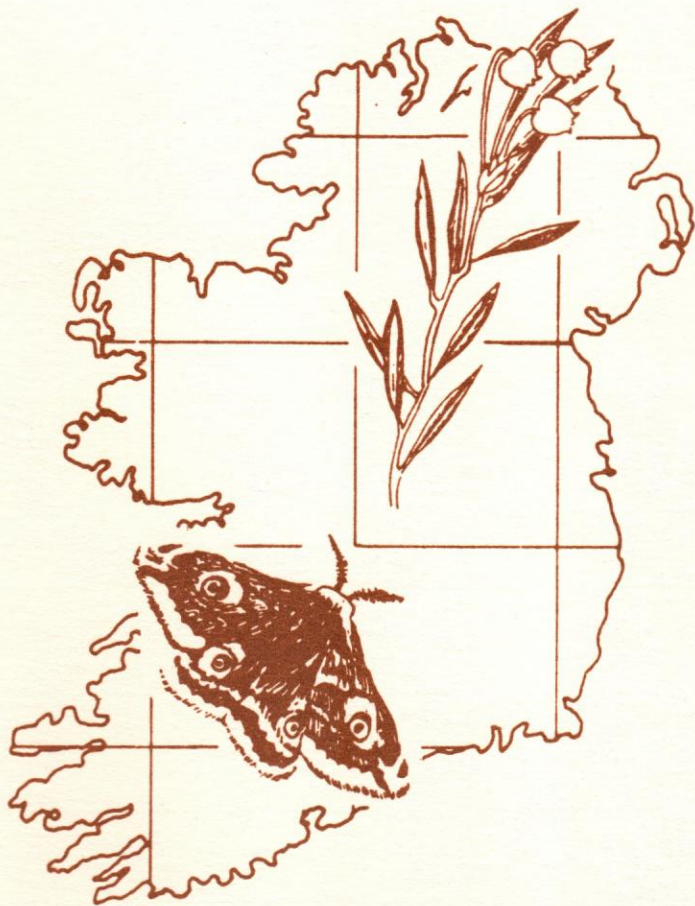


IRISH BIOGEOGRAPHICAL SOCIETY



Bulletin No. 23

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THIS BULLETIN IS DEDICATED TO THE MEMORY OF PROFESSOR CARMEL HUMPHRIES (1909-1986) IN RECOGNITION OF HER CONTRIBUTION TO OUR KNOWLEDGE OF THE CHIRONOMIDAE (INSECTA: DIPTERA).

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BULLETIN OF THE IRISH BIOGEOGRAPHICAL SOCIETY

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EDITORIAL

This year's bulletin contains a very diverse range of papers and the Society is very grateful to the authors for their contributions. Since, the issue is dedicated to the memory of Professor Carmel Humphries, it is appropriate that two marine coastal-dwelling Chironomidae (Diptera) new to the fauna of Iceland are reported in an article by one of her former students.

On 21 May 1999, Occasional Publication No. 4 was published by the Society. Entitled *A catalogue of the Irish Braconidae (Hymenoptera: Ichneumonoidea)* by J. P. O'Connor, R. Nash and C. van Achterberg, it reviews the Irish fauna of these small but interesting parasitic wasps. There are superb figures by Dr van Achterberg and four colour plates from *British Entomology (1823-1840)* by John Curtis. Further details are given elsewhere in this *Bulletin*. Publication was generously sponsored by The Heritage Council and as a result, it is possible to include the catalogue, free, with *Bulletin no. 23* for all 1999 subscribers to the Society.

On behalf of the Society, I wish to also thank our sponsors, the referees for their marvellous advice and Mr J. M. C. Holmes for his usual invaluable assistance with the production of this *Bulletin*.

J. P. O'Connor

Editor

15 October 1999

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RESURVEY, BIOGEOGRAPHY AND CONSERVATION OF THE NATTERJACK TOAD *BUFO CALAMITA LAURENTI* (ANURA: BUFONIDAE) IN THE REPUBLIC OF IRELAND

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Abstract

This report updates the distribution and status of the Natterjack toad, *Bufo calamita*, in the Republic of Ireland. Many previously reported sites of occurrence in County Kerry were revisited; observations are compared with those of previous authors. Two new possible sites (Cos Kerry and Sligo) and introductions (Cos Kerry and Wexford), as well as historic biogeographic aspects relative to the origin of natterjacks in Ireland, are discussed. Audiospectrographs of toads from Cos Kerry and Wexford are compared. General life history and habitat requirements are noted relative to proposed conservation measures.

Key words: Anura; Bufonidae; Natterjack Toad; *Bufo calamita*; Introductions; Status in Ireland; Audiospectrographs; Historic Biogeography; Conservation.

Introduction

Laurenti (1768) first described this taxon as a toad, *Bufo calamita*, a toad sometimes found among river reeds. Frost (1985) reported the type specimen as untraced, the type locality as central Germany, subsequently restricted to the Nürnberg area, and that the species belongs to the *Bufo viridis* group. Its common name, Natterjack, comes from two Old English words: *nether* for low-lying and *jack* for a diminutive, collectively "a lowly little thing," as noted by Joseph (1970). Its name in Irish is Cnádán, as recounted by Marnell (1996).

Along with the Common or Smooth Newt, *Triturus vulgaris* Linnaeus, 1758, and Common Frog, *Rana temporaria* Linnaeus, 1758, the Natterjack is but one of the three species of

amphibians found in Ireland (Marnell, 1997). Curious attributes include short hind legs in adults, hence they walk or run rather than hop; a monotonic, single note in calling males that is audible for over a mile; and a tadpole, seldom 30mm in length, the smallest of European species. Its curious distribution in Ireland with natural populations currently restricted to Co. Kerry, and speculation as to its ancestral origin and duration in Ireland as an introduced species, result in a truly intriguing species to investigate. There are at least approximately 200+ literature citations that deal with various aspects of the species' biology across its entire European distributional range. Boulenger (1898) provided a comprehensive description consisting of all life history stages, adult osteology, taxonomic synonymy, and (1897) a tadpole illustration. He noted it to be a western species, abundant in France and the Iberian Peninsula, with populations in Ireland and the rest of the British Isles (at the northwestern fringe of its distribution) extending eastward across Scandinavia and Baltic islands to Poland and the current Czech Republic, and that it was absent south of the Alps and from Mediterranean islands. Additionally, its distribution has been documented in the now independent states of Estonia, Latvia, Lithuania and Belarus.

It is known locally in Ireland as the "running toad" since, as mentioned, its short hind legs preclude saltation; the "golden back" because of the adults' prominent, mid-dorsal, yellow stripe; and the "black frog" as Irish phenotypes are typically darker than their Scottish or English counterparts (Smith, 1964). A drawing of adults is provided by Boulenger (1898), Angel (1946), and Joseph (1970), a black and white photograph by Cochran (1961) and O'Rourke (1970), and a color photograph by Obst *et al.* (1984), Sinsch (1998), and at the toad internet website <<http://www-astro.physics.ox.ac.uk/~erik/toad>> (Fig. 1).

Previous investigations

Bufo calamita was first reported in Ireland in 1805 at Callanfersy, south of Castlemaine Harbour (Co. Kerry) by Mackay (1836). O'Rourke (1970) related aspects of the toad's biology, along with interesting local anecdotes and speculation as to its origin in Ireland. He and subsequent authors provided useful bibliographies, some references of which are cited herein. Gresson and O'Dubhda (1971) recounted the early expanding distributional records in the circle of Castlemaine Harbour and at Inch in the southern part of the Dingle Peninsula, and they

reported the first records of occurrence from the northern side of the Dingle Peninsula at Castlegregory and Fermoy. Gresson and O'Dubhda (1974) attempted to determine occurrence in Co. Kerry from sites recorded in the previous century; their visits in 1971 and 1972 to the first reported region in Ireland at Callanfersy resulted in no sightings of the toads, or indications of their presence by tunnels, and they concluded that progressive destruction of breeding sites and habitat by drainage had led to the toad's disappearance. O'Connor and Jeal (1975) confirmed and augmented data on the location and habitat of the species in a survey in 1975, which was submitted to the Department of Lands by O'Connor (1975); this report included proposed conservation measures for a number of existing sites and reintroduction to former sites, as well as translocations to new suitable sites. Ní Lamhna (1979) also provided distributional data. Gibbons (1981) submitted a report to the Forest and Wildlife Service dealing with the toad's reproduction, demography, and feeding; her seven maps detailed pre- and post-1970 distributional records (Fig. 2) and were invaluable aids for field work conducted in this study. McCarthy *et al.* (1983) prepared a report for the Forest and Wildlife Service that, among other facets of the toad's biology, described much of the species' breeding behaviour and habitat preference and included aerial views of selected breeding sites. Whilde (1993), as had earlier authors, treated the species as threatened, and that it has the legal status of an endangered species in Ireland under the Wildlife Act of 1976; he noted that some of its habitats are, in part or wholly, statutory Nature Reserves, while others remain unprotected as such, or are designated as within an Area of Scientific Interest (ASI), where detrimental development has occurred. He also noted *Bufo calamita* as listed on Appendix II of the Bern Convention, whose restrictions apply to the species in all of Europe. His account provides a thorough, short summary of the species in Ireland, including a useful distributional map (Fig. 3). Beebee (1991a) provided by far the most substantive summary of the toad's status in Ireland and the most thorough recommendations for its conservation; his report, as a consultant to the Council of Europe, was based on field work in Ireland, but also in past decades primarily in England, and, along with colleagues, has provided much of the primary data on this species that exists in the literature. Presumably, much of his data would be more applicable to Irish populations based on geographic proximity and insularity, habitat similarity, and possible common ancestry than comparisons made between Irish and more distant European populations.

Space does not permit a review of all autecological studies here, but the reader desiring further data is referred to the following selected topics:- Beebee (1977), environmental changes as a cause of declining natterjack populations in Britain; Beebee (1979), a review of scientific information on the natterjack throughout its distributional range; Beebee (1982), a 10-year study of relict toad populations, including environmental parameters, predators, and conservation measures; Beebee (1984), possible origins of Irish natterjack toads; Banks and Beebee (1987), factors for choice of breeding sites in heathlands and coastal dunes; Banks *et al.* (1994), conservation of the toad in Britain 1970-1990; Hitchings and Beebee (1996), colonization, habitat preferences, and genetic diversity of British populations; Denton and Beebee (1997), factors of tadpole mortality in replicated semi-natural ponds; Denton *et al.* (1997), a recovery programme for the natterjack in Britain; Bustard (1998), natterjack toads in Scotland.

Natterjack toad distribution in Ireland is currently restricted to a few sites of naturally occurring populations in Co. Kerry on the Dingle and Iveragh peninsulas, and to introduced populations, initially in 1991 at Ballyteige, and later at the Raven Wood east of the Wexford Wildfowl Reserve in Co. Wexford. The purpose of this study is to:- (1) assess the general status of previously reported habitats in Co. Kerry and sample selected environmental parameters; (2) attempt to locate and sample new habitats in Co. Kerry; (3) document the status of translocated toads in Co. Wexford; (4) evaluate data related to the toad's arrival in Ireland and ancestral origin outside of Ireland; (5) collect larval (= tadpole) samples for a subsequent study of geographic morphological variation.

Materials and methods

Field activities during the height of the spawning season in Co. Kerry by one of us (JKK) resulted in data on breeding at 12 sites. Additional habitat data on translocated populations in Co. Wexford was obtained (JKK) in January 1998 during the toad's winter hibernating period, and in August 1998. Tadpoles (sample size N=20) were collected under licence at five Kerry localities in May 1997. The terms "larvae" and "tadpoles" are used interchangeably. Larvae were collected by using small, fine-mesh hand nets, then preserved in 10% buffered formalin. Tadpoles are in the custody of the senior author and, eventually will be placed in the systematic collection of the Natural History Division, National Museum of Ireland, Dublin, following this

study and a subsequent one on morphological variation. Five adults from Kerry sites and no larvae are currently catalogued in the Museum. In the field, salinity of water samples was determined by means of a hand held refractometer, SPER Scientific Model 300011, and pH by use of a portable, battery powered pH meter, Oakton pH meter kit WD-35615-60. Samples were taken during daytime in clear water away from the bank and free of vegetation. Data on average and actual rainfall (Fig. 10) and temperature at Valentia, Co. Kerry, were provided by Met. Éireann, Dublin. Mating calls of adult males in Kerry were recorded by means of a hand held, battery powered tape recorder, General Electric Model 3-5300A, with sonograms prepared by Avisoft program SAS Lab Pro Version 3.4. Spectrogram parameters included:- FFT-length 512 pts.; effective bandwidth 223 Hz; sampling rate 44.1 KHz.

Habitat and life history

Adult natterjacks in Ireland are found near coastal dune slacks where areas between dunes reach the shallow water table, resulting in ephemeral, low-lying, natural, breeding areas. Dune pools accumulate windblown sea salts that buffer and stabilize pH (Hardy, 1974). The persistence of slacks depends on seasonally varying rainfall that provides lighter fresh water overlaying denser salt water; slacks are, therefore, prone to desiccation and catastrophic tadpole mortality if they dry up prior to the completion of larval metamorphosis or become too saline or acidic. Although abundant rainfall lessens desiccation, Banks and Beebee (1988) observed an increase in predation by invertebrate predators such as dytiscid beetles, notonectids, and odonate larvae that reduce metamorphic success; these authors also noted reduced reproductive success in dune slacks due to fungal *Saprolegnia* infestations, possible low temperature, and low pH of less than 6.0. Beebee and Griffin (1977) had previously shown reproductive success to be minimal, below pH 6.0, and no tadpole survival below pH 4.75. Beebee *et al.* (1990) subsequently reported no tadpoles in heathland bog pools, where the pH reached 4.5; this acidification was due to recent atmospheric pollution as determined by sediment core analysis, as well as to the accumulation of organic peat acids. Denton and Beebee (1997) further reported increased tadpole mortality induced by anoxic conditions, as well as desiccation and low pH *circa* 4.5. Denton *et al.* (1997) determined an optimal circumneutral pH range of 6.0-8.5. Adults near the slacks are fossorial and arenicolous, digging their own tunnels or occupying

unused rabbit burrows where they may be seen at entrances sometimes in daylight.

Adults in Ireland also are found up to 2.4km inland from coastal dune areas in shallow lakes and bog pools in heathlands. Here, adults and toadlets are typically found under rocks on hillsides overlooking the breeding areas. They are protected under the rocks from desiccation and predators and absorb transferred heat from the sun. They are highly nocturnal, emerging at night to feed on their primary food of beetles and ants (Banks *et al.*, 1993), and probably snails and spiders. They scamper down from the hillsides to the water in early and late evening to form breeding choruses. About 10% of the local adult population is observed in a given evening, especially after rain and an air temperature of 7-9°C. (Denton and Beebee, 1992). Denton and Beebee (1993), in their five-year study, recorded the breeding season in England between April and June, with 44-66% of females breeding in any one year, and that a direct correlation existed between calling males and positive response by females. Diaz-Paniagua (1988) recorded considerable flexibility of the general two-month larval period in southwest Spain that reflected the unpredictability of environmental conditions. Tejedó and Reques (1994) noted a more lengthy larval period for Spanish populations with more spawning females coincident with an increased habitat hydroperiod, and that tadpoles in low densities in short-duration ponds had abbreviated larval periods. A further response to the unpredictable nature of spawn sites in England is the observed double-clutching by females in a given breeding season (Banks and Beebee, 1986). In a subsequent four-year study at the same site in England, Denton and Beebee (1996) also recorded double-clutching in some females, but no toadlets in any of the four years.

Marnell (1996) characterized the toad's annual cycle in Ireland as:- February-April, spring, scarce; May-July, summer, locally abundant; August-October, autumn, scarce; November-January, winter, hibernating. However, variables may slightly alter these generally accurate month-intervals (e.g. adults at the Raven Wood, Co. Wexford, were first active 14 March 1998 *fide* a Wildlife Ranger, pers. comm.).

The common feature of the Irish habitats is shallow waters that easily warm. Bregulla (1988), in a three-year study of spawning sites, noted a preference of adults for warm spawning water. Grosse and Schoepke's (1992) report of tadpoles as positively thermotactic was confirmed by our tadpole collections that were most often obtained from the shelving edge of spawn sites in

the shallowest and warmest waters, where congregated tadpoles were nearly stranded. Exposed eggs and tadpoles have a noxious substance, reducing their palatability to potential predators like foxes, dogs, otters, and herons (Griffiths and Denton, 1992). Adults are protected by skin secretions described as venomous and hemorrhagic (Tan and Ponnudurai, 1992), and may live to seven years in the wild. Most adults in Ireland become active by mid-April, with peak calling and spawning occurring in late May into June. Alvarez *et al.* (1992) reported Spanish populations breeding earlier, February to June, with most clutches laid in March. Egg strings, initially double, but after swelling by absorbing water, a single string, number about 3,000 eggs/clutch, and are often strung among submerged aquatic vegetation in shallow water (<10cm); each egg displays a prominent light vegetal pole and darkly pigmented animal pole. Black neurulae stages hatch in a week in warm water and tadpoles metamorphose in two months or perhaps less, depending on water temperature in extreme shallows. Toadlets about 10mm long have a yellow mid-dorsal stripe. Toads reach sexual maturity in three years, at body lengths of 60-80mm. Males call from dusk into the night to attract females and maintain acoustic territories (Arak, 1988). A release call by females terminates axillary amplexus (Weber, 1977), and both sexes can produce a distress call when disturbed (Weber, 1978). The release and distress calls are shorter in duration and of a lower frequency than the distinctive mating call, described as a monotonic ra-ra-ra heard over perhaps a mile (Boulenger, 1898). Boulenger (1898) and O'Rourke (1970) both noted that skin secretions of disturbed adults may have a fetid odour and, as the former author noted, was responsible for the previously proposed synonyms, *faetidissimus* and *mephiticus*. We did not notice this phenomenon in handling adults at various localities.

Localities

The first 12 of the 16 listed sites are in Co. Kerry (mapped in Fig. 4; some of these sites are also depicted in Fig. 3). All May visitation dates are for the year 1997. Other sites of interest, including introductions, are in Cos Kerry, Sligo, and Wexford. Site information may include Irish grid map reference and elevation.

1. Lough Yganavan, V705955, 11m, 16 May.

O'Connor and Jeal (1975) described this very open lake with little emergent vegetation as

somewhat oligotrophic. It is accessible from the Lake Road extending from Cromane Upper that runs parallel to its northern perimeter. A stock animal and tractor trail encircles the lake, whose bog border is heavily scarred from brush clearance and fill dumping and levelling. Adult toads were first discovered here in 1973 by Gresson and O'Dubhda (1974) and tadpoles in 1975 by O'Connor and Jeal at the shallow eastern end of the lake and at a second site at its southern side. McCarthy *et al.* (1983) described it as the premier breeding site on the Iveragh Peninsula. We collected a tadpole sample (N=20) from the shallow northeastern border of the lake at 15:04 hours; the water was clear, with some algae, and had a sandy bottom mixed with small gravel. Larvae were confined to these shallows in large numbers, but were absent from deeper water with coarser gravel. The shallows were noticeably warmer to the touch than deeper waters; the pH was 6.4 at 17.4°C., the air temperature 18°C., and the salinity 1.0 ppt. No adults were observed at this time, nor were tadpoles observed at any other site around the lake's entire perimeter. O'Connor and Jeal (1975) reported large flocks of seagulls feeding in the vicinity of tadpoles at the eastern end of the lake and commented on the possibility of tadpole predation. We also observed three gulls present at the time of our collection, but no other potential predators. Larvae swam downwards when netted; the dorsum and venter of the larvae were jet black and tail fins showed diffuse, black flecks dispersed in orchid tissue.

In returning to the lake *via* the Lake Road on 17 May the following evening at 23:30 hours, we observed numerous adults and juveniles on the road descending to the lake from the adjacent hillside. The air temperature, initially 15.5°C. fell to 13.5°C. as time passed. Showery spells had occurred earlier in the late afternoon. The numerous toads on the road could have easily been run over had care not been taken to avoid them. Toads had small parotoids, prominent cranial crests, and a prominent yellow mid-dorsal stripe on a dark black dorsum; the venter was white with black markings arranged as a rounded shield radiating from the cloacal region in distinct, broken lines. Intermittent calling could be heard from the lake area below the road. Although Ordnance Map No. 78 indicates the western end of the lake as a designated Nature Reserve (encircled in red), the breeding site at the eastern end is not designated, nor are there any road signs along the Lake Road to warn motorists of the adults' presence during evening or night hours.

2. Lough Nambrackdarrig, V702939, circa 30m, 17 May.

The first record of toads, four adults and one juvenile, was reported by O'Connor and Jeal (1975). The site is 2.4km from the sea and the farthest inland that natterjacks have been found in Ireland. The east-west trending lake is separated by a narrow strip of land, perhaps resulting from a decline in water level. The westerly, but not the eastern, part is designated as a posted Nature Reserve, Lough Nambrackdarrig on Ordnance Map No. 78. Rough pasture surrounds the western edge of Lough Nambrackdarrig with bogland on the remaining border of both ponds; this bogland has little vegetation and has suffered severe mechanical disturbance. No evidence of adult toads or tadpoles was found in any of the isolated, small pools of the bogland.

Mr David O'Connor lives on Dooaghs Mountain overlooking the lake on its northern side and was most helpful in locating toads and supplying information. Above the ponds on his hillside property, numerous adults and juveniles were abundant underneath stones in late afternoon. O'Connor related that many toads accumulated in water pools provided by roof drains at his house, and that he also regularly heard calling males at dusk. Full choruses soon pulsed in both bodies of water after 21:31 hours at an air temperature of 17.5°C. We descended to Lough Nambrackdarrig by means of a lane he had opened with his tractor. The lake lacks a sloping edge at any place along its perimeter; no tadpoles could be located in the knee deep water, but they must certainly occur as the presence of calling adults and juveniles on the slopes indicate a vigorous colony. Calling extended past 24:00 hours and will be discussed later. No further data were taken at this site.

3. Dooaghs Golf Links, V680944, 10-20m, 17 May.

Macdougald (1942), Gresson and O'Dubhda (1974), and O'Connor and Jeal (1975) recorded adults present at this site. Additionally, McCarthy *et al.* (1983) reported their presence on the golf links and at an adjacent site (4, below). Mr Michael Shannon, club secretary, granted permission to survey the links and advised that toads were present at two water hazards located off a gravel service road adjacent to the fifteenth tee. Interestingly, the club logo is an adult toad embossed on carpeting in the clubhouse and elsewhere. Both hazards were marshy ponds of about the same size and 0.3m, depth and appeared to be permanent sites. No other ponds or slacks were seen. The call of an adult was heard at 17:35 hours, but no others were heard or

seen in the grassy areas about the sites. Twenty tadpoles were obtained from both ponds (more in the southern one). The pH was 6.0 at 14.5°C., air temperature 15°C., and salinity 1.0 ppt; the sea is present just off the northern fringe of the links.

4. Dooghs Commons, V695944, 12m, 16 May.

This site is accessible over a fence paralleling a north-south road to the beach and consisted of a single flooded, ephemeral area in contrast to the large number of temporary pools reported by McCarthy *et al.* (1983). The pH was 7.3 at 17°C. A solitary heron *Ardea cinerea* L. was walking about at 18:15 hours and an adult toad called for about a 10 second duration, but could not be located and did not call again. No adults were seen in a walk about the entire border of the shallow (0.1m) soft-bottomed wet area (difficult walking) or adjacent pasture. An extensive search determined no spawn or tadpoles.

5. Glenbeigh Environs, V671916, 25 m, 17 May.

This region of rough and rocky pasture lies between Glenbeigh and Rossbehy Creek, and is bounded by the Behy River to the west and Caragh Creek to the east. O'Connor and Jeal (1975) found a single toad after three days of search and commented on the dry breeding conditions. McCarthy *et al.* (1983) reported choruses, numerous adults and tadpoles. Our search of this region encompassed all the area mentioned above with road N70 as its southern margin. A local person had reported toads in an old quarry area (V671916, 25m) within the region, however, a thorough daytime search of the entire area revealed very dry conditions, with no water in field drains and low-lying areas. No adults were found under rocks, nor were their burrows seen, and no tadpoles were found owing to the lack of suitable breeding sites. The salinity of a sample of sea water taken at the strand facing Inch Point at the end of Kilnabrack Road was 36 ppt.

6. The Inch Peninsula, V656998, 2-4m, 18 May.

This peninsula extends south from the Dingle Peninsula and its eastern border abuts Castlemaine Harbour. O'Connor and Jeal (1975) found adults, their tracks, and tadpoles present at various sites on the peninsula and commented that this population has a long history of documentation, but is more restricted in area than years past and is subject to sea incursion. Gibbons (1981) provided a map which indicated spawn sites. Our extensive survey was conducted in daytime over 13 hours. A search of the marram grass (*Ammophila arenaria* (L.)

Link) covered dunes along the western side of the peninsula above the strand, revealed dry conditions with no slacks present, and no adults or their burrows or tracks. A thorough traverse of the pastures along the eastern side revealed dry conditions and no standing water or signs of adults. The interconnected pastures contained free-roaming, grazing sheep and meandering, frequently travelled dirt roads. The salt marsh on the eastern side and the incoming drains were extensively searched. All drains were completely dry with no indications of adults or breeding activity. On the seaward side of the marsh, standing water was frequently encountered, but its salinity was 27 ppt and marine crabs and shrimp were trapped in isolated pools. Also, the evident highwater drift-line around the marsh indicated past extensive sea incursions which, doubtless, exerted a major negative impact on reproduction of this population, as well as a lack of rain and ongoing drainage schemes as discussed by Gresson and O'Dubhda (1974). Another factor of potential impact on this population is a prospective golf course, possibly two, on the Inch Peninsula.

7. Lough Naparka, Q623170, 4m, 18 May.

This small peninsula, with Castlegregory at its base, is flanked by Tralee Bay on the east and Brandon Bay on the west and terminates at Rough Point. O'Connor and Jeal (1975) reported no breeding in 1975, as both slacks in the vicinity and the Lough itself were dry. They did record adults and their tracks in the sand dune system to the north of the Lough, and commented that a large nearby caravan site was a major threat to this site. Gibbons (1981) provided maps and documented successful breeding at the Lough and adjacent sites and indicated more than one half the peninsula north of Lough Gill to be toad habitat. Our survey commenced at 17:21 hours and determined no slacks or suitable standing water in the vicinity except at the Lough itself, which lay just inland and above the eastern shore dune system abutting a narrow beach and Tralee Bay. The Lough, unmarked by Wildlife Reserve signs, consisted of a small isolated southern part adjacent to the bulk of the Lough's waters running north and parallel to the dunes above Tralee Bay. Both bodies of water were shallow with emergent rushes rising from their centres. Locals reported toads calling as early as a month prior to our visit, and that a toad migration in the day from the western portion of the peninsula to the Lough had stopped traffic on the main north-south road about a fortnight ago. Isolated calls from the Lough itself and the adjacent dunes were intermittent. Numerous adults in burrows of the dunes retreated when

approached. The pH of a sample from the larger body of water was 7.2 at 20.5°C., the salinity 0.5 ppt. Tadpoles were abundant at the margins of both bodies of water, with some marooned in animal hoof prints, indicating use of the area sometimes as a commonage, although no animals were present at this time. A sample of 20 tadpoles was obtained. Large bird tracks, probably gulls, were evident in mud about the water. Although no caravans were in evidence, human presence was evident in the form of car hulks and dumped household appliances scattered among dunes inland of the Lough. Another factor of probable negative impact on the viability of this population is a vegetable farm located over a stone wall in close proximity to the western shore of the Lough. Nutrient runoff into the Lough and leached insecticides/pesticides, if used, will result in eutrophication and accelerated succession at best, and possible toxic contamination at worst. A more acute cause of concern during our visit was the ongoing removal by lorry of sand and gravel from the dunes just north and inland of the Lough. If this area coincides with the area "north of Lough Naparka" reported by O'Connor and Jeal (1975) as containing toads and also within Gibbons' (1981) toad distributional area, this continuing habitat destruction may ultimately affect the dune area at the Lough itself.

8. Lough Gill, Q61250, 3-5m, 18 May.

Adults, spawn, and tadpoles were first found at this locality in 1970 (Gresson and O'Dubhda, 1971; O'Connor and Jeal, 1975; and by subsequent investigators). Lough Gill was the largest aquatic habitat in our survey. Gibbons (1981) provided a map indicating its eastern primary outlet to the sea *via* a sluice-controlled trench and a secondary branch westward that provides water to the Castlegregory Golf Course (see site 10). The pier at the eastern end of the Lough and the shoreline to the north entails the region often cited as the shallow end of the Lough, where most toad occurrences have been recorded (deeper parts appear unsuitable for breeding). Our survey began at the pier in late afternoon (water temperature 18°C., depth at shoreline 0.7m among reeds) and continued north from the pier past the trench exit and continued along the northern shore with searching both in the reeds and adjacent fields. No spawn, tadpole, or adult was seen anywhere, or during a search 100m south of the pier. The lack of spawn and tadpoles may result from water deeper than the preferred 10cm. It appears that the water level of the Lough has increased considerably in recent years, owing to the dam-effect of silt build-up in the exiting trench to the sea. A local person remarked that the pier itself was under water

the previous winter, indicating the severity of this problem. The result has been the loss of shallows and gradual sloping shoreline that natterjacks prefer. In addition, possible high phosphate levels from runoff may have impacted on water quality. The lone avian predator observed was a single heron. No calling adults were heard in late afternoon or during a return in early evening.

9. Dune Slacks North of Lough Gill, Q606152, 3-5m, 18 May.

Gibbons (1981) recorded spawn at a number of major and minor slacks among the dunes located just north of Lough Gill and inland of Brandon Bay. Our survey began at 19:27 hours, with the air temperature at 12°C. The most westerly slack closest to a dirt road adjacent to two barns and with hoof prints encircling the sloping margin contained water a few cm deep and was about one half its original 30 x 60m dimension due to desiccation. The original water line was easily discernible, and dried algal mats on stick-tops indicated evaporation of 0.5m or slightly more. Larvae were numerous and a sample of 20 was obtained; the pH was 7.6 at a water temperature of 16.4°C., and salinity measured 0.5 ppt. No spawn was observed, nor were adults seen or heard in the dunes towering about the slack. Adjacent slack areas among the dunes had completely dried.

10. Castlegregory Golf Course at Stradbally, Q592137, 3m, 18 May.

Beebee (1991a) visited this site as part of his appraisal of natterjack sites in Ireland and recounted the nine-hole course's creation during the period 1989-91 among coastal dunes stabilized by marram grass, *Ammophila arenaria*. He made observations and recommendations for this site and others that the informed reader should review. Our survey centered on a number of interconnected man-made ponds adjacent to the ninth hole that were created by draining and subdividing a large previous slack area overlooked by dunes. Water in the ponds is maintained *via* a channel leading from the western end of Lough Gill which, as noted (site 8), may have a phosphate eutrophication problem. Our survey, as had Beebee's, indicated a flourishing population here, with perhaps hundreds of adults located in the dunes above the ponds and indicates, at least in the short-term, the viability of man-made habitats. Adults began to call at 20:30 hours about the ponds and soon loud choruses developed that were tape recorded. Many adults ambled down to the ponds and splashed into the water, which had receded a meter or so from a previous higher level. Water temperature was 17°C. and the air

10°C.; the pH was 8.9 at 16.5°C. At 21:33 hours, adults were still moving to the ponds, swimming freely and seeking suitable amplexic partners. No tall emergent vegetation was present, but abundant long, filamentous, submerged vegetation had many entwined single strands of eggs with noticeable animal and vegetal poles. Some strands also had neurula stage embryos, indicating earlier deposition. Thousands of tadpoles teemed in the sandy shallows, some almost stranded on shore. Water depth in pond centres easily exceeded a meter. Some insect larvae and adults were present, but not in excessive numbers. A local person reported a one-pound trout taken a week ago in the channel draining Lough Gill. Vigorous calling continued at dusk and into the night. As grazing animals are precluded from the course, the succession of vegetation needs to be closely monitored to control invasive scrub, which severely inhibits adult feeding and movement. Presently, electric golf carts are not used at the course and only compost, rather than artificial fertilizer, is applied to the turf as a means of controlling entrophication.

11. Fermoyle Strand, Q550122, 3m, 19 May.

Adults were first found here in 1970 (Gresson and O'Dubhda, 1971). They were found in burrows under stones very near the sea's high water mark. These same authors noted in 1974 that sea incursions had greatly reduced the viable area for the toad in wetlands inland of the strand. O'Connor and Jeal (1975) again noted the sea incursion problem, but were successful in locating adults. Gibbons (1981) provided a locality map and noted three major areas of sea incursion through the dune ridge, indicating a serious, continuing problem. Our survey began at 10:09 hours with a search for adults among the boulders placed on the dunes as a sea wall, from the entrance of the strand road at the beach to 1,000m eastward. No adults, or their burrows or tracks, were found among or under rocks anywhere. All the above authors had found them along this area at various points. Despite the reinforced sea wall, two major points of incursion were visible, as indicated by washed sand, seaweed, and fish netting. These incursions extended well into the inland, low-lying, wet area, where a water sample indicated 11 ppt salinity. A search of the entire inland area, including both sides of the small river paralleling the strand, and westward under a bridge where the river flows, revealed no adults, tadpoles, or spawn at this time.

12. Possible New Co. Kerry Locality, Q642123, 4m, 19 May.

A local person familiar with natterjacks believed toads were calling at this locality east of Castlegregory along the Tullaree Road. The road to this site passes beneath a metal footbridge over the River Owennamallagh which, at the time of our visit, was low enough to be traversed by car. The river parallels a coastal dune system along the strand. As it was early afternoon, no calling was heard. A search along the dunes revealed no adults or their burrows, or suitable breeding sites along the banks of the river east of the bridge. However, west of the bridge, several large basins of fresh water were found along an elevated area above the river and appear to be suitable, ephemeral areas for breeding. No spawn or tadpoles were present at this time, but these basins warrant further monitoring.

13. Possible New Co. Sligo Locality, G684314.

O'Rourke (1970) mentioned the possibility of the toad existing outside of Kerry in the Strandhill area of Sligo, where suitable habitat exists, but offered no supporting data. If Sligo populations were confirmed, the biogeographical implications would be far reaching. Time and distance did not permit us to visit this site, but we were fortunate in contacting Don Cotton, Sligo Regional Technical College, who is knowledgeable concerning the toad's biology and occurrence. He and a local man visited a marsh at Carrowgobbadagh, between Sligo and Ballysadare, at the above grid reference during the time of our May 1997 visit to Kerry. Both frogs and toads were reported to be calling at this site. They searched from dusk into night on a warm, calm evening at this, "the right time of the year," but, unfortunately, reported neither sightings nor calls. Additional monitoring of this site would appear warranted.

14. Possible Fossil Co. Sligo Locality, G620340.

This site at Carrowmore, adjacent to Strandhill village, is the largest cemetery of megalithic tombs in Ireland. The cemetery consists of passage-tombs, dolmens, and stone circles, covering 3.8 sq. km. Portions have been reliably dated to 3825 B.C., and controversially as early as 4600 B.C. Swedish archaeologists from the University of Stockholm researched the site in the 1977 to 1979 seasons and suggested the tombs as early burial places of immigrant farming families. The tombs contained human and other animal bones, some of which were cremated, others unburned. Ove and Persson (1980) analysed the osteological remains, which were catalogued by taxon. They listed (pp. 122-124), among the unburned material for grave No. 27,

two lots identified as *Bufo calamita*, "Recent?", consisting of portions of the cranium, pelvis, and extremities. Important questions relating to these bones include: their proper identification; their availability for confirmation; and their determination as either contemporaneous with the assigned B.C. dates, or whether the bones represent toads introduced somehow at a much later date? JKK has been in contact with Nigel Monaghan, Geological Section, Natural History Division, National Museum of Ireland, in an attempt to answer these questions. He related that the Museum is the official repository of all archaeological material in the Republic which, under law, belongs to the State. Additionally, all Carrowmore material had been returned to the Museum as of September 1997. Examination of this material has now been arranged by Ferdia Marnell, Dúchas, The Heritage Service, National Parks and Wildlife Service, Dublin. If the identity and dating to B.C. are confirmed, it would have a major impact on the conventional biogeographical theory of when, where, and how the toad came to Ireland, which will be discussed subsequently.

15. Reintroduction at Caherdaniel, Co. Kerry, V5559.

The return of natterjacks to areas where they historically existed, but have recently become extinct, is a viable means of rescuing a threatened species. It is most easily done by bringing spawn in buckets from a flourishing site to the historic site, given that the latter is now a suitable habitat again. O'Connor (1975) suggested a reintroduction at Ballycarbery, where they existed prior to the drainage of two small ponds in 1945. He also mentioned reintroduction in the Waterville region of the Iveragh Peninsula. Beebee (1991) mentioned a possible reintroduction at Caherdaniel, south of Waterville, where they possibly had occurred (Gresson and O'Dubhda, 1971), although these authors failed to find them there in 1973 (Gresson and O'Dubhda, 1974). Gibbons (1981) indicated toads at Caherdaniel as a pre-1970 record. Marnell (pers. comm.) related to JKK that a reintroduction occurred in 1991 on the State-owned Daniel O'Connell property, Derrynane House and demesne, and that the population has been self-sustaining. This site thus represents at least one extant population on the south of the Iveragh peninsula (Fig. 2).

16. Translocations in Co. Wexford.

Translocations involve transport of spawn from flourishing sites to entirely new suitable habitats, sometimes far removed from the species historical distribution. While some may argue

that translocations result in non-natural populations, it is a method of increasing their numbers and avoiding a possible catastrophic extinction of relict, natural populations, as in the case of those in Kerry. An initiative by the National Parks and Wildlife Service (NPWS) in 1991 created four ponds at the Ballyteige Nature Reserve (S9207). The reserve is comprised of 585ha on a 9km shingle bar in an estuary and is on the opposite side of the country relative to the historical Kerry sites. Since no dune slacks occur in the aeolian sands, where dunes to 20m occur because of the gravely shingle substrate, entirely new ponds had to be dug. They consisted of a fresh water layer overlying the salt groundwater below. Initially, the salinity was thought to be within the tolerance of the toads and several buckets of spawn were introduced from the Castlegregory Golf Course (see site 10). The spawn survived for about two weeks until high spring tides pushed the groundwater upwards, allowing salt water to mix with the fresh, resulting in loss of the spawn. The current thinking of the Wildlife Service is that further translocations at this site would not be worthwhile unless suitable conditions of water quality were found that would permit the colony to become self-sustaining (Eugene Wallace, Wildlife Ranger, pers. comm.). Recently, the Wildlife Service acquired land adjoining the Nature Reserve and hopes to create sites with suitable water quality so that further translocations can proceed in the future. Ballyteige was designated a Nature Reserve on 28 September 1987, and declared a Biogenetic Reserve on 10 March 1989. The ecosystem contains both rare and protected species of plants and animals and the progressive management program has a focus to control damaging activities, such as horse and motorcycle use, plus gravel and sand removal. Some controlled cattle grazing is permitted.

The other sand dune site in Co. Wexford is at the Raven Nature Reserve (T112250) and is one of three Eurosites in Ireland. It lies along the coast immediately east of the North Slob, Wexford Wildfowl Reserve, and is comprised of about 200ha extending a length of 4.8km (Fig. 5). It was afforested with conifers in the 1920s-1930s and trees extend from inland to dunes just above the strand. The reserve is accessed by foot *via* a north-south, 3.5km "road" from a car park and locked gate (that prohibits vehicles) at the northern end near Curracloe village (Fig. 5). Mechanical diggers were used to excavate pond sites, surrounding forest was clear cut in some cases, some ponds had the removed trees cast into them as substrate, and rock lodges of piled flat sheets (with identifying painted numbers on top) were constructed with internal

tunnels near pond edges to house adults. These lodges were in addition to high surrounding dunes with rabbit burrows that overlooked ponds nearest the coast. Management practice includes mowing of brush near pond edges in early spring-summer to permit toads easy access. Some ponds were relatively clustered to aid in establishing a metapopulation structure with source and satellite dynamics. Spawn from Castlegregory was initially introduced to some sites in 1990, but did not survive due to low salinity. Subsequently, spawn from the same origin were introduced in 1991 and survived at a number of sites. Further spawn translocations, plus that of 1991, have resulted in successful breeding (i.e., larvae metamorphosing to toadlets resulting in reproducing adults) at a number of the ponds, at least for the short-term. Since a definitive minimum viable population size (MVP) is not known for this species, the longer term success of these colonies will require care and close monitoring, with perhaps Beebee's (1997) suggestion of 100 adults as a target goal at each pond.

Our visit to nine of the Raven ponds (Fig. 6) began at 14:00 hours on 16 January 1998. As expected during winter dormancy, no adults were seen about the ponds, lodges, or any nearby dunes, nor were spawn or tadpoles present. Our survey resulted in the first mapping of some ponds and their physical description, as well as determination of temperature, pH, and salinity for four ponds. Each pond (number refers to Fig. 6) and data are as follows:

Pond 1: clear water, sandy bottom, some filamentous vegetation, center depth > 1m, water temperature 6.5°C., air temperature 6°C., pH 7.5, salinity 0 ppt, few dystiscid adults, 5 adult smooth newts swimming or under rock ledges, tunnels for toads in rock lodges noticeably warm to touch.

Pond 2: clear water, sandy bottom, water and air temperature 6°C., pH 7.9, salinity 0 ppt (closer to sea than Pond 1), several swimming adult smooth newts, 2 dead sticklebacks, near to monkey puzzle trees.

Pond 3: clear water, sandy bottom, very large pond with clear cut trees thrown into water, water and air temperature 6°C., pH 7.9, salinity 0 ppt, toad rock lodge completely submerged, pond area flooded out, high surrounding dunes.

Pond 4: clear water, sandy bottom, water and air temperature 5.5°C., pH 7.8, salinity 0 ppt, high dunes on coastal side.

Pond 5: only location beyond forested area noted.

Pond 6: pond area flooded out, no further data.

Pond 7: pond area flooded out, no further data.

Ponds 8 and 9: location off access road noted, water levels not excessively high, no further data.

The precipitation recorded at the North Slob, Wexford Wildfowl Reserve was nearly twice the average for January 1998 (Wilson, pers. comm.) and, no doubt, resulted in the inundated ponds and rock ledges, and influenced pH and salinity as well. Ponds 8 and 9 were revisited on 6 August 1998 at 17:00 hrs. The surrounding, eye-level vegetation had not been cut back and extended to the water line, thus probably preventing adults from frequenting the ponds. No signs of adults or larvae were present. The water in Pond 8 had a pH of 6.3 and 1 ppt salinity and in Pond 9 a pH of 6.4 and similar salinity.

Additional data for some of the Raven ponds were provided by Kehoe (1995) and appear with his written permission. He recorded data (Table 1) for five ponds (1-4, 6) and made other observations for the period 4 May-21 July 1995. Pond numbers refer to Fig. 7. Tadpole counts were estimated in the afternoons. The first adults of the year were seen on 4 May, coinciding with the day two 2.5 litre buckets of translocated spawn from Castlegregory were introduced to Ponds 1 and 4. Pond 5 was never visited by adults and subsequently produced no spawn or tadpoles that breeding season. The other five ponds were frequented by toads at night and did produce spawn and tadpoles. As noted, Ponds 1 and 4 received translocated spawn that season in addition to having visiting adults. Only Ponds 1 and 6 of the fecund ponds successfully produced toadlets, most likely due to insect predation at the others. The first toadlets were observed at Pond 1 on 23 June, approximately 10mm total length. On the night of 16 May a total of 29 adults were observed at Ponds 1, 2, 3, and 6, with calling at the first three, but none at Pond 6. The most adults counted in one night was 48 on 23 May, distributed as follows (first number indicates pond, number in parenthesis is number of adults): 1(17); 2(14); 3(8); 4(4); 6(5). That night, minimum air temperature was 11.6°C. and minimum ground temperature was 9.1°C. On cooler nights, fewer adults were observed or heard calling. Calling was last heard on 29 June and the latest spawn was observed in Pond 6 on 21 July from which no tadpoles survived.

Audiospectrographic results

The sonogram in Fig. 8 is based on a mating call recorded 18 May 1997 at Castlegregory Golf Course (Co. Kerry) at an air temperature of 10°C. The top graph shows amplitude, the bottom frequency with the Y-axis 1-3 KHz and the X-axis is time in seconds. The small inset graph to the left shows two amplitude spikes at 1.64 and 1.89 KHz and a mean frequency of 1.72 KHz. The mating call analysed in Fig. 9 from the Raven (Co. Wexford) was provided by Chris Wilson, no further data recorded. Top graph is amplitude, the bottom frequency, Y-axis 0-3 KHz, X-axis is time in seconds. The small inset graph on the left shows a single amplitude spike at 1.72 KHz and a mean frequency of 1.81 KHz.

Discussion

The documented decline in numbers and increase in malformations among amphibians worldwide have raised the alarm that amphibians are like the caged birds miners once took with them to warn of impending disaster. The amphibians are, in effect, responding to major, negative, selective pressures exerted on them that are reducing their ability to survive as individuals or a species, and are portents of what humans may eventually face. Since extinction of the majority of living species is the rule over geologic time, some amount of the present decline, occurring at a rate greatly exceeding any seen in the fossil record, may be attributable to natural causes (e.g. increased predation, increased parasitism (trematodes), increased intra or interspecific competition, increased fungal pathogens (chytridiomycosis), and climatic fluctuations). When a population is initially small and scattered, like the Irish natterjacks, the margin of error relative to survival is severely and abruptly reduced.

Ecological and population genetic considerations arise from the natterjacks present distribution consisting of older, disjunct, relictual, contracted populations in Kerry and the more recent translocated ones in Wexford. The latter more closely conform to the metapopulation model due to the purposeful creation of adult habitat and breeding ponds in proximity to one another, relatively untraversed by motor ways or other barriers to movement. Reh and Seitz (1990) discussed the negative effect of barriers on *Rana temporaria* in Germany, with recommendations to alleviate the effects. Sinsch (1992) discussed the importance of the "rescue-effect" in natterjacks, whereby recruitment of juveniles from self-sustaining populations

maintain those prone to extinction by low reproductive success. This should promote the source-sink dynamic and gene flow between subpopulations enhancing genetic diversity and probability of survival.

The Kerry sites in contrast are more geographically isolated from one another by sheer distance, as well as barriers (roads, car parks, towns, mountains). These should reduce gene flow resulting in inbreeding depression, loss of genetic diversity, and therefore reduced survival probability. Although no confirmatory data exists for Kerry sites, Hitchings and Beebee (1996) sampled British populations relative to the above scenario by allozyme analysis. The isolated populations sampled from British sites exhibited an unusually low level of genetic diversity in contrast to wide-ranging conspecifics in Germany. Yet in spite of this, 10 to 25 year studies of the British populations indicate they are not experiencing inbreeding depression, but instead show breeding vigour and good recruitment when climatic conditions are favourable. Thus, if the British data apply to Kerry sites, they may not be as disabled by isolation as one would initially imagine. Natterjack mortality bears further study, but appears to be somewhat independent of genetic fitness and more a function of human influence on habitat quality.

As habitat specialists, natterjacks generally are poor competitors with sympatric amphibians. The number of competitors is limited in Ireland by the island's depauperate fauna. Although adult natterjacks have been shown to breed in water slightly more acidic than that tolerated by common frogs (Beebee and Griffin, 1977), natterjacks as habitat specialists are more restricted to preferred habitats than the less specialized common frogs that utilize a wider range of habitat types, as reflected in their broader geographic distribution (Korky and Webb, 1993). Toad larvae are at a disadvantage compared to *R. temporaria* larvae because of their habit of coprophagy of common frog larval faeces. Beebee (1991b), Beebee and Wong (1992), and Griffiths *et al.* (1993) have documented growth inhibition of natterjack larvae with sympatric common frog larvae that is mediated by ingestion of a growth inhibiting factor in the unicellular alga *Prototheca*. Thus, adults and larval natterjacks are inferior competitors to sympatric common frog adults or larvae. Heusser (1972) examined larval competition and demonstrated that older natterjack larvae inhibited growth of younger conspecifics in conditioned water by means of a proteinaceous skin secretion. Thus, natterjacks are inferior competitors with the common frog, and also on the intraspecific level.

The other potential amphibian competitor for natterjacks in Ireland is the smooth newt, *Triturus vulgaris*. Marnell (1998) studied the niche parameters of this species. He suggested frog tadpoles as an important food source for adult newts across Ireland. We noted the presence of adult newts at several of the Wexford natterjack sites (also confirmed by unpublished data of Marnell, pers. comm.). However, his analysis of the stomach contents of *circa* 80 adult newts on the Raven showed no natterjack tadpole tissue present, in spite of the fact they potentially represent a very large portion of the available biomass. This avoidance is most likely due to the noxious secretions of natterjack eggs, larvae and adults that renders them unpalatable to many predators, including newts. This suggests natterjacks may be able to coexist with newts to a greater degree than with frogs in Ireland and that aquatic beetle adults and their larvae seen in some Raven ponds are most likely prime agents of early natterjack tadpole mortality. These complex ecological interactions require further study for clarification.

In recognizing that the main non-natural causes of amphibian decline is anthropogenic, and that if humans generated them, humans should be able to lessen them, a number of global clearinghouses have been set up on the internet to share data. The North American Amphibian Monitoring Project <<http://www.im.nbs.gov/naamp3>> is such a site and also includes information on British and Dutch monitoring programs. Another site, the North American Reporting Center for Amphibian Malformations, has an extensive bibliography at <<http://www.npwr.usgs.gov/narcam>>. Anthropogenic factors include widespread use of synthetic molecules as pesticides and herbicides that bioaccumulate to sublethal and lethal levels. This could be lessened by integrated pest management and organic farming. Ozone depletion in the stratosphere due to use of chlorofluorocarbon (CFC) compounds in aerosols and refrigerants has increased ultraviolet exposure, particularly ultraviolet B on thin-skinned amphibians. This could be lessened by replacement of CFC compounds with ozone safe ones, as begun by the 1987 Montreal Protocol international agreement. Global acid precipitation, because of fossil fuel dependence, has lowered habitat pH levels and impacted natterjacks particularly because of their pH sensitivity, especially regarding breeding ponds. This could be mitigated by adding lime to raise pH, plus mandating more efficient vehicles and cleaner burning fuels. Related to fossil fuel dependence is greenhouse global warming. Relative to warming of the oceans, any increase in the melting of polar ice-caps will translate to rising sea

levels and inundation of coastal regions. Rignot (1998) documented this phenomenon in a west Antarctic glacier for 1992-1996. Irish natterjack populations, given their coastal preference, would thus be vulnerable to rising sea levels and catastrophic extinctions. Perhaps the NPWS should give thought to translocating some populations to suitable inland sites. Alternative safe sources of energy clearly need to be explored to replace dwindling and polluting fossil fuels; these could include more solar sources, windfarming, and use of biofuels from organic decomposition. Although Ireland and its touted Celtic Tiger economic boom in financial services, computer, and pharmaceutical sectors is expanding rapidly, the country has a long heritage of attempting to increase arable acreage and exploit resources of the land. These practices have involved draining and filling wetlands, turf cutting, sand and gravel removal, etc., and have collectively altered or entirely destroyed natterjack habitats. Thus, marginal survivors are pushed yet closer to extinction.

Our 1997 habitat survey indicates both adults and larval natterjacks as scarce in many localities. Besides the anthropogenic and ecological factors mentioned, others clearly played a role. The 1997 monthly rainfall data (Fig. 10), recorded at Valentia Island, Co. Kerry, by Met. Éireann, were below average for four of the five months, January through the May breeding season, with three months less than 50% of the norm. Although the data show May was 94% of normal, the reality at inland Kerry sites may have been considerably less, as Cahirciveen on the mainland east of Valentia Island is reputed to have the greatest annual rainfall in Ireland. A recording site at Rough Point, north of Castlegregory (Q628196, 11m), showed a monthly total of 65.4mm versus 80.1 at Valentia. This suggests a deficient hydroperiod prior to breeding in Kerry and explains the lack of observed adults and tadpoles, and even suitable standing water, in a number of localities. This deficiency, coupled with recurring marine incursions, severely impacted breeding in the 1997 season, limiting breeding success, and probably reduced recruitment of individuals from core populations to satellite ones. Our survey of the Raven sites, Wexford, demonstrated the difficulties encountered in translocation projects. The creation of suitable breeding sites and successful reproduction involves more than just the desired depth, water quality, hydroperiod duration, surrounding vegetation, shelving edge, surrounding soil quality, and accessibility to other sites; other uncontrollable factors include seasonal and annual fluctuations in temperature, rainfall, and marine encroachment. Our results indicate excessive

rainfall in the winter of 1998 that completely submerged some of the adult lodges provided for hibernation, and may have resulted in the loss of some adults unless they moved to burrows in adjacent high dunes. Although adult newts were observed in some ponds, they probably do not account for toad tadpole mortality; rather adult predacious diving beetles and stickleback are most likely the major predators of tadpoles. Vegetational succession about non-maintained toad sites (see discussion of Raven ponds 8 and 9) with otherwise suitable pH and salinity, seemingly impedes vagility of natterjacks, since the ponds had neither adults, tadpoles, nor juveniles. The 1995 data of Kehoe confirm a number of self-sustaining sites that are probable sources of recruits for satellite populations nearby; he also noted that insect predation on tadpoles is often catastrophic, leaving no survivors for a season at some sites, and tadpole metamorphosis to toadlet has about a one in ten chance on average. Given all the variables and possible synergisms that may exist, it is much to the credit of the NPWS that they have successfully translocated natterjacks on the Raven.

Our audiospectrographic results show great similarity between the Kerry and Wexford sites. This would be expected, since Castlegregory, Kerry, has been the source of the spawn for the Wexford population over the period 1991 to 1997 when the recordings were made. Slight variations between the spectrographs are attributable to different recorders being used at, presumably, different air temperatures and distances from a calling individual (no data on Wexford available) and perhaps other variables. Although the six year time span represents two toad generations (given sexual maturity attained in three years), some of the variation between the two localities may be due to accrued genetic divergence between the founder and translocated population in that brief time. Rowe *et al.* (1998, England) used molecular methods and determined three of four founder-translocated pairs significantly differed at 95% C.L. over a period of no more than five toad generations. Since no molecular clock presently exists for the molecular method used, the rate of divergence cannot be determined, but is most likely cumulative over generations.

Biogeography

The origin and distribution of natterjacks in Ireland have been the subject of speculation and investigation for more than a century since the species was first observed at Callanfersy, south

of Castlemaine Harbour in 1805. Joseph (1970) dismissed the Irish toads as an "introduced colony" without further qualification. O'Rourke (1970), referring to Praeger (1950), related the commonly held notion that a ship had discharged some (perhaps from sandy ballast) at the head of Dingle Bay, thus accounting for their sightings in a circle from Castlemaine Harbour north and south on the adjacent peninsulas. He credited Praeger with describing the toad as a "relict species, like some of the Kerry plants," that represented a Lusitanian element within Irish biota (Lusitania was the Roman provincial name for the Iberian peninsula, much of which is presently Portugal); no data are available to prove or disprove a Lusitania origin. This does not mean, however, that the toad did not previously exist in Ireland and that the discharge simply augmented the population.

A variety of data:- geographic distributional; geological; paleontological; and molecular (allozyme and microsatellite loci analyses) support the contention that natterjacks have been in the British Isles (*sensu lato*) for thousands of years before the present (BP). Considering the present rangewide distribution of *B. calamita*, the Irish and British populations are at the northwest fringe relative to those of continental Europe. This suggests they have emigrated from the species center of origin on the continent at an earlier time and that their marginalized ecological niche on the islands probably is less optimal than the more pristine fundamental niche of conspecific continentals. Bell and Walker (1995) provided supporting geological data; the peak of the last glacial episode occurred about 18,000 BP, when sufficient water had been removed from ocean sea levels and stored in continental ice sheets, and global sea level was lower by 130m than today. Land bridges then existed at varying times between continental Europe and Britain and Britain and insular Ireland, and natterjacks could have moved overland from glacial refugia on the Iberian peninsula. The British ice sheet had virtually disappeared by 13,000 BP and all glaciers had been removed from the British Isles by 10,000 BP. The melting of the ice caused eustatic (= global) sea level increases that gradually inundated the land bridges. While the eustatic increase proceeded, isostatic (= local tectonic activity) uplifted coastal regions and dunes developed on these regions from windblown sand from intertidal areas. Immigration from Europe to Britain ended about 8.7-8,000 BP. Immigration into Ireland from Britain had terminated some 2,000-3,000 BP earlier, when that land-link was lost to eustatic sea level rise. Palaeontological confirmation of the long-standing presence of

natterjacks in Britain is provided by fossils dated to *circa* 8,800-10,000 BP by Holman and Stuart (1991). Further study is needed to confirm the presence of natterjacks in Ireland, based on putative fossil remains from Carrowmore, Sligo, dated *circa* 4,000 BP (see site 14).

Molecular data supporting the land-bridge scenario centers on the application of population genetics analytical techniques to biogeography, or as it is referred to collectively, phylogeography. Hitchings and Beebee (1996) employed allozyme analysis to investigate genetic diversity and relatedness in isolated British populations. Some portion of the low genetic diversity they found could be explained by the founder effect, if indeed ancestral colonizers represented a small fraction of the species continental genome and were subject to strong directional selection for a specialized phenotype in a limited realized niche. This founder effect phenomenon is consistent with the land-bridge scenario.

A more recent and powerful molecular technique that has become the method of choice to investigate genetic divergence and relatedness of biological populations is microsatellite loci analysis. Microsatellite loci are relatively short, repetitive, nucleotide sequences in an organism's nuclear DNA that can be detected and quantified by appropriate primers and PCR amplification. Essentially, the more shared microsatellite loci a number of samples have in common, the more closely they are related. Rowe *et al.* (1997) developed the primers necessary to analyze natterjacks for this character state and these authors then (1998) used it to analyze British natterjacks from 40 sample sites that divided into three main population clusters. Their data determined genetic distance between regional clades and indicated a long-standing separation, especially between east-southeast and northwest populations, consonant with the land-bridge scenario and subsequent isolation over thousands of years. Unfortunately, microsatellite analysis does not presently contain a molecular clock to provide a more accurate timeline relative to isolation and divergence. Beebee (pers. comm.) and colleagues now have a manuscript in review that will include Kerry populations, and some continental ones, that presumably will support the land-bridge scenario and determine to which British populations the Kerry ones are most closely related, most probably those in the northwest where the land-bridge once existed. If so, the toads migrated from the land-bridge in Ireland's northeast to Kerry in the southwest and elsewhere, thousands of years BP. Fossils at appropriate sites and ages could confirm this, but as Monaghan (pers. comm.) has related to us, amphibian localities

in Ireland do exist, "but in general vertebrate sites are quite rare." Fossil natterjacks are therefore yet another area warranting further investigation.

Conservation

We conclude with the following observations (see, also, Beebee and Denton, 1996) that hopefully will assist in conserving the natterjack toad in Ireland.

1. A proactive program of public information on the conservation of natterjacks is desirable, making them conservation icons. The Irish public, generally biophilic, needs to be informed about them as long-term members of the island's fauna with a proven role in controlling destructive agricultural insects, lessening the need for insecticides. The various conservation and wildlife societies need to be mobilized, as they are in Britain and Scotland, to lobby their elected representatives to appropriately fund the NPWS and Dúchas heritage service so they can conserve the toad for future generations.

2. The mobilized public can then be enlisted as "toad loggers" who "adopt" a species to assist the NPWS in gathering baseline data on populations as is done in other countries, and the Board na Mona sponsored Irish Peatland Conservation Council's survey of the common frog in Ireland. Protocols exist for population studies by volunteers who use vocal surveys, egg string counts, night eye-shine counts, and safe mark and recapture methods. Such data are then used in indices of relative abundance to estimate population size at various times in the year. This will help the NPWS in constructing a species action programme (SAP) and a population viability analysis (PVA) that delineates core (source) *versus* satellite (or sink) populations and which deserve conservation priority. The data can also be used in constructing population simulation models that, along with extinction variables, can compute the % probability of extinction of a given population in a given number of years. This information will be helpful in prioritizing sites. Since all of County Kerry is monitored by only four Wildlife Rangers, volunteers must be used if a toad conservation and recovery SAP is to succeed that can establish viable metapopulations.

3. The identification of critical core-zone habitats and their designation as reserves with perhaps a 100m buffer zone is the only way to counteract habitat deterioration and destruction. This goal is being realized as detailed in *The Kerryman*, 14 March 1997. Therein, the Minister

for Arts, Culture, and the Gaeltacht, whose departments include the NPWS, notified Kerry landowners and users that he intended to designate certain lands as Special Areas of Conservation (SAC) in accordance with the "European Communities (Natural Habitats) Regulations, 1997." These areas include many of the known natterjack sites. Those owning or using land in the designated sites will be identified by NPWS, notified in writing, and be provided with a site map and description, list of activities that may damage the site, procedures for objecting to the designation proposals, and details of compensation provisions. The last feature is vitally important if land is to be withdrawn from use affecting income.

It should be noted that adding acreage alone in certain circumstances may be detrimental. Pulliam and Danielson (1991) demonstrated that a smaller metapopulation may result if most of the additional land is sink habitat that depletes the source population. Thus, designating critical core (source) habitat by field survey is most desirable.

4. Statutory authorities must fully implement all legal protection afforded by Irish and/or European Community law. This would go a long way in preventing grossly destructive activities like the blatant sand and soil removal observed at Lough Naparka. This should include careful scrutiny of touristic and recreational project proposals that involve planning permission, like the golf course proposed on the Inch peninsula (see site 6) that is currently the subject of a court injunction.

5. Encouragement of further relocations or translocations in Kerry, where interconnecting self-sustaining metapopulations can be established in identified core habitat. Translocations have been successful on a variety of sites, including artificial ones in the Netherlands (Boomsma and Arntzen, 1985) and on gravel pits no longer in use in Germany (Sinsch, 1988).

6. Since high amphibian mortality is associated with vehicular traffic (Ruprecht, 1995), appropriate road signs should alert drivers to toad crossing sites and other potential high density occurrences, e.g. along the Lake Road at Lough Yganavan (see Kerry site 1).

7. Since eustatic sea level has continued to rise at 10-15cm over the last century as indicated by tidal gauge data, and may be enhanced by recent glacial melting, consideration should be given to establishing some inland populations safe from marine inundation. This might involve some of the successful artificial habitats.

8. Techniques should be employed to prioritize populations for conservation based on

molecular markers, such as the rarefaction technique that measures allelic richness proposed by Petit *et al.* (1998). It could be determined if Castlegregory (site 10) is indeed the best sole source of spawn for relocations and translocations, or if spawn from other sites should be used as well to maximize genetic diversity. If Castlegregory spawn were deficient, a very detrimental founder effect would already have been introduced into the Raven sites and perhaps others as well.

Another source for measuring and monitoring amphibian biological diversity is provided by Heyer *et al.* (1994). It could be employed to design a SAP and PVA for the natterjacks.

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FIGURE 1. Adult natterjack toad showing prominent mid-dorsal stripe and short hind legs.



FIGURE 2. Pre- and post-1970 natterjack locations in Co. Kerry (after Gibbons, 1981).

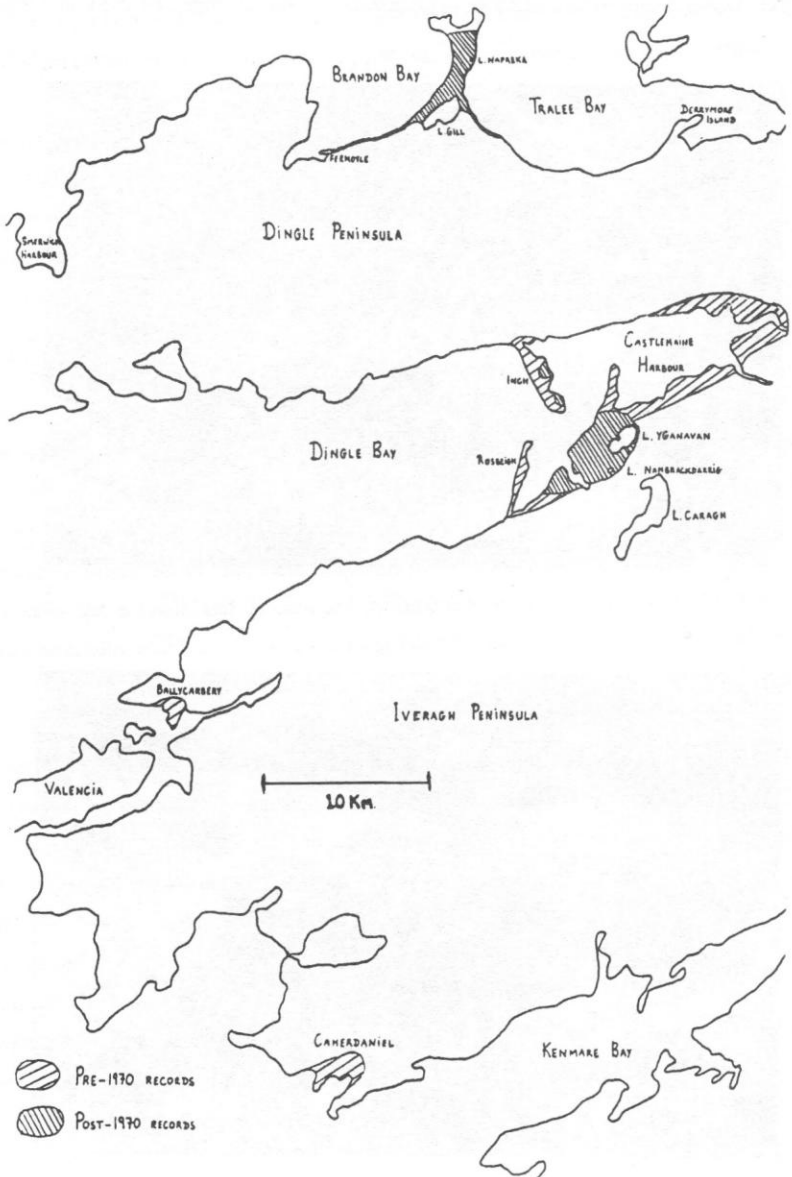


FIGURE 3. Natterjack localities in Co. Kerry (after Whilde, 1993).

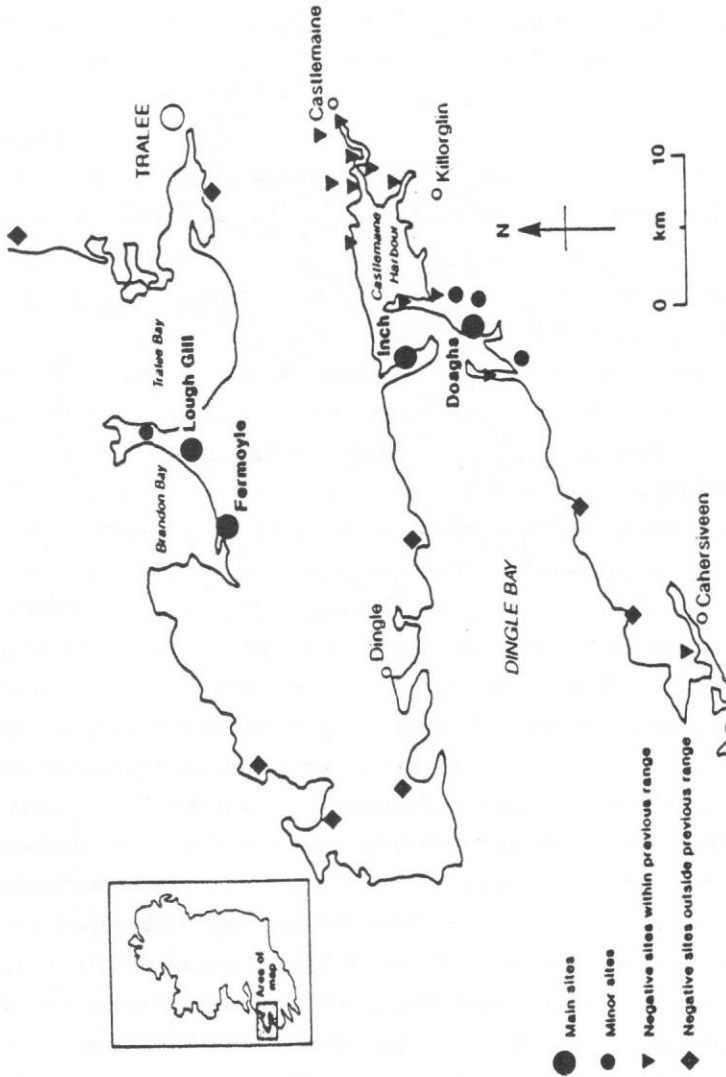


FIGURE 4. Kerry natterjack localities discussed in this study. Numbers 1-12 correspond to localities discussed in text.

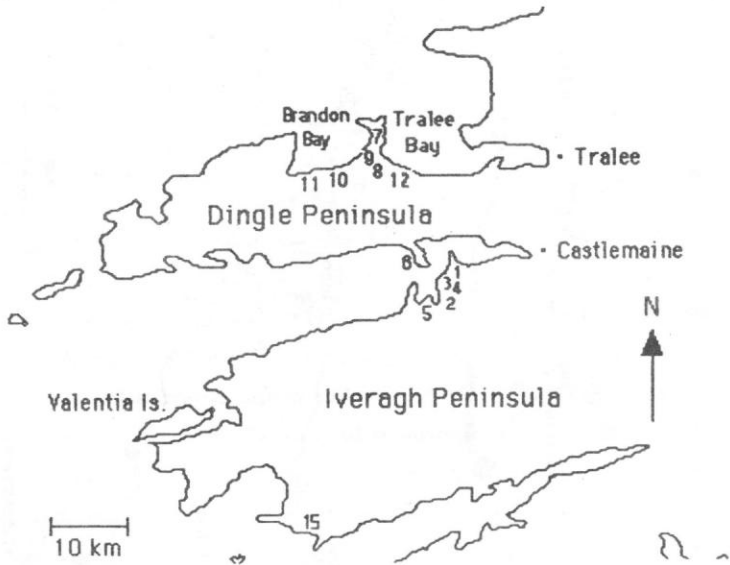


FIGURE 5. Wexford natterjack translocation site indicated by number 16 on the Raven peninsula, east of the Wexford Wildfowl Reserve (WWR).

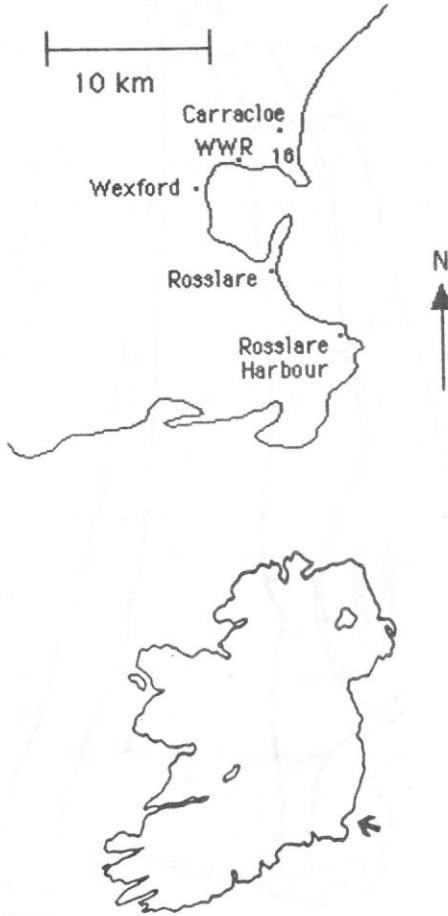


FIGURE 6. Ponds (1-9, see text) located on the Raven reserve where observations/data were recorded in 1998 by JKK.

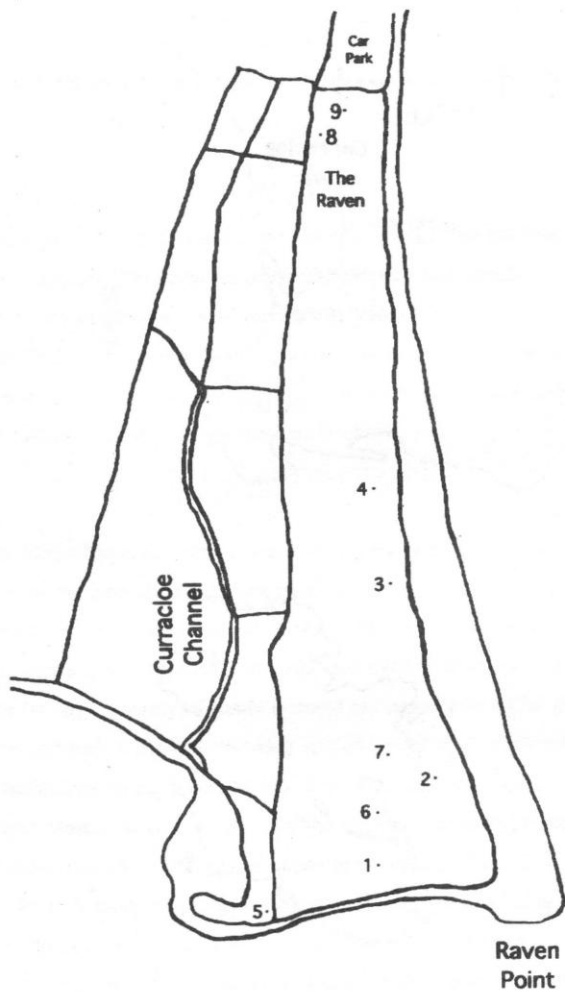


FIGURE 7. Ponds (1-4, 6) located on the Raven reserve where observations on spawning were recorded in 1995 by J. Kehoe (numbered pond sites do not correspond to those in Fig. 6).

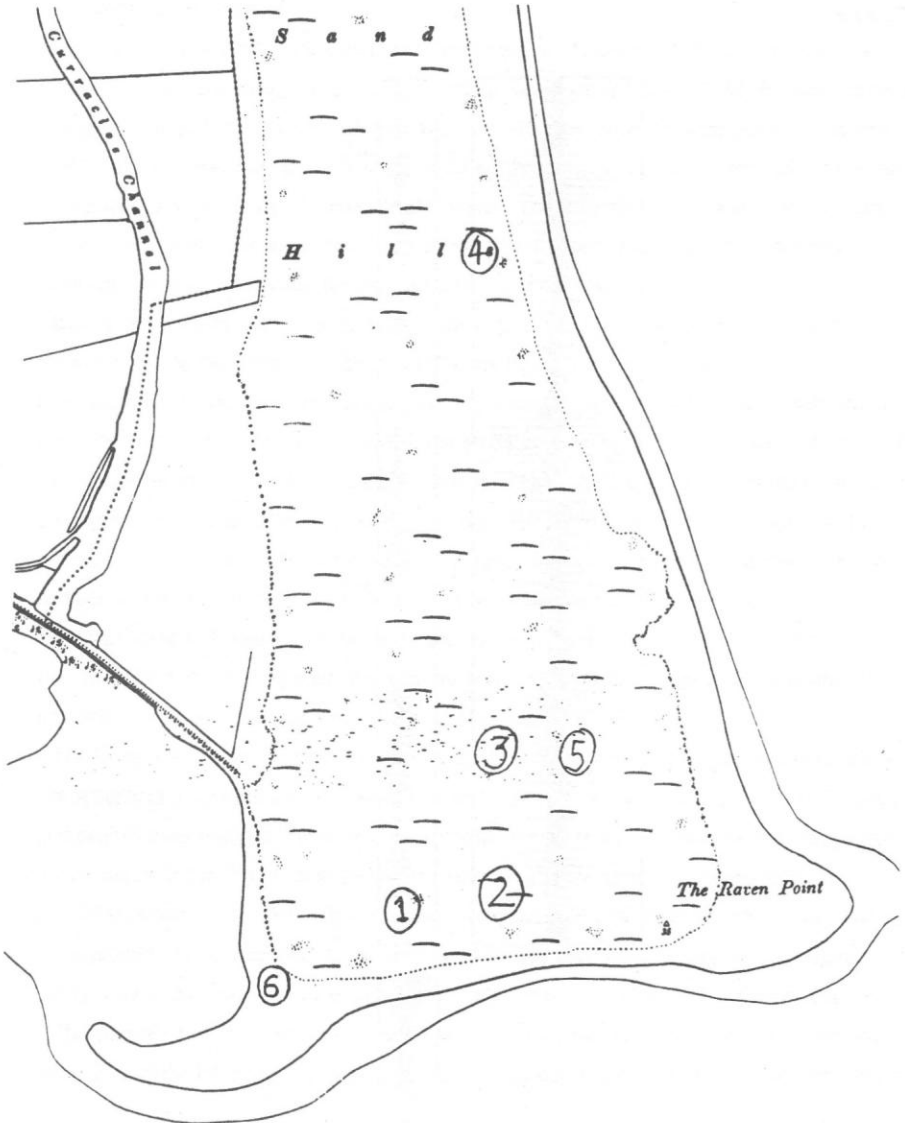


FIGURE 8. Audiospectrograph of natterjack toad mating call recorded at Castlegregory golf course, Co. Kerry, 18 May 1997 at an air temperature of 10°C., with a mean frequency of 1.72 KHz.

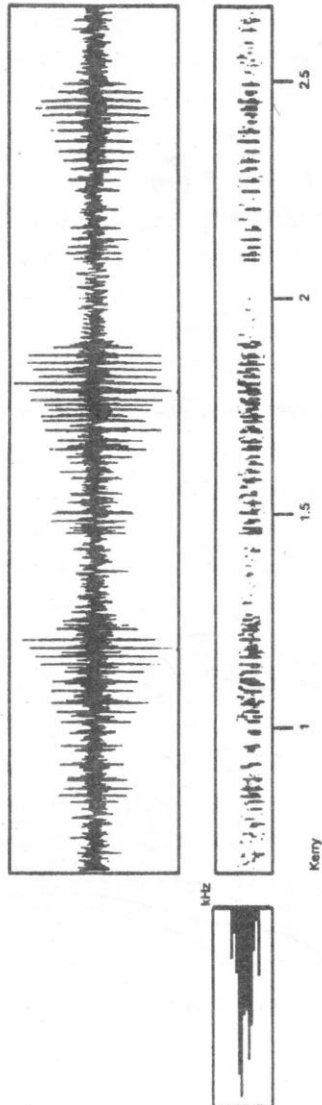


FIGURE 9. Audiospectrograph of translocated natterjack toad mating call recorded on the Raven reserve, Co. Wexford, with a mean frequency of 1.81 KHz. No further data available.

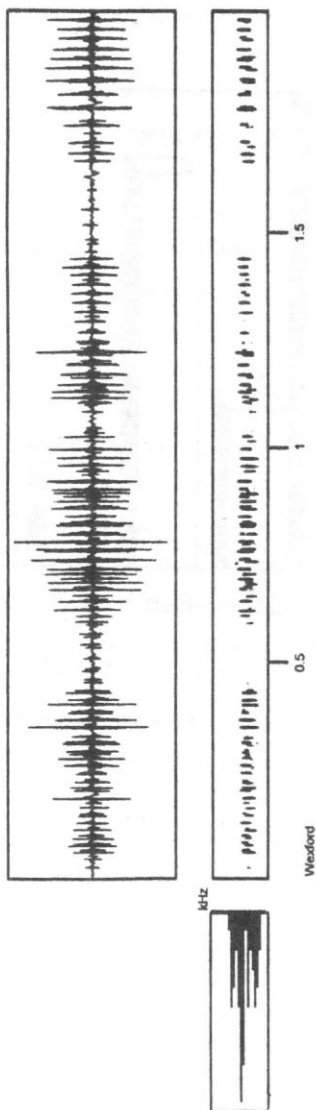


FIGURE 10. Rainfall (mm) recorded at Valentia Island, Co. Kerry, for the period January through May 1997. Monthly % indicates amount of rainfall recorded relative to the monthly norm for the period 1951-1980.

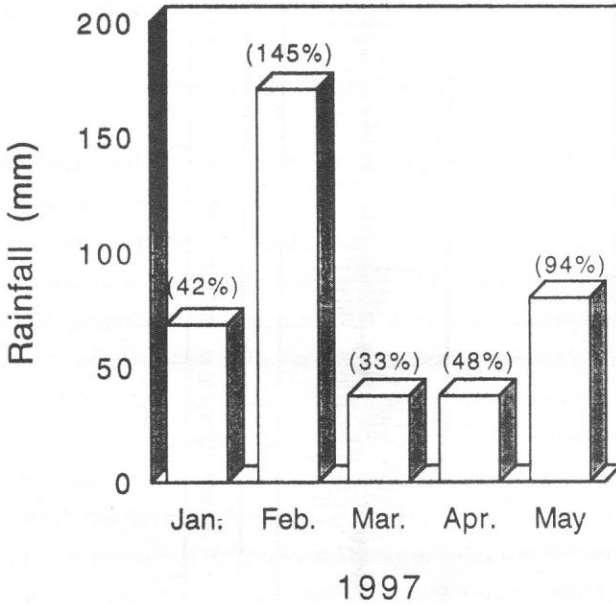


TABLE 1. Ferdia Marnell, formerly of the Department of Zoology, Trinity College, analyzed water quality of pond nos. 1, 2 and 6. Results as follows:

	pH	Conductivity	Salinity
Pond No. 1	8.0	399 us	< 100 ppm
Pond No. 2	8.0	236 us	< 100 ppm
Pond No. 6	9.5	272 us	< 100 ppm
	pH is a little high for No. 6	conductivity is normal for fresh water ponds	salinity does not suggest brackishness

TABLE 1 (continued)

Pond No. 1

Date	Tadpoles	Average Size (mm)	Spawn/Toadlets	Comments
17 May	8,500	10		Smooth newts present, up to 40 visible at night
23 May	8,500	13		Biggest tadpole 16mm, toad croaking under stone
30 May	6,000	18	5 eggs per cm roughly 500cm	
7 June	4,000	20+6		Large numbers of beetles (diving, backswimming)
14 June	1,200	20+8		Large tadpoles showing hind legs and protruding eyes
23 June	960	20	toadlets	Browning eyes, legs, toes, some tadpoles at 10mm
28 June	600	20+	400 toadlets	At water's edge, very active among weed and under stones
5 July	60	20+	900 toadlets	Up to 3m from pond, large numbers of dragon and damselflies
13 July	20	20+	850 toadlets	
21 July	25	20+	800 toadlets	Toadlets up to 10m from pond, very difficult to count; estimate

Survival rate of tadpole to toadlet stage:

tadpole : toadlet

8,500 : 900

85 : 9

9.5 : 1

TABLE 1 (continued)

Pond No. 2

Date	Tadpoles	Average Size (mm)	Spawn/Toadlets	Comments
17 May	60	7	300cm: 10 eggs per cm	On 19 th , spawn began to float but was buried in mud prior to hatching; large numbers of backswimmers and whirligig beetles and diving beetles
23 May	25	10	hatching 4mm; changing to string	
30 May	0			All tadpoles gone, possibly due to large numbers of beetles; adult toads continued visits until pond dried up

No. 2 pond dried up by 21st July.

TABLE 1 (continued)

Pond No. 3

Date	Tadpoles	Average Size (mm)	Spawn/Toadlets	Comments
17 May	155	8		
23 May	270	10		Toad croaking under stone
30 May	130	12		Large numbers of backswimmers and diving beetles
7 June	100	16		
14 June	170 50	7 20		Weed growth is high, beetle numbers up, water levels down
23 June	75 25	8 20+		Larger tadpoles, legs, eyes, colour change
28 June	2	12		No toadlets visible
5 July	0			Pond full to lip with stonewort
21 July	0			Dragon and damselflies in abundance

TABLE 1 (continued)

Pond No. 4

Date	Tadpoles	Average Size (mm)	Spawn/Toadlets	Comments
17 May	1,200	10		Tadpoles well dispersed throughout whole pond, not just on edges
23 May	1,100	13		
30 May	400	16		Large numbers of backswimmers
7 June	60	18+7		
14 June	20	20	5 eggs per cm	500+-cm
23 June	40	7		Large numbers of backswimmers and whirligig, some greater diving beetles
28 June	4	10		
5 July	6	12		No visible toadlets
21 July	0			Dragon and damselflies

TABLE 1 (continued)

Pond No. 6

Date	Tadpoles	Average Size (mm)	Spawn/Toadlets	Comments
17 May	200	10		
23 May	610	11		Some have blunted tails, as if bitten
30 May	400	13		Some greater diving beetles and backswimmers present
7 June	210	16		
14 June	170	20		Water levels down, tadpoles beginning to show legs
23 June	60 50	20+7		
28 June	95	20+8	5 eggs per cm 500+cms	Weeds high, water level down
5 July	20 30	20+8	50 toadlets at 10mm	30+ toadlets in group among reeds
21 July	350 20	8+20	50 toadlets	Dragon nymph cases over twenty on surface

Survival rate of tadpole to toadlet stage:

tadpole : toadlet

610 : 55

122 : 11

11 : 1

Bull. Ir. biogeog. Soc. No. 23 (1999)

**ORIGINS OF THE NATTERJACK TOAD *BUFO CALAMITA LAURENTI* IN IRELAND:
RE-EXAMINATION OF SUBFOSSIL BONES FROM CARROWMORE, CO. SLIGO**

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Introduction

Only three amphibians are found in Ireland (smooth newt, *Triturus vulgaris* L.; common frog, *Rana temporaria* L.; and natterjack toad, *Bufo calamita* Laurenti). Of these, the natterjack has attracted the most attention from zoologists (O'Connor and Jeal, 1984; Whilde, 1993; Korky and Webb, 1999). In particular, the origin of this species in Ireland (natural colonisation *versus* human introduction) has been the subject of much debate (e.g. Scharff, 1916; McDougald, 1942; Yalden, 1982; Frazer, 1983; Wilson, 1983; Beebee, 1984) since the animal was first recorded in Ireland from Castlemaine Harbour in 1805 (Mackay, 1836). O'Connor and Jeal (1984) found it incredible that toads could have gone unrecorded for so long if they had been an established element of the local fauna. However, it is not impossible that, although well known to locals, the Kerry toads were unknown to the scientific community before 1836. Either way debates are still conjectural as there is to date no hard documentary evidence to support or refute either argument. While it seems unlikely that we will ever acquire data to support the sand ballast theory, the discovery of physical (osteological) evidence would certainly benefit the theories of natural colonisation. Korky and Webb (1999) have recently published an in depth review of the natterjack species which examines the issue of its provenance in Ireland in greater detail. They concluded that the natural land-bridge route from north-west England into Ireland

thousands of years ago was the most plausible scenario explaining the ancestral origin of Irish natterjacks based on available data, namely phylogeographic rather than palaeontological.

The aim of the current article is to examine supposed palaeontological (subfossil) evidence for a long-standing natterjack residence in Ireland, and to discuss the likelihood of natural colonisation in view of the pertaining geographical and climatic factors. The palaeozoogeography of *B. calamita* in the British Isles has been examined by Gleed-Owen (1997, 1998: Chapter 9), and direct AMS radiocarbon dates show that this animal colonised south-west England twice after the end of the last Ice Age. First, during the Lateglacial Interstadial *circa* 11,000 radiocarbon years ago, and second towards the end of the Lateglacial Stadial (or Younger Dryas) and into the early Holocene *circa* 10,000 radiocarbon years ago. The results of radiocarbon dates from south-west Wales are awaited, to see if a similar chronology of colonisation took place there. One subfossil record from Ireland has been attributed to the natterjack and this forms the basis of this re-examination.

The Carrowmore archaeozoological record

Between 1977 and 1979 a Swedish team carried out an archaeological excavation of a Megalithic cemetery site at Carrowmore, in Co. Sligo. Grave number 27 contained amphibian bones which were identified at the time as natterjack toad, *B. calamita* (Ove and Persson, 1980). Their association with the archaeology might suggest that the bones are of a similar age (perhaps 5,000 years old) although the authors believed that they might not be of any antiquity. Whatever their age, this discovery clearly had significant implications for natterjack biogeography and appeared to be the first real evidence that the natterjack may once have been more widespread around the Irish coast.

Twenty years later, the question of Irish natterjack origins has not been resolved. As a matter of course, a re-examination of the Carrowmore remains ought to be a priority, in order to check their identification. The bones have been tracked down to the Irish Antiquities Division at the National Museum of Ireland (Dublin) and, with support from the National Museum and Dúchas The Heritage Service, one of us (CGO) undertook a detailed re-appraisal of them. Three bags of amphibian bones were examined: two marked 'Section I' and 'Section II' respectively, and the third unlabelled. Identification was done visually and confirmed using a

low-power binocular microscope. The diagnostic criteria used for identifying anuran skeletal remains were presented by Gleed-Owen (1998).

Results

The bones are dark brown and the crania contain a dark brown/black peaty soil filling. It was immediately clear that the bones belonged to common frog *Rana temporaria*. There is no questioning that these are the same remains as those identified by Ove and Persson (1980) - the bags contained drawings of toads, labelled 'Strandgroda - *Bufo calamita*' (= Swedish for natterjack). A systematic palaeontological account is presented below:

Rana temporaria

Material. Section I: One incomplete fused cranium consisting of left and right frontoparietals, left and right prootics, left and right exoccipitals, and parasphenoid. One pelvis consisting of fused left ilium, ischium, pubis and right ilium (with ala missing), and a right ilial ala (evidently broken from the rest of the pelvis). One left and one right femur, one left and one right tibiofibula. Section II: One incomplete fused cranium consisting of left and right frontoparietals, left and right prootics, left and right exoccipitals, parasphenoid, and sphenethmoid. One right humerus (female), and one tibiofibula. Unlabelled bag (= Section II): One left and one right ilium, one left humerus (female), one tibiofibula, and one fused tibiae and fibulare.

Remarks. There is no doubt that all of these remains belong to *Rana*, and the most diagnostic elements (ilia, frontoparietals) confirm them as belonging to *R. temporaria*. The slender, gracile hind limb bones are immediately diagnostic of *Rana*, and contrast with the much stouter limb bones of all European toads. The blade-like dorsal vexillum on each ilium characterises *Rana*, and its relative depression ahead of the rugose tuber superior confirms that all four ilia belong to *R. temporaria*. The crania are best identified using the frontoparietals. These are narrow, symmetrical, sub-triangular bones forming the roof of the skull. -In *B. calamita* they have an irregular, saw-toothed medial edge and taper to a point anteriorly (with a cartilage-filled gap between them), and a pronounced fossa and crista parietalis. In *R. temporaria* the frontoparietals meet along their length, and none of the European *Rana* have frontoparietals

which compare with those of *B. calamita*. There is also no doubt that the remains from Section I and Section II represent distinct partial skeletons of two mature individuals. The Section II skeleton is from a female, but the sexually-diagnostic humeri are lacking from the Section I skeleton. The elements in the unlabelled bag are those missing from the Section II skeleton. A bird long bone was also found in the Section II bag.

Discussion

It can only be concluded that Ove and Persson (who were undoubtedly not amphibian specialists) made their identifications without consulting comparative skeletons. Even to the untrained eye, the differences between the short, stocky limb bones of a natterjack and the long, slender bones of a common frog are clear. The Carrowmore bones are quite clearly of the latter species. It can only be surmised that the archaeologists made their referral to natterjack based on what they believed was the most likely option. In the literature, the common frog in Ireland has an even more doubtful pedigree than the natterjack. It seems to have been almost unanimously accepted that the common frog was introduced - despite the lack of any scientific backing, and the weight of biogeographic and palaeontological evidence in favour of natural colonisation (McCormick 1999). Crucially, Ove and Persson's publication of the Carrowmore bones came before most debate over natterjack origins (e.g. Yalden, 1982; Wilson, 1983; Beebee, 1984) entered the literature. The natterjack was ostensibly Ireland's only native anuran, and this must have swayed Ove and Persson's identification of the Carrowmore bones.

Conclusions

Re-examination of the Carrowmore amphibian bones has shown that they do not belong to *B. calamita*, but that they represent the partial skeletons of two common frogs, *R. temporaria*. Thus, there is still no known subfossil evidence of natterjacks in Ireland, despite a dozen or so sites in south-west Britain producing natterjack bones spanning much of the last 11,000 radiocarbon years in regions where the toad is extinct today (Gleed-Owen, 1997, 1998). Obviously this does not mean that such evidence does not exist in Ireland - the problem is that almost no work has ever been carried out on Irish subfossil amphibians and reptiles with most research so far concentrating on the mammalian fauna (e.g. Woodman *et al.*, 1997). The

feasibility assessment of natural colonisation *via* a land-bridge is complicated by sea-level models which offer conflicting pictures. Wingfield (1995) suggested that a land-bridge stretched from Britain to Ireland throughout the Lateglacial and early Holocene, gradually shifting northwards through time. Lambeck (1996), on the other hand, calculated that no land-bridge has existed since climatic amelioration took place *circa* 13,000 radiocarbon years ago. Devoy (1995) even noted that there is still no conclusive evidence for any land-bridge. Even today, too little is known about the palaeobathymetry of the Irish Sea basin. The drowned surface of any ex-land-bridge has by now almost certainly been largely or completely destroyed, its elevation lowered by erosion. As a result, crustal models based on modern bathymetry can at best provide an estimate of palaeobathymetry. Furthermore, marine transgression scoured a channel through Dover Strait sediments (Gibbard, 1995; Scourse and Austin, 1995) and could have helped deepen the St. George's Channel too.

Only subfossil remains from Ireland can determine when *B. calamita* arrived in Ireland. In the absence of physical evidence, other avenues may prove more fruitful. A recent genetic analysis of European natterjack populations has thrown new light on their inter-relatedness, and on the time elapsed since their dispersal to different regions (Beebee and Rowe, in press).

Microsatellite DNA data supports the idea that the Kerry toads are descended from animals that colonised Ireland approximately 10,000 years ago (presumably *via* a natural land-bridge). We are also awaiting the results of AMS radiocarbon dates on common frog bones from Carrowmore and from several cave sites which are expected to help elucidate that species' history and antiquity in Ireland. It is difficult to see how this and so many other vertebrate and invertebrate species could have arrived without a land-bridge - it must have been some floating log!

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THE DISTRIBUTION OF THE COMMON FROG *RANA TEMPORARIA* L. IN IRELAND

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Introduction

The common frog (*Rana temporaria* L.) is one of only three amphibians, (the other two being the smooth newt, *Triturus vulgaris* L., and the natterjack toad *Bufo calamita* Laurenti), found in Ireland. The status of these three amphibians within the Irish fauna has generated considerable debate over the years (e.g. Scharff, 1916; Praeger, 1969; Wilson, 1986), and the last twelve months have seen some important work in this area. In particular, frog bones from Irish cave systems have recently been subjected to radiocarbon analysis and a paper detailing the results is being prepared (Gleed-Owen, Marnell and Monaghan, in prep.). Furthermore, recent genetic investigations of the Irish toad populations by Beebee and Rowe (in press) add considerable weight to the theory that the natterjack is also a native species, i.e. that it reached this island soon after the end of the last glaciation *circa* 10,000 years ago. Although the newt is considered native (Wilson, 1986), there is, of yet, no genetic or archaeological data to support this belief.

The common frog, which is protected under Section 23 of the Wildlife Act and is listed in the Irish Red Data Book as Internationally Important, is the most widespread and abundant amphibian in Ireland. However, as is often the case for such species, its distribution here has never been systematically investigated and described. By contrast, the restricted Irish distribution of the endangered natterjack toad has received much attention (e.g. O'Connor and Jeal, 1984; Whilde, 1993), and the distribution of the smooth newt has also been examined recently (Marnell, 1998a). The first map to show the distribution of the frog was published by Taylor (1948). This collation of sightings showed the frog to be present in fifteen of the island's forty vice-counties. The animal appeared to demonstrate a coastal distribution, and was

absent from much of the midlands. In an updated version 15 years later (Taylor, 1963), most of the new records were in the north-east with a few other sightings from around the island. In 1974, a map was produced by the Irish Biological Records Centre showing all the records from 1950-1973 (Crichton, 1974). The frog appeared to be widespread and the distribution was less evidently clustered, although sizeable gaps in its range were evident in the north midlands, and in the mid-west and the south-west. The last Irish atlas to show the distribution of the common frog was edited by Ní Lamhna (1979). She believed that the frog was widespread throughout the country and the records presented included data from a Breeding Frog Survey coordinated by the Irish Biological Records Centre and a Schoolchildren's Survey conducted in Northern Ireland in 1966. More recently, Korky and Webb (1993) published a description of 17 widely spread breeding locations for the frog in Ireland and the Irish Peatlands Conservation Council collated sightings of breeding frogs in an investigation of the timing of breeding and the reproductive success at ponds (Foss and O'Connell, 1997). They received records from all 26 counties in the Republic of Ireland and from three of the counties in Northern Ireland. The Atlas of Amphibians and Reptiles in Europe displayed distributional records at the 50km square level. All of the Irish squares, bar one in the West, were positive for *Rana temporaria* (SEH, 1997).

The frog is a well known and easily recognised animal. Over much of Europe *Rana temporaria* shares its range with one or more frog species, but in Ireland it is the only frog and there is no opportunity for confusion. While this removes one potential source of error from the distribution maps produced to date, there remains a further limitation to the usefulness of the collation of frog records presently available: it is likely that these distribution maps are, to some extent, a reflection of the spread of the activities of recorders around the country. This situation is by no means singularly Irish; in Britain, the distributional changes of the common amphibians over the last 50 years, as seen in the national distribution maps (e.g. Taylor, 1948; Arnold, 1995), can be largely explained by the increase in recording effort (Beebee, 1996). To achieve a better understanding of the true distribution of the common frog in Ireland, an objective survey was required. Equally, while there is concern about the commercial exploitation of the animal, (the species is listed on Annex V of the E.U. Habitats Directive), and about the loss of breeding waters due to pollution, drainage of wetlands and destruction of

bogs (Whilde, 1993), without a baseline field survey the true extent of this problem will remain unknown. The present work was carried out in an objective and systematic way in an attempt to overcome the shortcomings of the previous maps and to provide baseline information for the distribution of the frog in Ireland.

Methodology

A brief outline of the survey methods are given here, for a detailed description of the methodology employed the reader should refer to Marnell (1998a). Because of the inevitable constraints of time and money, only a small proportion of the island could be surveyed. In an effort to make this fraction as representative and unbiased as possible a semi-random sub-sampling technique was used. In total 50 x 10km study squares were surveyed in the Republic of Ireland with a further 10 in Northern Ireland, covering approximately 6% of the island (see Fig. 1).

The fieldwork was carried out over the springs and summers of 1993 and 1994. Within each square, I attempted to find and sample six potential frog breeding sites. In several squares it was not possible to find six sites because of topography, land drainage, or, at certain coastal sites, owing to the large area of sea within the study square. While the first two factors were judged to be valid reflections of potential habitat, the final problem was seen to be a consequence of the sampling methodology and as a result might have unfairly affected the distribution findings. To counter this, the four coastal squares containing large areas of sea (G65, V59, W43 and X59) were replaced by adjoining land-locked squares (G64, Q50, W44 and S50 respectively). These final four squares were sampled during the early summer of 1995.

A survey of herpetologists found that spawn searches were regarded as the best method for detecting frogs (Griffiths and Raper, 1994). However, this technique is only reliable for a 3-4 week period each spring before hatching occurs. Thereafter, breeding can only be confirmed by the presence of larvae and dip-netting was shown to be the most effective method of surveying for those (Griffiths and Raper, 1994). Consequently, a combination of dip-netting and spawn searches was employed at each site.

In total, 278 sites were investigated in sixty 10km squares. Each site was examined for frog spawn and was also netted for approximately half an hour using a 2mm mesh hand-net. Large

waterbodies (>5000m²) were generally avoided during the survey because of the difficulties involved in sampling them effectively for amphibians.

Results

A total of 44 out of the 60 squares surveyed (73%) proved positive for frogs (Fig. 1). Of the 278 individual water bodies investigated, 36.5% were found to contain frogs. All the 10km squares in the midlands and the north-east proved positive. However, a number of the study squares in the north-west (south Donegal and Sligo) produced no frog sightings. This is probably because that area was not sampled until late June/early July by which time tadpoles may have metamorphosed and left the water. Four squares in south Tipperary/Cork also failed to produce a single positive breeding location. Of the remaining four negative 10km squares, two were in the west and two were located in the east of the country.

Discussion

Searching for spawn clumps is a very effective method for detecting the presence of common frogs at a breeding pond (Griffiths and Raper, 1994). However, the usefulness of this technique is limited to a brief period of a few weeks (or slightly longer in cold weather) in spring. Tadpole surveys are less reliable; dispersal of the larvae after hatching and the gradual decline in tadpole numbers as a result of predation make tadpole surveys progressively less practical as the season progresses (Griffiths and Raper, 1994). Tadpole behaviour partly offsets these problems, because frog tadpoles are often conspicuous around the edges of water bodies due to their tendency to aggregate in warm sunny spots. Nonetheless, a combination of spawn searches and dip-netting, as used in the present study, is likely to overlook some frog populations, particularly in areas which were surveyed late in the season. It is difficult, however, to assess to what extent false negatives have been recorded.

In other parts of Europe, tadpole surveys are complicated by the need to distinguish *Rana temporaria* larvae from several other similar looking species. The only opportunity for such confusion in Ireland is in the small number of sites where the natterjack toad breeds. These sites are all relatively well documented (O'Connor and Jeal, 1984; Marnell, 1996) and the differences in breeding time and colouration make it relatively straightforward to distinguish the

two species where they cohabit.

The pattern of positive squares identified in this survey suggests that the common frog is widespread throughout the country. The negative squares in the north-west can probably be largely explained by the time of sampling. Korczyk and Webb (1993) found frogs there as did Ní Lamhna (1979) and Foss and O'Connell (1997). The 10km squares in the other parts of the country which produced no positive breeding sites are less easily explained.

Ildos and Ancona (1994) examined the habitat preferences of seven amphibians, including two ranidae, in northern Italy. They concluded that even seemingly generalist species such as *Rana esculenta* L. and *Bufo bufo* (L.) were in fact selective in their choice of breeding site. Marnell (1998b) showed that while *Rana temporaria* in Ireland bred in a wide variety of water bodies, it showed a significant preference for ponds which were surrounded by good terrestrial cover. The availability of suitable terrestrial microhabitats (logs, stones etc.) which provide refuges for the animal was also shown to be a significant factor in determining the suitability of potential breeding sites.

The absence of suitable aquatic and/or terrestrial habitat probably plays an important role in determining the presence or absence of frogs. The dry, limestone area of the north Burren in Co. Clare, holds little standing water and therefore affords limited breeding opportunities for the frog. Not surprisingly this square proved negative in the present survey. Previous maps have also noted the absence of the frog here (e.g. Taylor, 1948, 1963; Smith, 1969).

As in the present work, Taylor (1963) and Ní Lamhna (1979) recorded concentrations of sightings from the north-east and the greater Dublin area. These patterns appear to an extent to reflect human population density and the availability of recorders and provide a good example of one of the benefits of the systematic and objective survey approach.

Based on the results of the present survey, the frog appears to be far more widespread and common in Ireland than the smooth newt (Marnell, 1998a). Using the same survey approach the newt was recorded in only 40% of the 10km study squares compared to 73% for the frog, and a mere 13% of all waterbodies sampled (Marnell, 1998a), compared to 36.5% in the case of the frog.

Some comparisons can be drawn between the results of the present study and findings from more detailed, small-scale investigations in Britain. Beebee (1985) found common frog

distribution to be positively associated with recent geological substrates. Post-carboniferous sedimentary rocks have survived erosion in Ireland in few places. Noteworthy exceptions are in the north-east of the island (Nevill, 1974). The largest surviving area of tertiary basalt is also in the north east - the Antrim Plateau. Conversely, the most extensive outcrop of basement rocks to be found in Ireland - the schists, gneisses and quartzites of the Dalradian period - occurs in the north-west (Nevill, 1974). Ildos and Ancona (1994) believed that the importance of the geology in breeding site selection was explained by its impact on the quality and quantity of inorganic ions available to plants. The geological structure of a region undoubtedly has considerable influence on the soils and groundwater that overlie it, and it seems reasonable to assume that this factor has some effect on the distribution of the frog in Ireland. A similar association has been proposed for the smooth newt (Marnell, 1998a).

Lakes are a common feature of the landscape in the north-west and south-west and it should not be overlooked that lakes were generally eschewed during the present survey because of the considerable difficulties involved in sampling them with any degree of efficiency. The frog, therefore, may be more widespread in the south-west and north-west than it appears from this survey, if it exploits the lacustrine habitat.

As early as 1963, Taylor (1963) noted that *Rana temporaria* was "not as abundant in many districts as it used to be." He suggested that declines were probably due to the capture of frogs for laboratory work and the infilling of ponds as a result of changes in agriculture. More recently, habitat loss was the most frequently cited explanation for amphibian declines in a survey of herpetologists and wildlife biologists in Britain (Hilton-Brown and Oldham, 1991). The decline of ponds in Britain has been well documented - an estimated 75% of ponds have been lost there during the last 100 years (Oldham and Swan, 1993). No similar survey has been undertaken for Ireland, but Marnell (1998a) estimated that approximately 50% of ponds had disappeared since the beginning of this century, with some areas incurring a much higher rate of loss. Details of the extensive and well-funded programme of land drainage carried out in this country and the difficulties associated with calculating the extent of terrestrial habitat lost have been previously discussed (Marnell, 1998a). Intensive farming may account for the lack of frogs in some of the 10km squares examined during the present survey.

Although Good (1998) suggested that ecological corridors are of limited practical conservation

value in Ireland, the fragmentation of suitable habitat and the interruption of wildlife corridors such as hedgerows and wet ditch systems, inevitably lead to the isolation of populations of relatively sedentary animals such as the common frog. A landscape which holds small islands of suitable habitat surrounded by oceans of inhospitable farmland inhibits dispersal, thereby reducing the rate of recolonisation and increasing the chances of local extinctions (Laan and Verboom, 1990). Systems of wet or damp ditches have been shown to facilitate frog migration and may act as important corridors for dispersal and genetic exchange (Reh and Seitz, 1990). Despite the adaptable nature of the frog and its ability to breed in a wide variety of waterbodies (Marnell, 1998b), the loss of breeding ponds and the removal of suitable terrestrial habitat has probably caused local extinctions and may also be leading to inbreeding of frog populations in certain parts of Ireland.

Nonetheless, the common frog is an adaptable creature and is quick to locate new potential breeding sites. Beebee (1983) remarked on the impressive colonising potential of *R. temporaria* and certainly in parts of Britain it appears to have adapted well to the availability of new suburban ponds (Beebee, 1979). A survey of suburban areas in Ireland might demonstrate similarly encouraging results.

The frog is clearly an important vertebrate in certain habitats and Beebee (1996) has noted that the common frog has an important role to play in energy flow through systems, "with total population sizes measured in tens of millions even after several decades of declines". Although no estimate of the Irish population size is available, the common frog appears to be widespread and common here, and undoubtedly plays a major role in the ecology of certain habitats. Blackith and Speight (1974) estimated that the common frog was the most important vertebrate predator in bog systems although, interestingly, Beebee (1983) noted that the same species avoids heathland in Britain. Further work in other habitat types needs to be undertaken in Ireland before an overall impression of the significance of this vertebrate in Irish ecosystems can be made.

The Irish populations of the common frog have been acknowledged as Internationally Important (Whilde, 1993), as in many parts of its European range this species is in serious decline. Reports of mass mortalities among frog populations of several species have been causing concern worldwide (e.g. Wake and Morowitz, 1991) and the Declining Amphibians

Populations Task Force has been set up specifically to investigate this situation. Apparent increases in the disease known as 'red-leg', which has been associated with the bacterium *Aeromonas hydrophila*, has caused considerable concern in recent years - it is certainly the best known pathogen of adult frogs in western Europe. Viral infections may be equally important in frog mortality, however, and the *Saprolegnia* fungus has also been shown to cause massive egg losses (Beebee, 1996). Destruction of terrestrial and aquatic habitats and the erosion of the ozone layer have also been implicated in the worldwide declines.

This paper has detailed the results of an extensive and objective field survey of the common frog in the island of Ireland and an overall impression of the distribution of this widespread amphibian has been produced for the first time. Some possible explanations for the apparent distribution are also proposed. More detailed, follow-up studies are required, however, to establish whether the species is declining, as has been reported over much of its European range, and investigations at local level will be necessary before site-based conservation measures, which are now the standard approach in amphibian conservation, can be considered.

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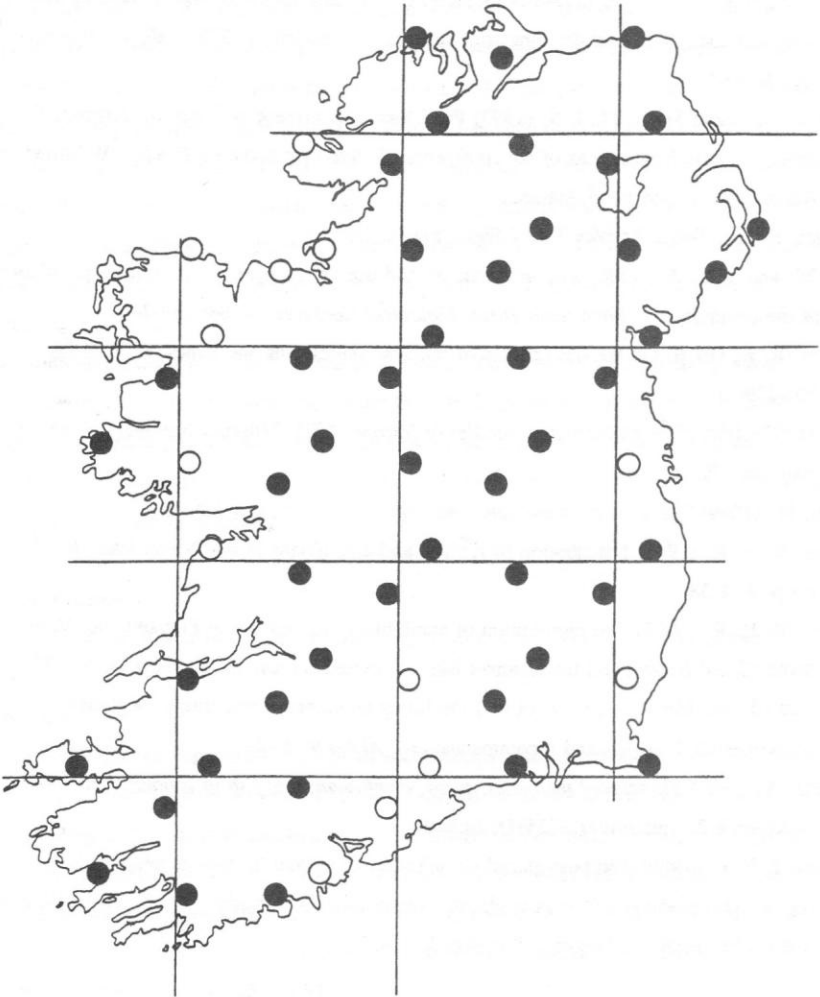
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FIGURE 1. Distribution of *Rana temporaria* in Ireland; results of the survey, 1993-1995.



RECOLONISATION BY STAPHYLINIDAE (COLEOPTERA) OF COPPER MINE TAILINGS AT AVOCA AND BEREHAVEN MINES, IRELAND

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Summary

Fewer species and individuals of Staphylinidae were recorded from copper mine tailings rehabilitated with a thin shale/soil cover, at Avoca, compared to an average of ten unmanured, non-metalliferous Irish grasslands. Typical old grassland species were present, but in low numbers. A higher number of typical old grassland/wetland species were recorded from naturally revegetated copper tailings at Allihies, where marshy conditions had developed. The poor development of a typical grassland staphylinid fauna on revegetated Avoca tailings, seven years after rehabilitation, may have been due to poor soil moisture retention during dry weather.

Introduction

There are over forty-five historical copper mine sites in Ireland, of which the Berehaven Mines (Allihies, Co. Cork) and Avoca Mines (Avoca, Co. Wicklow) were the largest in terms of ore production (Cole, 1922; Williams, 1991). Large quantities of waste rock (spoil) occur on the surface at these two mine sites, in addition to finer sandy-textured milled rock (tailings) from twentieth century mining operations.

The Berehaven Mines ceased operation in 1930, and, in addition to a large coarse sand deposit which now forms a sea beach, generated a relatively small area of finer textured tailings (*circa* 0.25ha) near to the road from Allihies village (Williams, 1991). This tailings deposit lies at the base of an Old Red Sandstone ridge, visually dominated by the Mountain Mine engine house, with heath, sheep pasture and rock outcrops. The tailings were not rehabilitated, and

natural recolonization by vegetation has been patchy, including stands of *Ulex gallii* Planchon, *Calluna vulgaris* (L.) Hull and *Erica cinerea* L., and a marshy area through which water flows over the tailings. The vegetation of the marsh includes grasses, carices, *Equisetum* sp., *Eriophorum* sp., *Lychnis flos-cuculi* L., *Orchis mascula* (L.) L., *Dactylorhiza maculata* (L.) Soó and *Trifolium repens* L.

Mining continued until more recently at Avoca, using milling technology which could process much larger quantities of lower grade ore. The last mine operated between 1969 and 1982 (Williams *et al.*, 1986), producing several million tonnes of tailings as waste from the ore-extraction process, which was pumped downstream to a 32ha tailings impoundment near Shelton Abbey, north of Arklow (Platt, 1975). The tailings impoundment dam is of a sidehill construction, built in an arc against the excavated wall of the valley slope, above which is mature oak (*Quercus*) woodland. The Avoca tailings were rehabilitated by covering the surface with limestone chippings, broken shale (specification 200mm depth) and imported soil (specification 100mm depth), and sown with grasses in 1985 (Wardell Armstrong, 1992). The vegetation cover is, at the time of writing (1998), mainly gorse (*Ulex europaeus* L.) scrub, with areas of ungrazed rough grassland, patches of rushes (*Juncus effusus* L.), grey willow (*Salix cinerea* L.), silver birch (*Betula pendula* Roth) and broom (*Cytisus scoparius* (L.) Link) scrub. The area is managed as a winter pheasant (*Phasianus colchicus* (L.)) shoot, and no longer grazed or cut for hay.

The extent to which recolonization by soil and epigeal fauna is inhibited by elevated soil concentrations of copper and other elements at these sites is not known. A mature staphylinid fauna has been shown to develop relatively rapidly on revegetated non-metalliferous kiln waste (Good and Wistow, 1997). The recolonisation by staphylinids of revegetated metalliferous tailings from Avoca and Allihies is reported here.

Methods

Three areas of the Avoca tailings (T2175, near Arklow) were sampled as follows: (1) *Agrostis/Festuca* grass sward with *Trifolium repens* under *Ulex europaeus* bushes, sampled using plastic cup pitfall traps with ethylene glycol preservative (15 June - 7 July 1991, n = 4 traps, laid for *circa* 4 weeks) and a D-vac suction sampler (9 September 1992, *circa* 3m²); (2)

Grasses dominated by *Holcus lanatus* L., sampled using pitfall traps (as above), and a Stihl® BR 400 suction apparatus ('S-vac'; see Good and Butler, 1998) modified as a suction sampler (7 May 1993, circa 2m²); (3) Grasses dominated by *Agrostis/Festuca* spp, sampled using pitfall traps (as above) and a D-vac suction sampler (16 July 1991, circa 3m²).

The Allihies tailings marsh (V5845) was sampled using pitfall traps as above (10 June - 3 July 1991) and a D-vac suction sampler (10 June 1991, circa 3m²).

Tachyporus transversalis Gravenhorst was identified using Booth (1984), Campbell (1979) and Lohse (1964). Voucher specimens of this and other species have been retained in the senior author's collection. Botanical nomenclature follows Stace (1997). Soil elemental analyses were undertaken by OMAC Laboratories, Loughrea, using aqua regia extraction.

Species were selected as typical of an old grassland or a wetland fauna if they: (1) occurred frequently in old grasslands and wetlands; and, (2) were absent or occurred only sporadically, and at most as single (and likely vagrant) individuals in combined pitfall and suction samples, from recently cultivated or nutrient-amended soils (data from Good and Giller, 1990; 1991; Good and Butler, 1996; Horion, 1963-67; see also Good and Wistow, 1997).

Results

The staphylinid fauna recorded at the Avoca tailings site was poor in comparison to what would be expected from a mature grassland soil. There were, on average, 52 individuals (range 33 - 65) of 14 species (range 13 - 16) for each total sample (Table 1), compared to an average of 182 individuals (range: 67 - 322) of 21 species (range: 14 - 24) from ten unmanured Irish grasslands using the same sampling procedures (data from Good and Giller, 1990; Good and Butler, 1996; Good and Wistow, 1997). Of the three areas sampled at Avoca, the *Agrostis/Festuca* sward was the poorest (33 individuals of 13 species). Low numbers also occurred in the Allihies sample (61 individuals of 15 species), but the latter had a much better representation of typical grassland/wetland species than Avoca (9 compared to a mean of 3.3, for each total sample; Table 1). Within the Avoca site, the *Ulex*/grass had the highest number of typical species (5), but none were represented by more than two individuals (Table 1).

In general, species of *Quedius* tend to replace species of *Philonthus* as a grassland develops from a cultivated or nutrient-amended state with fertilizer inputs, to an old sward without

nutrient inputs (Good and Giller, 1990; 1991; Good and Wistow, 1997). The presence of *Q. boops* (Gravenhorst), *Q. nitipennis* (Stephens), and *Q. semiobscurus* (Marshall) at the Avoca site demonstrate the potential for development of a typical old grassland assemblage, although they were recorded in low numbers (Table 1). There were also other typical species such as *Encephalus complicans* Kirby, *Metopsia retusa* (Stephens), *Othius myrmecophilus* Kiesenwetter and *Staphylinus dimidiaticornis* Gemminger, but none of the *Quedius*, nor of these, were represented by more than three individuals.

The recorded species from Allihies were a mixture of grassland and wetland species. Of note was *Tachyporus transversalis* Gravenhorst, a stenotopic species occurring in wet marshes and bogs, and especially in *Sphagnum*, according to Horion (1967). Although a distinctively coloured species, it was not recorded in Ireland until 1914 (Anderson *et al.*, 1997). It appears to be widespread but local in most parts of Europe, becoming more frequent in the marsh and bog regions of lowland northern Germany (Horion, 1967), although some of these areas may have been drained since the time of these records. The species has a scattered distribution in North America, also occurring in bog and swamp habitats (Campbell, 1979). Campbell (1979) suggests that the species could be overlooked because of its habitat restriction, but it is the first time that it has been found by the authors in wetland samples, despite the relatively frequent occurrence of a species like *Stenus picipennis* Erichson, which is equally restricted in its habitat (Horion, 1963): *T. transversalis* is therefore regarded as an indicator of well-developed habitat of potential biological conservation value, based on the criteria of stenotopic habitat preference and local distribution (see Good and Butler, 1996).

Seven *Aleochara curtula* (Goeze) were recorded from the Avoca tailings *Agrostis/Festuca* sward (Table 1). This species has not, to the authors' knowledge, been previously recorded in numbers from Irish grassland. The larvae of beetles of this genus are puparial ectoparasitoids of flies (Diptera), and the species is especially associated with carrion (Horion, 1967; Welch, 1997). The captured beetles may have bred in the carcase of an unretrieved pheasant.

Discussion

The results from Allihies show that it is possible for a typical staphylinid fauna to develop under wetland conditions on copper mine tailings. Although the concentration of copper was not

determined from these tailings, it will have occurred in elevated concentrations by nature of the origin of the tailings. Large numbers of predatory Coleoptera have also been recorded from copper- and metal-contaminated soils near smelters, with deep layers of leaf litter, undecomposed due to the absence of earthworms (Hopkin, 1989). Soil arthropods generally may be able to tolerate higher concentrations of soluble copper than earthworms (Streit, 1984).

The low numbers of typical old grassland species at Avoca, cannot be explained by concentrations of copper and other potentially toxic elements. The upper soil layer on Avoca tailings had low levels of copper, and also arsenic (Table 2). There was also sufficient time (six to seven years) for recolonisation from the surrounding area. Good and Wistow (1997) showed that a typical staphylinid fauna can recolonise grass established on topsoiled kiln waste within four years of establishment.

A more likely explanation for the low populations of typical staphylinids recorded at Avoca tailings is the susceptibility of a compacted flat shallow stony soil, with a relatively open grass sward, to drying out in summer, and surface flooding in winter. Low numbers of *Stenus* species, as recorded from Avoca tailings, are characteristic of dry grasslands. This was the case for suction and pitfall trap samples from south-facing grass slopes recorded by Good and Wistow (1997), and many typical Irish grassland *Stenus* species are restricted to marshes in the drier climate of Central Europe (Good and Giller, 1990). Most staphylinids are hygrophilous (Tikhomirova, 1968) and their populations may be limited by the inability of the larvae to tolerate dry soils in late spring and early summer. On the Avoca tailings, the number of species typical of old grasslands increased with vegetation cover (and, in consequence, moisture retention) from sparse open *Agrostis/Festuca* swards, through denser *Holcus* to grass swards with *Ulex europaeus* cover (Table 1). Observations of the sampled areas in 1998 revealed that the vegetation cover density and plant species richness had increased in the *Agrostis/Festuca* and *Holcus* areas. It is likely that the moisture retention capacity of the soil had also increased with cover, and may have, by 1998, supported a more abundant fauna typical of old grassland.

The reason for the absence of the ant-associate *Drusilla canaliculata* (Fabr.), which is usually abundant in dry grassland soils, and can recolonise relatively rapidly (Good and Wistow, 1997), is not as readily explained. It may be due to winter waterlogging of a flat surface inhibiting ant colonisation, or possibly the absence of sufficient food for ants to survive.

The poor development of a typical grassland staphylinid fauna on revegetated Avoca tailings, six to seven years after rehabilitation, may be due to poor soil moisture retention rather than elevated copper or arsenic concentrations. Topp (1971) found relatively poor recolonisation by staphylinids on refuse dumps under dry conditions, near Mainz in Germany, and Dunger (1989) demonstrated that a typical soil fauna took up to 30 years to develop under xerothermic conditions in brown coal spoils in Central Europe. Under wetland conditions, however, such as at Allihies, a typical fauna can recolonise revegetated copper mine tailings.

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TABLE 1. Staphylinidae recorded from revegetated copper mine tailings near Avoca, Co. Wicklow, and Allihies, Co. Cork (suction samples and pitfall traps combined). Nomenclature follows Anderson *et al.* (1997). Species associated with old grasslands and wetlands, and not with disturbed or nutrient-amended soil, are marked with an asterisk. *Sepedophilus nigripennis* is in this category, but is excluded because it is associated with accumulations of undecomposed litter.

Species	Avoca			Allihies
	<i>Ulex</i> /grass	<i>Holcus</i>	<i>Festuca</i>	Marsh
<i>Amischa analis</i> (Gravenhorst)	3	6	4	-
<i>Atheta amplicollis</i> (Mulsant & Rey)	9	9	2	-
<i>Metopsia retusa</i> (Stephens)*	2	-	-	1
<i>Othius myrmecophilus</i> Kiesenwetter*	1	-	-	-
<i>Quedius boops</i> (Gravenhorst)-agg.*	2	-	-	-
<i>Quedius nitipennis</i> (Stephens)*	1	1	-	-
<i>Quedius semiobscurus</i> (Marsham)*	1	-	1	-
<i>Sepedophilus nigripennis</i> (Stephens)	11	6	6	3
<i>Stenus clavicornis</i> (Scopoli)	1	2	3	-
<i>Stenus ossium</i> Stephens	22	14	2	4
<i>Tachyporus hypnorum</i> (Fabr.)	2	4	-	-
<i>Tachyporus dispar</i> (Paykull)	4	1	1	-
<i>Xantholinus glabratus</i> (Gravenhorst)	2	-	5	-
<i>Xantholinus longiventris</i> Heer	4	-	-	-
<i>Atheta fungi</i> (Gravenhorst)	-	3	3	1
<i>Encephalus complicans</i> Kirby*	-	1	-	-
<i>Liogluta longiuscula</i> (Gravenhorst)	-	1	-	-
<i>Quedius tristis</i> (Gravenhorst)	-	2	-	-
<i>Staphylinus dimidiaticornis</i> Gemminger*	-	1	3	-

TABLE 1 (continued)

Species	Avoca			Allihies
	<i>Ulex</i> /grass	<i>Holcus</i>	<i>Festuca</i>	Marsh
<i>Tachyporus chrysomelinus</i> (L.)	-	6	-	-
<i>Tachyporus solutus</i> Erichson	-	1	-	-
<i>Tinotus morion</i> (Gravenhorst)	-	1	-	-
<i>Aleochara curtula</i> (Goeze)	-	-	7	-
<i>Mycetoporus longulus</i> Mannerheim	-	-	1	-
<i>Quedius molochinus</i> (Gravenhorst)	-	-	1	-
<i>Drusilla canaliculata</i> (Fabr.)*	-	-	-	8
<i>Euaesthetus ruficapillus</i> Lacordaire*	-	-	-	5
<i>Myllaena intermedia</i> Erichson*	-	-	-	1
<i>Stenus fulvicornis</i> Stephens*	-	-	-	12
<i>Stenus impressus</i> Germar*	-	-	-	9
<i>Stenus latifrons</i> Erichson*	-	-	-	8
<i>Stenus picipennis</i> Erichson*	-	-	-	3
<i>Tachinus laticollis</i> Gravenhorst	-	-	-	1
<i>Tachyporus nitidulus</i> (Fabr.)	-	-	-	1
<i>Tachyporus transversalis</i> Gravenhorst*	-	-	-	3
<i>Xantholinus linearis</i> (Olivier)	-	-	-	1
No. species	14	16	13	15
No. old grassland/wetland species	5	3	2	9
No. individuals	65	59	33	61

TABLE 2. Total metal and arsenic concentrations from revegetated Avoca tailings (soil surface and underlying tailings). Mean values in mg/kg (range in parenthesis, n = 9 samples for soil, n = 1 (composite) for tailings). Trigger concentrations refer to threshold concentrations above which phytotoxicity or zootoxicity may occur in mine wastes (ICRCL, 1990). Soil surface pH varied from 4.9 - 5.6 (D. Dunnells, pers. comm.).

Element	As	Cu	Cd	Pb	Zn
Avoca soil	35 (30-40)	48 (42-68)	< 0.3 (< 0.3)	42 (34-55)	106 (98-116)
Avoca tailings	80	700	< 0.3	155	79
Trigger concentrations	50	250	3.0	300	1000

NEW IRISH VICE-COUNTY RECORDS FOR HARVESTSPIDERS (ARACHNIDA: OPILIONES)

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Introduction

The following article gives brief details of 153 new vice-county records for harvestspiders, mostly gathered between 1992 and 1997. A fuller consideration of the Irish species will appear in a review of the group which I am currently finalising. The most important source of information on the vice-county distribution of harvestspiders in Ireland remains Pack-Beresford (1926). Additional vice-county records are contained in Bristowe (1949), Sankey (1951, 1993), Mackie and Millidge (1970), Mackie (1970, 1972), Bailey (1973), Fussey (1981), Cowden *et al.* (1990), Cawley (1995) and Cotton and Cawley (1997). In addition, data gathered between 1970 and 1984, and used to compile the distribution maps contained in Sankey (1988) contains 83 new vice-county records which have never been published separately. It should also be noted that Bristowe (1949) and Sankey (1951) contain a small number of new county records for Kerry, Cork, Tipperary and Donegal which cannot be assigned to any particular vice-county. Seven species, *Nemastoma bimaculatum*, *Paroligolophus agrestis*, *Mitopus morio*, *Phalangium opilio*, *Rilaena triangularis*, *Leiobunum blackwalli* and *L. rotundum* have now being recorded from all 40 of the vice-county divisions.

Nemastoma bimaculatum (Fabricius, 1775)

Wexford: Enniscorthy, S9839 11 October 1994, hedgerow. East Mayo: Claremorris, M3474, 2 September 1993, waste ground. Monaghan: Aghlatacru, H8301, 7 June 1995, deciduous woodland. Tyrone: Edendork, H8165, 9 October 1995, field border.

Mitostoma chrysomelas (Hermann, 1804)

South Tipperary: Bansha, R9233, 3 November 1996, path through conifer plantation. Wexford: The Raven, T1122, 10 October 1994, sand dune foreshore. Wicklow: Wicklow, T300947, 26 October 1997, under rubbish in hedgerow. Westmeath: Killpatrick, N425502, 31 May 1995,

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path through conifer plantation.

Now recorded from vice-counties H02, H06, H07, H10, H12, H13, H20, H23 and H33.

***Anelasmacephalus cambridgei* (Westwood, 1874)**

East Cork: Fota, W782715, 28 May 1995. Waterford: Grace Dieu, S6006, 2 February, 1995.

North-east Galway: Merlin Park, M3325, 23 June 1996.

In all cases sieved from leaf litter in deciduous woodland. Now recorded from vice-counties H02, H05, H06 and H17.

***Oligolophus tridens* (Koch, 1836)**

South Tipperary: Rathdough, S1242, 18 October 1995, hedgerow. Laois: Portlaoise, S4698, 15 September 1995, hedgerow. East Mayo: Claremorris, M3474, 2 September 1993, waste ground. West Mayo: Ballina, G2417, 13 September 1995, field border. Monaghan:

Castleshane, H7132, 2 October 1995, hedgerow. East Donegal: Finner, G8260, 21 September 1995, sand dunes. Tyrone: Dungannon, H7962, 9 October 1995, edge of field.

Recorded from all vice-counties except H30 (Cavan).

***Oligolophus hanseni* (Kraepelin, 1896)**

North Kerry: Killarney, V9590, 2 November 1995, mixed planted woodland. Limerick: Limerick, R5654, 11 November 1994, garden wall. South-east Galway: Loughrea, M6216, 6 October 1996, lightly wooded lakeshore park. Meath: Abbeyland, N8869, 29 August 1997, conifer plantation. Westmeath: Mullingar, N4252, 8 September 1995, town park. Roscommon: Doyles Bridge, N0141, 6 October 1996, abandoned garden. Cavan: Virginia, N6087, 13 November 1995, garden walls. Monaghan: Monaghan, H6733, 2 October 1995, nettle *Urtica* bed. Fermanagh: Belcoo, H0939, 5 November 1996, garden wall. East Donegal: Ballybofey, H1394, 5 July 1995, hedgerow. Tyrone: Omagh, H4572, 22 October 1996, garden walls. Armagh: Portadown, J0153, 12 September 1996, garden walls. Down: Warrenpoint, J1418, 26 September 1996, garden walls. Derry: Roe Park, C6621, 24 October 1996, coniferous woodland.

Now recorded from vice-counties H02, H08, H11, H13, H15, H19, H22, H23, H25, H30, H32-H34, H36-H38 and H40.

***Paroligolophus agrestis* (Meade, 1855)**

South Tipperary: Rathordan, S1039, 18 October 1995, beaten from roadverge nettles *Urtica*.

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West Galway: Seaweed Point, M2522, 1 August 1995, coastal headland. East Mayo: Claremorris, M3474, 2 September 1993, waste ground. Cavan: Virginia, N6087, 13 November 1995, conifer plantation. Louth: Drogheda, O0975, 19 July 1995, waste ground.

***Lacinius ephippiatus* (Koch, 1835)**

West Cork: Macroom, W3372, 24 July 1997, hedgerow. Mid Cork: Shippool, W5555, 30 April 1996, *Quercus-Fagus* woodland. East Cork: Fota, W7871, 28 May 1995, mixed woodland. Laois: Durrow, S4077, 3 May 1996, gravelly scrape in field. Offaly: Clonard Wood, N3219, 25 May 1997, conifer plantation. East Mayo: Annagh, M4982, 1 June 1995, rough grassland. Monaghan: Aghlatacru, H8301, 7 June 1995, deciduous woodland.

Now recorded from vice-counties H01, H03-H06, H08-H10, H13-H15, H17, H18, H20, H21, H23, H25-H29, H32-H34 and H39.

***Mitopus morio* (Fabricius, 1799)**

Kilkenny: Thomastown, S5841, 18 September 1995, garden wall. Wexford: Wexford, T0521, 9 October 1994, waste ground. Monaghan: Monaghan, H6733, 2 October 1995, nettle *Urtica* bed.

***Phalangium opilio* Linnaeus, 1758**

North Kerry: Tralee, Q8213, 8 September 1996, waste ground. Meath: Ashbourne, O0652, 16 August 1992, rough grassland. Cavan: Virginia, N6087, 13 November 1995, garden wall. Monaghan: Sheétrim Lake, H6831, 2 October 1995, disused quarry. Armagh: Portadown, J0153, 12 September 1996, garden wall.

***Opilio parietinus* (De Geer, 1778)**

East Cork: Mallow, W5598, 2 November 1997. South Tipperary: Thurles, S1258, 1 October 1996. Limerick: Plassey, R6257, 20 October 1996. Wexford: New Ross, S7127, 26 October 1994. South-east Galway: Clarinbridge, M4120, 20 October 1996. West Galway: Taylors Hill, M2824, 8 October 1996. North-east Galway: Galway, M2925, 5 October 1996. Kildare: Athy, S6894, 18 September 1996. Meath: Ashbourne, O0652, 15 September 1995. Fermanagh: Lisbellaw, H3040, 14 October 1996. West Donegal: Letterkenny, C1611, 12 October 1995. Tyrone: Dungannon, H7961, 9 October 1995. Armagh: Portadown, J0153, 12 September 1996. Down: Warrenpoint, J1418, 26 September 1996. Antrim: Portrush, C8540, 23 October 1996. Derry: Derry, C4417, 22 October 1996.

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In all of the above cases specimens were collected from house or garden walls in urban areas. Now recorded from vice-counties H04-H08, H12, H13, H15-H17, H19-H23, H25, H28-H29, H33 and H35-H40.

***Opilio saxatilis* Koch, 1839**

North Kerry: Tralee, Q8213, 8 September 1996, waste ground. Kilkenny: Kilkenny, S4857, 19 September 1995, disused sand pit. Carlow: Royaloak, S6861, 16 September 1996, edge of field. Laois: Steatygraique, S7076, 14 September 1996, waste ground. Wicklow: Bray, O2718, 12 October 1997, grassy waste area. Meath: Gormanstown, O1866, 30 August 1997, sandy coastal bank. Roscommon: Doyles Bridge, N0140, 6 October 1996, calcareous scrape. Louth: Drogheda, O1175, 19 July 1995, sandy coastal field. Down: Murlough, J4034, 14 October 1997, sand dunes.

Now recorded from vice-counties H01-H07, H09-H14, H18-H23, H25, H28, H31 and H38.

***Megabunus diadema* (Fabricius, 1779)**

Mid Cork: Mount Leader, Millstreet, W2689, 6 July 1997, *Fagus* woodland. Westmeath: Crookedwood, N4662, 25 April 1996, deciduous woodland. East Mayo: Ballindine, M3668, 20 June 1995, conifer plantation. East Donegal: Ballyar Nature Reserve, C1820, 21 February 1996, deciduous woodland. West Donegal: Troopers Hill, H1295, 17 January 1996, acid woodland.

Now recorded from vice-counties H01-H04, H08-H10, H13, H16-H21, H23, H25-H35 and H37-H39.

***Rilaena triangularis* (Herbst, 1799)**

East Cork: Cobh, W7966, 4 May 1995, waste ground. Limerick: Limerick, R5654, 17 November 1994, rough grassland. Wexford: Johnstown Castle, T0116, 25 February 1996, planted woodland. Laois: Abbeyleix, S4282, 3 May 1996, mixed woodland. North-east Galway: Tuam, M4351, 14 April 1995, waste ground. Offaly: Charleville, N3121, 25 May 1997, *Quercus* woodland. Westmeath: Mullingar, N4253, 25 April 1995, field border. Longford: Newtown Forbes, N1080, 29 March 1995, planted woodland. East Mayo: Barnalyra, M4495, 2 February 1994, acid woodland. Monaghan: Lough Naglack, H8402, 7 June 1995, grassy waste area. East Donegal: Ballyshannon, G8762, 31 January 1994, *Corylus* woodland. Down: Newry, J0826, 26 September 1996, disturbed field.

***Dicranopalpus ramosus* (Simon, 1909)**

South Kerry: Dingle, Q4301, 13 August 1998. North Kerry: Tralee, Q8414, 8 September 1996. West Cork: Dunmanway, W2252, 21 September 1997. Mid Cork: Cork Docks, W6871, 13 August 1995. East Cork: Lotamore, W7072, 23 September 1996. Waterford: Waterford, S6112, 22 September 1996. Limerick: Islandmore, R4940, 18 November 1998. Clare: Ennis, R3377, 13 October 1996. Kilkenny: Newrath, S5913, 22 September 1996. Carlow: Bagenalstown, S7061, 16 September 1996. West Galway: Taylors Hill, Galway, M2824, 8 October 1996. Wicklow: Bray, O2718, 12 October 1997. Dublin: Raheny, O2138, 7 October 1997. Sligo: Knappagh Beg, Sligo, G6835, 3 October 1996.

In all cases present on house, or more usually garden walls. Now recorded from vice-counties H01-H06, H08, H09, H11-H13, H16, H20, H21 and H28.

***Leiobunum rotundum* (Latreille, 1798)**

North Kerry: Killarney, V9590, 2 November 1995, mixed woodland. Laois: Portlaoise, S4698, 15 September 1995, house wall. Kilkenny: Kilkenny Castle, S5155, 17 September 1995, planted woodland. South-east Galway: Lough Cutra, R4699, 25 July 1995, mixed woodland. Meath: Ashbourne, O0652, 16 August 1992, rough grassland. Monaghan: Monaghan, H6733, 2 October 1995, nettle *Urtica* bed. West Donegal: Letterkenny, C1610, 3 October 1995, garden wall. Tyrone: The Bush, H8263, 9 October 1995, house wall. Armagh: Laurel Vale, J0048, 12 September 1996, rank vegetation. Down: Green Island, J1121, 26 September 1996, conifer plantation.

***Leiobunum blackwalli* Meade, 1861**

South Tipperary: Thurles, S1158, 1 October 1996, edge of field. Limerick: Plassey, Limerick, R6157, 20 October 1996, *Fagus* woodland. Kilkenny: Coolmore, S5938, 18 September 1995, hedgerow. Laois: Carrick Wood, N5410, 4 November 1997, *Fagus* woodland. South-east Galway: Gort, M4501, 25 July 1995, garden. West Galway: Spiddal, M1222, 8 October 1996, *Alnus* carr. Offaly: Tullamore, N3324, 26 July 1995, field border. Longford: Edgeworthstown, N2771, 8 September 1995, beaten from *Urtica*. East Mayo: Ballindine, M3669, 20 June 1995, waste ground. Cavan: Virginia, N6087, 13 November 1995, field border. Monaghan: Castleshane, H7132, 2 October 1995, hedgerow. East Donegal: Bundoran, G8159, 3 September 1989, base of wall. West Donegal: Letterkenny, C1610, 4 July 1995, waste ground. Tyrone:

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Edendork, H8165, 9 October 1995, hedgerow. Antrim: Collinward, J3281, 13 October 1997, shrubby roadverge. Derry: Coleraine, C8531, 23 October 1996, hedgerow.

***Nelima gothica* Lohmander, 1945**

North Kerry: Tralee, Q8415, 8 September 1996, mixed woodland. South Tipperary: Cashel, S0740, 18 October 1995, garden. Limerick: Limerick, R5857, 1 August 1996, waste ground. Kilkenny: Coolmore, S5938, 18 September 1995, hedgerow. Wexford: Barnawheel, T1003, 25 October 1994, sand dunes. Carlow: Bagenalstown, S7161, 16 September 1996, edge of field. Laois: Portlaoise, S4698, 15 September 1995, field border. West Galway; Nimmo's Pier, Galway City, M2924, 25 July 1994, base of wall. North-east Galway: Tuam, M4351, 28 July 1995, waste ground. Meath: Ashbourne, O0652, 16 July 1992, rough grassland. Westmeath: Mullingar, N4352, 26 July 1992, waste ground. East Mayo: Claremorris, M3474, 2 September 1993, waste ground. West Mayo: Ballina, G2418, 10 August 1992, river bank. Cavan: Virginia, N6087, 13 November 1995, one specimen on a house wall. Louth: Drogheda, O1175, 19 July 1995, sandy coastal field. Monaghan: Monaghan, H6733, 2 October 1995, nettle *Urtica* bed. East Donegal: Letterkenny, C1610, 4 July 1995, waste ground. Tyrone: Omagh, H4572, 22 October 1996, riverbank. Down: Newry, J0825, 26 September 1996, disturbed field.

Recorded from all vice-counties except H18 (Offaly), H37 (Armagh) and H40 (Derry).

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TWO MARINE COASTAL-DWELLING CHIRONOMIDAE (DIPTERA) NEW TO THE FAUNA OF ICELAND: *TELMATOGETON JAPONICUS* TOKUNAGA (TELMATOGETONINAE) AND *CLUNIO MARINUS* HALIDAY (ORTHOCLADIINAE)

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Introduction

Lying between two tectonic plates on the active Reykjanes Ridge in the north-east Atlantic Ocean, Iceland visibly demonstrates the forces of nature in continental drift, volcanic and glacial activity, erosion and weathering. Although the bedrock of the surrounding seas has an age of 65 million years, no rocks over 20 million years have been found on land and it is believed that large areas have been built up in the last million years - only then to be subjected to the vicissitudes of the last Ice Age, 20,000 years ago, when most of the country was covered with ice. The flora and fauna of Iceland is significantly influenced by this geological history. Iceland's flora is restricted; only about 520 species of flowering plant occur and these are generally regarded as north European in character (Carwardine, 1988). The insect fauna of Iceland is likewise restricted in diversity. The early studies of Lindroth (1931) gave over 700 species while the checklist of Gigja (1945) cited 750 species. Continuing investigations on the country's insect fauna gave a total of 1,245 species in the most recent checklist by Ólafsson (1991). This list includes 373 species of Diptera of which only 74 belong to the Chironomidae. Hrafnisdottir *et al.* (in press) give an updated checklist of the Icelandic chironomid fauna adding three species to the list prepared by Ólafsson (1991).

Although most interest to date on Iceland's Chironomidae has centered on those taxa with juvenile stages in freshwaters the existing list contains records of the marine coastal-dwelling chironomid *Halocladius variabilis* (Staeger) - also recorded from Surtsey which erupted from the ocean south of Heimay in 1963. During a brief visit to Iceland in June/July 1999 collections were undertaken in some marine coastal regions to obtain material of *H. variabilis* for comparison with populations from other Atlantic islands (Ireland, Azores and Madeira).

Amongst the chironomid taxa found were specimens of two species hitherto not recorded for Iceland. This communication details these records. Voucher material of these species has been deposited at the Icelandic Institute of Natural History, Hlemmur 3, Reykjavik.

New records

Subfamily Telmatogetoninae

Genus *Telmatogeton* Schiner, 1866

***Telmatogeton japonicus* Tokunaga, 1933**

Dyrhólaey: seafront at the most southerly coastal promontory of Iceland, 28.vi.1999. Numerous adult male and female imagines were seen and collected from and between wet rocks and boulders splashed by waves from an incoming tide.

Reykjanes Penninsula: at Þórkötlustaðir, adjacent to road 427 approximately 3km east of Grindavík, 29.vi.1999. One adult male was obtained between rocks over coastal pools.

These are the first records of the subfamily Telmatogetoninae from Iceland. According to Ashe and Cranston (1990), *T. japonicus* has a widespread distribution and is known from Japan, Asia, the USA and Hawaii. In Europe, it is known from the Baltic coastal regions of Germany and Poland (Ashe and Cranston, 1990) and from Norway (Schnell and Aagaard, 1991). It was found in Madeira in 1996 (Murray and Hughes, in press).

Subfamily Orthocladiinae

Genus *Clunio* Haliday 1855

***Clunio marinus* Haliday 1855**

Aegisiða, Reykjavik: at seafront, numerous male pupal exuviae, pharate adults and adult males collected in foam formed from an on-shore breeze blowing over a large off-shore growth of *Fucus*, 24.vi.1999.

Reykjanes Penninsula: at Þórkötlustaðir, approximately 3km east of Grindavík adjacent to road 427, 29.vi.1999. Adult males and pupal exuviae obtained while emerging from a shallow coastal pool with extensive growth of *Fucus*.

Originally described by Haliday from Ireland, this common marine coastal species has a widespread distribution in European coastal waters. It was recently reported from the north

coast of Madeira (Murray and Hughes, in press) but was not previously known from Iceland.

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**RECORDS OF OTTERS *LUTRA LUTRA* (L.) IN THE VICINITY OF IRISH BADGER
MELES MELES (L.) SETTS**

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Various surveys of badgers (*Meles meles* (L.)) in Ireland have established that they are common (Dolan *et al.*, 1994; Feore, 1994; Smal, 1995). National and subsequent local surveys of otters (*Lutra lutra* (L.)) have also found them to be common in suitable habitats (Chapman and Chapman, 1982; Gormally *et al.*, 1983; Murphy and Fairley, 1985; Kyne *et al.*, 1990; O'Sullivan, 1991; Smiddy, 1993; Tangney and Fairley, 1994). This situation is unusual in Europe as in many other areas where badgers are studied, for example southern England, otters are scarce or absent (Chanin, 1985). The following instances of otters (or evidence of otters) in the vicinity of badger setts were noted by the authors during the course of fieldwork on badgers in the years 1996-1999.

Definitions of terms frequently used in this paper are given here: badger 'sett' = a burrow or series of burrows used by badgers; badger 'latrine' = a shallow pit or pits where badger droppings are deposited; otter 'holt' = a burrow or burrows used by otters; otter 'spraint' = otter dropping. Badger setts are here described as either 'main setts' (Thornton, 1988) or 'other setts'. The true status of other setts was unknown.

Each instance, listed under county, include general location, grid reference, date and details of the way in which the otters were detected. When spraints were found near a sett, it was not of course known whether an otter had in fact also been using it, but in some instances the number of spraints suggest that this was likely. These burrows are always referred to here as 'setts', despite that on at least some occasions they may also deserve the title 'holt'.

Co. Cork

- (1) Marlogue Wood, Great Island, on seashore, W8467, March 1996. Spraints at main sett next to a latrine and within 2m of used sett entrance.
- (2) Glenmore, Great Island, on seashore, W8367, March 1996. Spraints at main sett within 4m of used sett entrance. The Marlogue and Glenmore setts are two of eight on the shore on the eastern half of Great Island, but there was no evidence of otters at any of the others.
- (3) River Allow, near Kanturk, near river bank, R3909, September 1997. Otter seen at main sett during fieldwork on the Four Area Badger Study (Griffin, 1996).
- (4) River Owennacurra, near Middleton, bank of estuarine river, W8772, February 1996. Three piles of spraints at other sett. All spraints were within 3m of sett entrance with more on the river bank.

Co. Donegal

- (5) Ballymagowen, Mulroy Bay, on seashore, C2134, February 1997. Three piles of spraints at entrances to main sett. Spraints were about 1.5m apart at the seaward side of the sett, and nearby there was a steep slide to the sea - almost certainly that of an otter - with remains of a black-headed gull (*Larus ridibundus* L.) at the bottom. Moreover, there were fox (*Vulpes vulpes* L.) droppings to the landward side of the sett. This suggests that all three species of carnivore regularly visited this site.
- (6, 7) Moross Point, Mulroy Bay, on seashore, C1839, June 1997. One spraint at entrances to two deserted other setts. Otter evidence was very common in this area and may be related to the farming of salmon (*Salmo salar* L.) nearby.
- (8) Ballykenny Point, Lough Swilly, on seashore, C2524, June 1997. Small pile of spraint within 3m of used main sett. The above are four of fifty setts found within 20m of the seashore on the Fanad peninsula during fieldwork on the Four Area Badger Study (Griffin, 1996).

Co. Kerry

- (9) Fenit Island, on bank near seashore, Q7217, April 1999. Spraints and latrine at small but well used other sett. Young otters have been seen playing near the sett by a local resident.

Co. Sligo

- (10) Coney Island, Sligo Bay, on seashore, G6139, March 1997. Spraints at entrance to other sett. This sett was one of nine within 20m of the seashore on the island. Otter spraints were common just above the shoreline throughout the island.

Discussion

The instances noted here are mainly from seashore habitats (eight out of ten), the other two being from an estuarine and freshwater river respectively. Therefore, it appears that otters regularly visit setts situated on or near the seashore. It is worthy of note that many of the seashore setts visited by otters were near freshwater streams. Kruuk and Balharry (1990) have pointed out that bathing in fresh water is important to otters which enter the sea. Without visiting fresh water, the otters' fur may lose its capacity for retaining air under water. Murphy and Fairley (1985) and Smiddy (1993) have already noted spraint concentrations near freshwater streams on the coast. It is possible that in at least some of these cases the otters may have been using the prominence of the setts spoil heaps as sprainting sites in the same way as they use other objects such as boulders and logs. The Coney Island sett (No. 10) was near a cattle drinking trough which was accessible to otters. It is of interest that spraints were never found at inland setts near watercourses, the one record (River Allow, No. 3) referring to a sighting of an otter.

It is well known that mammals other than badgers can be tenants in setts. In Ireland, rabbits (*Oryctolagus cuniculus* (L.)) and foxes are common at setts, in particular disused setts (Feore, 1994; Smal, 1995). However, otters have not been included in such lists either in Ireland or Britain, even as casual tenants (Neal and Cheeseman, 1996). However, a survey of holts in Britain by Coghill (1982) revealed that otters occurred 'rarely' at setts. Spraints have been found at setts on the west coast of Scotland (Hans Kruuk, personal communication). Otters should now be added to such lists, and it is clear that sometimes (Nos. 5 and 9, for example) they are more than casual visitors. We have also found situations where both species use separate setts and holts near each other. For example, at Little Island in the estuary of the River Suir, Co. Waterford, in December 1998, we found an occupied main sett within 0.5km of an active holt.

As many Irish badgers have bovine tuberculosis (O'Connor and O'Malley, 1989; O'Keeffe *et al.*, 1996; Eves, 1999), there is a risk of transfer of the disease to any other species that visit setts, which in Ireland at least must now include coastal otters. There have been some post mortem examinations of Irish otters (e.g. O'Sullivan and Fitzgerald, 1995), however, none have been screened for bovine tuberculosis. Otters also consume carrion (O'Sullivan *et al.*,

1992) which could further expose them to risks from this and other diseases. It is recommended that when they become available (e.g. as road casualties), otters should be screened for bovine tuberculosis. Efforts to control the disease have led to removal of badgers by culling using snares (O'Connor and O'Malley, 1989), and further culling to research the issue is either planned or in progress in both Ireland and Britain (Griffin, 1996; Krebs, 1997). Such culling at any habitat near water might sometimes be expected to accidentally catch otters. Other efforts in Ireland to control bovine tuberculosis in badgers may rely on a vaccine (Hughes *et al.*, 1996). Such a vaccine is likely to be delivered in oral baits at setts. Given that otters may frequently occur in the vicinity of setts on the seashore, they can be expected to be among the species exposed to such baits.

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SOME RECORDS OF SOCIAL WASPS (HYMENOPTERA: VESPIDAE) FROM NORTH-WEST IRELAND

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Introduction

In view of the recent interest in social wasps (Roberts, 1998; Anon, 1998) it would seem worthwhile publishing some records collected mainly between 1996 and 1999 from Counties Sligo and Leitrim, and other nearby parts of north-west Ireland. The only published records of social wasps that could possibly be ascribed to Counties Sligo and Leitrim are all for *Vespula vulgaris* (L.) in hectads G51, G63, G73, G80, G95, H03, H11, H20 and H21 (Archer, 1979). In all instances specimens were collected by the authors and identified by RC using the keys in Spradbery (1973), Archer (1979) and Archer and Edwards (1996) and the identifications verified by DC. Five species were recorded and the details are now presented.

ORDER HYMENOPTERA

Family Vespidae

Vespula vulgaris (Linnaeus, 1758)

DONEGAL (H35): Portnoo, G6999, 14 September 1996; Donegal town, G9278, 15 September 1996; LEITRIM (H29): Taash near Drumsna, N0299, 19 August 1996; River Shannon at Drumsna Harbour, M995969, 21 August 1996; River Shannon, Carrick-on-Shannon, G9504, 26 August 1996; St John's Lough near Ballinamore, H0911, 28 August 1996; MAYO (H26 and H27): Old Head near Louisberg, L8382, 7 September 1996; Lough Cara, Kilkeeran, Partry, M163728, 7 September 1997; SLIGO (H28): Cartron Point, Sligo town, G6836, 23 April 1996; Ballygawley Lough, G6928, 20 August 1996; Kevinsfort, Strandhill Road, Sligo town, G6735, 25 August 1996; Lough Skean, G8512, 28 August 1996; Carrownree near Skreen, G5434, 31 August 1996; Drumsoghla, Lough Arrow, G8111, 1 September 1996; Rathcormac National School, G6841, 2 September 1996; Stony Point, Lough Gill, G715330, 12 September 1996; Lough Anelteen, G7636, 13 December 1996; Bartragh dunes, Inishcrone, G2729, 17 September

1997; Moneygold, G6751, 8 June 1999.

***Vespula germanica* (Fabricius, 1793)**

SLIGO (H28): A single specimen was caught in a jam-jar trap along with 55 specimens of *V. vulgaris* in Sligo town, G6935, 5 October 1984 by Mr Martin Cawley.

***Vespula rufa* (Linnaeus, 1758)**

DONEGAL (H35): Portnoo, G6999, 14 September 1996; FERMANAGH (H33): Black River, Lough Macnean Upper, H0344, 25 August 1997; LEITRIM (H29): River Shannon at Drumsna Harbour, M995969, 21 August 1996; Moneyduff, Lough Gill, G8034, 12 June 1997; west side of Crocknagapple, Fallacara, Glenade, G873448, 6 August 1997; below Roosky, River Shannon, N0586, 12 August 1997; Lough Erril, near Mohill, N046968, 12 August 1997; MAYO (H26): Lough Cara, Kilkeeran, Partry, M163728, 7 September 1997; SLIGO (H28): Drumsoghla, Lough Arrow, G8111, 1 September 1996; near Black Lough, Highwood, G8113, 1 September 1996; Ballygawley bog at southern end of lough, G6928, 11 August 1997; Drummartin, G440120, 7 June 1999; Moneygold, G6751, 8 June 1999; Glencar, G7443, 8 June 1999.

***Dolichovespula sylvestris* (Scopoli, 1763)**

LEITRIM (H29): Derrycarne amenity, Lough Boderg, River Shannon, N0291, 21 August 1996; River Shannon at Drumsna Harbour, M995969, 21 August 1996; Sheemore, G9905, 2 August 1998; SLIGO (H28): Rathaberna, G6940, 5 June 1997; Bartragh dunes, Inishcrone, G2729, 17 August 1997; Rathaberna, G6940, 28 May 1999; Ballynacarrow, G6119, 7 June 1999; Oughavel, G3809, 7 June 1999; Culfadda, G6908, 14 June 1999; Greenan, G7310, 14 June 1999.

***Dolichovespula norwegica* (Fabricius, 1781)**

LEITRIM (H29): Glenfarne Wood, Lough Macnean Upper, H0239, 17 August 1996; SLIGO (H28): bank of Owenboy River, Carha, Ox Mountains, G5424, 30 July 1982; Rathaberna, G6940, 3 August 1996; Ballygawley Lough, G6928, 20 August 1996.

Discussion

From this study, it is clear that *Vespula vulgaris* is the most common and widespread social wasp in north-western Ireland. It was especially noted as being common when collecting from

near litter bins in urban areas. *V. rufa* and *Dolichovespula sylvestris* are also quite common in this region and can easily be collected from flowers such as *Symphoricarpos albus* (L.) S. F. Blake (snowberry) and *Fuchsia magellanica* Lam. (fuchsia). *D. norvegica* is a little less common than the former two species but is never-the-less widespread in distribution. It is estimated that well over 1000 wasps have been examined either for this study, or by Martin Cawley, yet only a single specimen of *D. germanica* has been detected and that was from Sligo, the largest urban area. The only Irish social wasp not recorded by this study was *Vespula austriaca* Panzer, which is a cleptoparasite of *V. rufa*. A special watch was kept for this and two other European cleptoparasite wasps, but without success. It is likely that *V. austriaca* is present in north-west Ireland but that its small population size militates against it being recorded.

The distribution maps published in Archer (1979) would suggest that Irish social wasps all have a southern and eastern distribution apart from *V. vulgaris*. This small study indicates that *V. rufa*, *D. sylvestris* and *D. norvegica* are probably as common in north-west Ireland as in other parts of the country. However, *D. germanica* would seem to be very scarce in these parts and may be confined to urban areas.

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RECORDS OF MACROBENTHIC CRUSTACEA FROM MAERL HABITATS IN IRISH WATERS

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Introduction

Maerl beds are a conspicuous and relative widespread component of Irish marine, subtidal ecosystems. These habitats occur all along the western and northern seabords from Roaringwater Bay, Co. Cork up to Mulroy Bay in Co. Donegal and are particularly abundant in the Galway Bay area. Their distribution was mapped by De Grave and Whitaker (in press). Maerl habitats are of some conservation importance, as the two main maerl bed forming species, *Lithothamnion corallioides* (P. and H. Crouan) P. and H. Crouan and *Phymatolithon calcareum* (Pallas) are listed in the EC Habitats Directive (De Grave and Whitaker, in press).

In spite of their relatively widespread nature, records of the associated fauna are scarce and, as far as Crustacea are concerned, are restricted to the works of Bosence (1979), Keegan (1974) and Myers and McGrath (1980, 1982, 1983). Bosence (1979), as part of a sedimentologically orientated study, listed six crustacean taxa (*Xantho* sp., *Pisidia longicornis* (L.), *Idotea* sp., *Portunus* sp., *Pagurus* sp., *Galathea squamifera* Leach) in the maerl bed of Mannin Bay, Co. Galway. Keegan (1974) recorded one species of Isopoda and 22 species of Decapoda from Galway Bay, but mentioned Amphipoda only as unidentified. Myers and McGrath (1980, 1982, 1983) described two species of Amphipoda new to science and recorded a further 13 species of Amphipoda from maerl beds in Kilkieran Bay, Co. Galway.

As part of a larger scale study into the distribution of maerl beds for both ecological and sedimentological reasons, in excess of 250 samples were processed for Crustacea. It is the aim of the present contribution to list these records, in order to provide some insight into the biodiversity of these habitats.

Materials and Methods

Samples were obtained by a variety of methods. These included using the following apparatus: 0.001m² Van Essen grab, 0.025m² Van Veen grab, Duncan's anchor dredge, 2m wide beam trawl, 0.01m² Day grab, and by means of SCUBA diving. The last consisted of either manually removing portions of the substrate or specifically searching for larger species (mainly decapods).

Samples were obtained from 12 locations along the coastline, ranging from Roaringwater Bay and Bantry Bay to Donegal Bay. The number of samples and the habitats they covered in each location varied from one (e.g. Inishbofin) to more than 50 (e.g. Mannin Bay). For each record the information consists of the following: number of specimens, location, co-ordinates of sampling point (only if known), water depth (corrected to Chart Datum), substrate notes and sampling method. If the species of coralline algae making up the maerl substrate was not identified, the indication 'maerl' is given. This applies only to samples containing live maerl, with maerl debris being given as 'broken maerl', and not identified to species level.

All samples were taken in the period spanning August 1995-October 1997, with no actual sampling dates given in the listed records. Under each species heading, records are listed from north to south.

Representative specimens of the rarer species have been deposited in the National Museum of Ireland, Dublin (NMI 27.1999).

Results

DECAPODA

Anapagurus chiroacanthus (Lilljeborg)

1 specimen, Bantry Bay, 51°38.800'N 9°47.250'W, 3m, live *Lithothamnion corallioides*, diver collecting.

Athanas nitescens (Leach)

1 specimen, Donegal Bay, 54°34.800'N 8°25.950'W, 6m, live maerl, Van Veen grab; 1 specimen, Mannin Bay, 53°27.700'N 10°4.500'W, 2.9m, live *Lithothamnion corallioides*, diver collecting; 1 specimen, Kilkieran Bay, 1m, *Zostera* on live *Phymatolithon calcareum*, diver collecting.

***Cancer pagurus* Linnaeus**

1 specimen, Mannin Bay, 53°27.700'N 10°4.500'W, 2.9m, live *Lithothamnion corallioides*, anchor dredge; 1 specimen, Bantry Bay, 51°38.800'N 9°47.250'W, 3m, live *L. corallioides*, diver collecting; 2 juvenile specimens, Bantry Bay, 51°39.400'N 9°46.400'W, 8m, live maerl, Van Veen grab.

***Carcinus maenas* (Linnaeus)**

3 specimens, Mannin Bay, 52°27.210'N 10°05.840'W, 15-7m, live maerl and brown algae, beam trawl; 1 specimen, Mannin Bay, 52°26.630'N 10°04.530'W, 6m, *Zostera* on live maerl, beam trawl; 1 specimen, Mannin Bay, 52°27.370'N 10°04.400'W, 5m, live maerl, beam trawl; 1 specimen, Roaringwater Bay, 51°31.909'N 9°25.148'W, 4m, sparse cover of live *Lithophyllum dentatum* on mud, beam trawl; 1 specimen, Roaringwater Bay, 51°31.635'N 9°25.474'W, 4m, live *L. dentatum* on mud, beam trawl.

***Crangon crangon* (Linnaeus)**

17 specimen, Mannin Bay, 52°27.210'N 10°05.840'W, 15-7m, live maerl and brown algae, beam trawl; 1 specimen, Mannin Bay, 52°27.370'N 10°04.400'W, 5m, live maerl, beam trawl; 1 specimen, Mannin Bay, 53°27.700'N 10°4.500'W, 2.9m, live *Lithothamnion corallioides*, diver collecting; 1 specimen, Mannin Bay, 53°27.700'N 10°4.500'W, 2.9m, live *L. corallioides*, anchor dredge; 4 specimens, Roaringwater Bay, 51°31.909'N 9°25.148'W, 4m, sparse cover of live *Lithophyllum dentatum* on mud, beam trawl; 5 specimens, Roaringwater Bay, 51°31.635'N 9°25.474'W, 4m, live *L. dentatum* on mud, beam trawl.

***Galathea intermedia* Liljeborg**

6 specimens, Donegal Bay, 54°34.800'N 8°25.950'W, 6m, live maerl, Van Veen grab; 1 specimen, Mannin Bay, 53°27.700'N 10°4.500'W, 2.9m, live *Lithothamnion corallioides*, diver collecting; 1 specimen, Kenmare River, 51°47.851'N 9°56.461'W, 10m, mud and minor amounts of live maerl, Van Essen grab; 2 specimens, Roaringwater Bay, 51°31.300'N 9°25.100'W, 4.5m, live *L. corallioides*, Van Veen grab.

***Galathea squamifera* Leach**

1 specimen, Mannin Bay, 52°26.630'N 10°04.530'W, 6m, *Zostera* on live maerl, beam trawl. Previously recorded from maerl habitat in Galway Bay (Keegan, 1974) and Mannin Bay (Bosence, 1979).

***Hippolyte varians* Leach**

1 specimens, Donegal Bay, 54°34.800'N 8°25.950'W, 6m, live maerl, Van Veen grab; 2 specimens, Mannin Bay, 53°26.800'N 10°04.300'W, 4m, *Zostera* on live maerl, anchor dredge; 1 specimen, Mannin Bay, 52°27.210'N 10°05.840'W, 15-7m, live maerl and brown algae, beam trawl; 1 specimen, Mannin Bay, 52°27.370'N 10°04.400'W, 5m, live maerl, beam trawl; 1 specimen, Bantry Bay, 51°39.400'N 9°46.400'W, 8m, live maerl, Van Veen grab. Previously recorded from maerl habitat in Galway Bay (Keegan, 1974).

***Inachus phalangium* (Fabricius)**

1 specimen, Mannin Bay, 53°26.800'N 10°04.300'W, 4m, live *Lithothamnion corallioides*, diver collecting; 1 specimen, Mannin Bay, 52°27.160'N 10°04.150'W, 4-5m, *Zostera* on live maerl, beam trawl.

***Liocarcinus arcuatus* (Leach)**

1 specimen, Donegal Bay, 54°34.800'N 8°25.950'W, 6m, live maerl, Van Veen grab; 2 specimens, Mannin Bay, 53°26.800'N 10°04.300'W, 4m, *Zostera* on live maerl, anchor dredge; 1 specimen, Mannin Bay, 53°27.700'N 10°4.500'W, 2.9m, live *Lithothamnion corallioides*, anchor dredge; 1 specimen, Mannin Bay, 52°26.630'N 10°04.530'W, 6m, *Zostera* on live maerl, beam trawl; 2 specimens, Mannin Bay, 52°27.370'N 10°04.400'W, 5m, live maerl, beam trawl; 1 specimen, Roaringwater Bay, 51°31.300'N 9°25.100'W, 4.5m, live *L. corallioides* and sandy mud, Van Veen grab; 2 specimens, Roaringwater Bay, 51°31.300'N 9°25.100'W, 4.5m, live and broken *L. corallioides* on muddy sand, Van Veen grab; 3 specimens, Roaringwater Bay, 51°31.800'N 9°24.820'W, 3.5m, live *Lithophyllum dentatum* on sandy mud, Van Veen grab; 1 specimen, Roaringwater Bay, 51°31.800'N 9°24.820'W, 3.5m, live *L. dentatum*, Van Veen grab; 1 specimen, Roaringwater Bay, 51°31.909'N 9°25.148'W, 4m, sparse cover of live *L. dentatum* on mud, beam trawl; 1 specimen, Roaringwater Bay, 51°31.635'N 9°25.474'W, 4m, live *L. dentatum* on mud, beam trawl. Previously recorded from maerl habitat in Galway Bay (Keegan, 1974).

***Liocarcinus corrugatus* (Pennant)**

1 specimen, Donegal Bay, 54°34.800'N 8°25.950'W, 6m, live maerl, Van Veen grab; 1 specimen, Mannin Bay, 53°26.800'N 10°04.300'W, 4m, live *Lithothamnion corallioides*, diver collecting; 2 specimens, Mannin Bay, 53°27.700'N 10°4.500'W, 2.9m, live *L. corallioides*,

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anchor dredge; 1 specimen, Mannin Bay, 52°27.370'N 10°04.400'W, 5m, live maerl, beam trawl; 1 specimen, Inner Galway Bay, 53°09.172'N 9°09.474'W, 6m, mixture of live and broken maerl, Van Essen grab; 1 specimen, Roaringwater Bay, 51°31.984'N 9°25.865'W, 4m, live *L. corallioides*, beam trawl. Previously recorded from maerl habitat in Galway Bay (Keegan, 1974).

***Liocarcinus depurator* (Linnaeus)**

25 specimens, Mannin Bay, 53°27.700'N 10°4.500'W, 2.9m, live *Lithothamnion corallioides*, anchor dredge; 6 specimens, Mannin Bay, 52°27.160'N 10°04.150'W, 4-5m, *Zostera* on live maerl, beam trawl.

***Liocarcinus marmoreus* (Leach)**

3 specimens, Mannin Bay, 53°27.700'N 10°4.500'W, 2.9m, live *Lithothamnion corallioides*, anchor dredge. Previously recorded from maerl habitat in Galway Bay (Keegan, 1974).

***Liocarcinus pusillus* (Leach)**

1 specimen, Mannin Bay, 53°26.800'N 10°04.300'W, 4m, live *Lithothamnion corallioides*, diver collecting.

***Macropodia rostrata* (Linnaeus)**

25 specimens, Mannin Bay, 53°27.700'N 10°4.500'W, 2.9m, live *Lithothamnion corallioides*, diver collecting; 12 specimens, Mannin Bay, 53°26.800'N 10°04.300'W, 4m, live *L. corallioides*, diver collecting; 9 specimens, Mannin Bay, 52°27.210'N 10°05.840'W, 15-7m, live maerl and brown algae, beam trawl; 1 specimen, Mannin Bay, 52°26.630'N 10°04.530'W, 6m, *Zostera* on live maerl, beam trawl; 12 specimens, Mannin Bay, 52°26.630'N 10°04.530'W, 6m, *Zostera* on live maerl, beam trawl; 4 specimens, Mannin Bay, 52°27.370'N 10°04.400'W, 5m, live maerl, beam trawl. Previously recorded from maerl habitat in Galway Bay (Keegan, 1974).

***Maja squinado* (Herbst)**

1 specimen (juvenile), Mannin Bay, 53°26.800'N 10°04.300'W, 4m, live *Lithothamnion corallioides*, diver collecting; 1 specimen, Mannin Bay, 52°27.370'N 10°04.400'W, 5m, live maerl, beam trawl; 1 specimen, Mannin Bay, 52°27.160'N 10°04.150'W, 4-5m, *Zostera* on live maerl, beam trawl. Previously recorded from maerl habitat in Galway Bay (Keegan, 1974).

***Necora puber* (Linnaeus)**

15 specimens, Mannin Bay, 53°27.700'N 10°4.500'W, 2.9m, live *Lithothamnion corallioides*, anchor dredge; 1 specimen, Mannin Bay, 52°27.370'N 10°04.400'W, 5m, live maerl, beam trawl. Previously recorded from maerl habitat in Galway Bay (Keegan, 1974).

***Pagurus bernhardus* (Linnaeus)**

3 specimens, Mannin Bay, 53°27.700'N 10°4.500'W, 2.9m, live *Lithothamnion corallioides*, diver collecting; 3 specimens, Mannin Bay, 53°27.700'N 10°4.500'W, 2.9m, live *L. corallioides*, anchor dredge; 3 specimens, Mannin Bay, 52°27.370'N 10°04.400'W, 5m, live maerl, beam trawl; 6 specimens, Mannin Bay, 52°26.630'N 10°04.530'W, 6m, *Zostera* on live maerl, beam trawl; 1 specimen, Kenmare River, 51°47.892'N 9°56.331'W, 10m, broken maerl, Van Essen grab.

***Pagurus cuanensis* Bell**

1 specimen, Mannin Bay, 53°27.700'N 10°4.500'W, 2.9m, live *Lithothamnion corallioides*, diver collecting.

***Palaemon serratus* (Pennant)**

1 specimen, Mannin Bay, 52°26.630'N 10°04.530'W, 6m, *Zostera* on live maerl, beam trawl; 1 specimen, Mannin Bay, 52°27.370'N 10°04.400'W, 5m, live maerl, beam trawl; 1 specimen, Roaringwater Bay, 51°31.909'N 9°25.148'W, 4m, sparse cover of live *Lithophyllum dentatum* on mud, beam trawl.

***Pandalina brevisrostris* (Rathke)**

2 specimens, Mannin Bay, 52°27.370'N 10°04.400'W, 5m, live maerl, beam trawl. Previously recorded from maerl habitat in Galway Bay (Keegan, 1974).

***Pandalus montagui* Leach**

3 specimens, Mannin Bay, 52°27.210'N 10°05.840'W, 15-7m, live maerl and brown algae, beam trawl.

***Pilumnus hirtellus* (Linnaeus)**

2 specimens, Mannin Bay, 52°27.160'N 10°04.150'W, 4-5m, *Zostera* on live maerl, beam trawl; 2 specimens, Bantry Bay, 51°38.800'N 9°47.250'W, 3m, live *Lithothamnion corallioides*, diver collecting. Previously recorded from maerl habitat in Galway Bay (Keegan, 1974).

***Pisidia longicornis* (Linnaeus)**

4 specimens, Donegal Bay, 54°34.800'N 8°25.950'W, 6m, live maerl, Van Veen grab; 10 specimens, Mannin Bay, 53°27.700'N 10°4.500'W, 2.9m, live *Lithothamnion corallioides*, diver collecting; 56 specimens, Kilkieran Bay, 1m, live maerl, diver collecting; 15 specimens, Kilkieran Bay, 1m, *Zostera* on live *Lithothamnion glaciale*, diver collecting; 90 specimens, Kilkieran Bay, 1m, *Zostera* on live *Phymatolithon calcareum*, diver collecting; 1 specimen, Inner Galway Bay, 53°10.940'N 9°01.659'W, 8m, live maerl, Van Essen grab; 2 specimens, Kenmare River, 51°48.089'N 9°55.852'W, 10m, sparse live maerl, Van Essen grab; 4 specimens, Kenmare River, 51°48.089'N 9°55.852'W, 10m, live maerl, Van Essen grab; 25 specimens, Bantry Bay, 51°38.800'N 9°47.250'W, 3m, live *L. corallioides*, diver collecting; 3 specimens, Bantry Bay, 51°39.400'N 9°46.400'W, 8m, live maerl, Van Veen grab; 36 specimens, Bantry Bay, 51°38.800'N 9°47.250'W, 3m, live *L. corallioides*, diver collecting; 5 specimens, Roaringwater Bay, 51°31.300'N 9°25.100'W, 4.5m, live *L. corallioides*, Van Veen grab; 1 specimen, Roaringwater Bay, 51°31.300'N 9°25.100'W, 4.5m, live *L. corallioides* and sandy mud, Van Veen grab; 2 specimens, Roaringwater Bay, 51°31.800'N 9°24.820'W, 3.5m, sparse cover of live *Lithophyllum dentatum* on mud, Van Veen grab; 2 specimens, Roaringwater Bay, 51°31.800'N 9°24.820'W, 3.5m, live *Lithophyllum dentatum*, Van Veen grab. Previously recorded from maerl habitat in Galway Bay (Keegan, 1974) and Mannin Bay (Bosence, 1979).

***Thoralus cranchi* (Leach)**

6 specimens, Donegal Bay, 54°34.800'N 8°25.950'W, 6m, live maerl, Van Veen grab; 6 specimens, Mannin Bay, 53°27.700'N 10°4.500'W, 2.9m, live *Lithothamnion corallioides*, diver collecting; 2 specimens, Mannin Bay, 53°26.800'N 10°04.300'W, 4m, Live *L. corallioides*, diver collecting; 6 specimens, Mannin Bay, 52°27.370'N 10°04.400'W, 5m, live maerl, beam trawl; 1 specimen, Kilkieran Bay, 1m, *Zostera* on live *Phymatolithon calcareum*, diver collecting; 1 specimen, Bantry Bay, 51°38.800'N 9°47.250'W, 3m, live *L. corallioides*, diver collecting; 1 specimen, Roaringwater Bay, 51°31.300'N 9°25.100'W, 4.5m, live *L. corallioides* and sandy mud, Van Veen grab; 1 specimen, Roaringwater Bay, 51°31.300'N 9°25.100'W, 4.5m, live *L. corallioides* on sandy mud, Van Veen grab; 1 specimen, Roaringwater Bay, 51°31.800'N 9°24.820'W, 3.5m, live *Lithophyllum dentatum* on sandy

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mud, Van Veen grab; 1 specimen, Roaringwater Bay, 51°31.635'N 9°25.474'W, 4m, live *L. dentatum* on mud, beam trawl.

***Xantho incisus* Leach**

2 specimens, Mannin Bay, 52°27.370'N 10°04.400'W, 5m, live maerl, beam trawl; 1 specimen, Roaringwater Bay, 51°31.300'N 9°25.100'W, 4.5m, live *Lithothamnion corallioides*, Van Veen grab. Previously recorded from maerl habitat in Galway Bay (Keegan, 1974).

***Xantho pilipes* A. Milne-Edwards**

1 specimen, Clifden Bay, 53°28.800'N 10°2.972'W, 2m, mud and live maerl, Van Veen grab; 1 specimen, Mannin Bay, 53°27.700'N 10°4.500'W, 2.9m, live *Lithothamnion corallioides*, diver collecting; 2 specimens, Mannin Bay, 52°27.160'N 10°04.150'W, 4-5m, *Zostera* on live maerl, beam trawl; 1 specimen, Mannin Bay, 53°26.800'N 10°04.300'W, 4m, live *L. corallioides*, diver collecting; 1 specimen, Kenmare River, 51°47.898'N 9°56.444'N, 12m, broken maerl, Van Essen grab. Previously recorded from maerl habitat in Galway Bay (Keegan, 1974).

ISOPODA

***Conilera cylindracea* (Montagu)**

1 specimen, Outer Galway Bay, 53°04.751'N 9°31.687'W, 20m, broken maerl and shell gravel, Van Essen grab. Previously recorded from maerl habitat in Galway Bay (Keegan, 1974).

***Cymodoce* sp.**

1 specimen (juvenile), Mannin Bay, 53°27.700'N 10°4.500'W, 2.9m, live *Lithothamnion corallioides*, diver collecting; 1 specimen (juvenile), Mannin Bay, 53°26.670'N 10°04.470'W, 2m, *Zostera* on live maerl, Van Veen grab; 7 specimens (juvenile), Inner Galway Bay, 53°11.448'N 9°01.685'W, 7m, broken maerl, Van Essen grab; 1 specimen (juvenile), Kenmare River, 51°47.888'N 9°56.512'N, 12m, broken maerl and mud, Van Essen grab; 1 specimen (juvenile), Bantry Bay, 51°38.800'N 9°47.250'W, 3m, live *L. corallioides*, diver collecting.

***Eurydice inermis* Hansen**

1 specimen, Inishbofin, 53°35.624'N 10°03.593'W, 18m, broken maerl, Van Essen grab; 1 specimen, Mannin Bay, 53°27.620'N 10°05.610'W, 20m, broken maerl, Van Veen grab.

***Gnathia vorax* (Lucas)**

1 specimen, Roaringwater Bay, 51°31.800'N 9°24.820'W, 3.5m, live *Lithophyllum dentatum* on sandy mud, Van Veen grab; 4 specimens, Roaringwater Bay, 51°31.800'N 9°24.820'W, 3.5m, live *L. dentatum*, Van Veen grab.

***Idotea baltica* (Pallas)**

1 specimen, Mannin Bay, 53°27.000'N 10°04.400'W, 1m, *Zostera* on live maerl, Van Veen grab.

***Janira maculosa* Leach**

2 specimens, Donegal Bay, 54°34.800'N 8°25.950'W, 6m, live maerl, Van Veen grab; 8 specimens, Mannin Bay, 53°27.000'N 10°04.400'W, 1m, *Zostera* on live maerl, Van Veen grab; 5 specimens, Mannin Bay, 53°27.590'N 10°05.260'W, 6m, live maerl banks, Van Veen grab; 1 specimen, Kilkieran Bay, 1m, live maerl, diver collecting; 1 specimen, Kilkieran Bay, 1m, *Zostera* on live *Lithothamnion glaciale*, diver collecting; 4 specimens, Kilkieran Bay, 1m, *Zostera* on live *Phymatolithon calcareum*, diver collecting; 4 specimens, Inner Galway Bay, 53°10.940'N 9°01.659'W, 8m, live maerl, Van Essen grab; 1 specimen, Inner Galway Bay, 53°11.448'N 9°01.685'W, 7m, broken maerl, Van Essen grab; 1 specimen, Inner Galway Bay, 53°09.060'N 9°09.741'W, 8m, broken maerl and cobbles, Van Essen grab; 1 specimen, Kenmare River, 51°47.898'N 9°56.444'N, 8m, broken maerl, Van Essen grab; 1 specimen, Kenmare River, 51°47.827'N 9°56.475'N, 10m, broken maerl, Van Essen grab; 1 specimen, Kenmare River, 51°47.851'N 9°56.461'N, 10m, mud and minor amounts of live maerl, Van Essen grab; 3 specimens, Bantry Bay, 51°39.400'N 9°46.400'W, 8m, live maerl, Van Veen grab; 4 specimens, Roaringwater Bay, 51°31.800'N 9°24.820'W, 3.5m, live *Lithophyllum dentatum*, Van Veen grab.

***Munna limicola* Sars**

1 specimen, Mannin Bay, 53°27.320'N 10°05.010'W, 10m, live maerl banks, Van Veen grab; 24 specimens, Kilkieran Bay, 1m, *Zostera* on live *Phymatolithon calcareum*, diver collecting; 1 specimen, Inner Galway Bay, 53°10.940'N 9°01.659'W, 8m, live maerl, Van Essen grab.

AMPHIPODA

***Abludomelita obtusata* (Montagu)**

5 specimens, Mannin Bay, 53°27.000'N 10°04.400'W, 1m, *Zostera* on live maerl, Van Veen

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grab; 1 specimen, Kilkieran Bay, 1m, *Zostera* on live *Lithothamnion glaciale*, diver collecting; 1 specimen, Kilkieran Bay, 1m, *Zostera* on live *Phymatolithon calcareum*, diver collecting; 1 specimen, Roaringwater Bay, 51°31.300'N 9°25.100'W, 4.5m, live *Lithothamnion corallioides* on sandy mud, Van Veen grab; 1 specimen, Roaringwater Bay, 51°31.300'N 9°25.100'W, 4.5m, live *L. corallioides*, Van Veen grab.

***Ampelisca tenuicornis* Liljeborg**

1 specimen, Kenmare River, 51°47.888'N 9°56.512'W, 12m, broken maerl and mud, Van Essen grab; 1 specimen, Bantry Bay, 51°39.400'N 9°46.400'W, 8m, live maerl, Van Veen grab.

***Ampelisca typica* (Bate)**

2 specimens, Inner Galway Bay, 53°13.680'N 9°03.393'W, 7m, shell gravel with 10% live maerl, Van Essen grab; 1 specimen, Inner Galway Bay, 53°14.647'N 9°02.536'W, 7m, sand and minor amounts of broken maerl, Van Essen grab.

***Amphilocheus neapolitanus* Della Valle**

1 specimen, Mannin Bay, 53°26.670'N 10°04.470'W, 2m, *Zostera* on live maerl, Van Veen grab; 1 specimen, Kenmare River, 51°48.089'N 9°55.803'W, 10m, broken maerl, Van Essen grab.

***Aora gracilis* (Bate)**

3 specimens, Donegal Bay, 54°34.800'N 8°25.950'W, 6m, live maerl, Van Veen grab; 2 specimens, Mannin Bay, 53°26.720'N 10°04.700'W, 2m, *Zostera* on live maerl, Van Veen grab; 2 specimens, Mannin Bay, 53°27.590'N 10°05.260'W, 6m, live maerl banks, Van Veen grab; 2 specimens, Roaringwater Bay, 51°31.300'N 9°25.100'W, 4.5m, live *Lithothamnion corallioides*, Van Veen grab; 1 specimen, Roaringwater Bay, 51°31.300'N 9°25.100'W, 4.5m, live *L. corallioides* and sandy mud, Van Veen grab, 5 specimens, Roaringwater Bay, 51°31.300'N 9°25.100'W, 4.5m, live and broken *L. corallioides* on muddy sand, Van Veen grab; 13 specimens, Roaringwater Bay, 51°31.800'N 9°24.820'W, 3.5m, live *Lithophyllum dentatum* on sandy mud, Van Veen grab.

***Apherusa bispinosa* (Bate)**

3 specimens, Donegal Bay, 54°34.800'N 8°25.950'W, 6m, live maerl, Van Veen grab; 1 specimen, Clifden Bay, 53°28.800'N 10°02.972'W, 2m, mud and live maerl, Van Veen grab;

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5 specimens, Mannin Bay, 53°26.720'N 10°04.700'W, 2m, *Zostera* on live maerl, Van Veen grab; 35 specimens, Mannin Bay, 53°27.590'N 10°05.260'W, 6m, live maerl banks, Van Veen grab; 2 specimens, Kilkieran Bay, 1m, live maerl, diver collecting; 1 specimen, Kilkieran Bay, 1m, *Zostera* on live *Phymatolithon calcareum*, diver collecting; 1 specimen, Inner Galway Bay, 53°11.448'N 9°01.685'W, 7m, broken maerl, Van Essen grab; 1 specimen, Inner Galway Bay, 53°01.307'N 9°11.841'W, 7m, broken maerl and live maerl (<5%), Van Essen grab; 1 specimen, Bantry Bay, 51°39.400'N 9°46.400'W, 8m, live maerl, Van Veen grab.

***Atylus swammerdamei* (H. Milne Edwards)**

2 specimens, Mannin Bay, 53°27.290'N 10°03.880'W, 6m, live maerl banks, Van Veen grab.

***Atylus vedlomensis* (Bate and Westwood)**

3 specimens, Mannin Bay, 53°27.590'N 10°05.260'W, 6m, live maerl banks, Van Veen grab; 1 specimen, Roaringwater Bay, 51°31.300'N 9°25.100'W, 4.5m, live *Lithothamnion corallioides*, Van Veen grab; 6 specimens, Roaringwater Bay, 51°31.800'N 9°24.820'W, 3.5m, live *Lithophyllum dentatum* on sandy mud, Van Veen grab.

***Caprella acanthifera* Leach**

7 specimens, Clifden Bay, 53°28.787'N 10°02.961'W, 3m, mud and broken maerl, Van Veen grab; 4 specimens, Clifden Bay, 53°28.800'N 10°02.972'W, 2m, mud and live maerl, Van Veen grab; 162 specimens, Mannin Bay, 53°27.590'N 10°05.260'W, 6m, live maerl banks, Van Veen grab; 3 specimens, Kilkieran Bay, 1m, *Zostera* on live *Phymatolithon calcareum*, diver collecting; 2 specimens, Kenmare River, 51°47.892'N 9°56.331'N, 10m, broken maerl, Van Essen grab; 1 specimen, Kenmare River, 51°47.898'N 9°56.444'N, 8m, broken maerl, Van Essen grab; 6 specimens, Kenmare River, 51°48.089'N 9°55.852'N, 6m, sparse live maerl, Van Essen grab; 54 specimens, Kenmare River, 51°47.888'N 9°56.512'N, 11m, live maerl, Van Essen grab; 64 specimens, Kenmare River, 51°47.851'N 9°56.461'N, 10m, mud and minor amounts of live maerl, Van Essen grab; 1 specimen, Bantry Bay, 51°39.400'N 9°46.400'W, 8m, live maerl, Van Veen grab; 9 specimens, Roaringwater Bay, 51°31.800'N 9°24.820'W, 3.5m, sparse cover of live *Lithophyllum dentatum* on mud, Van Veen grab.

***Caprella tuberculata* Bate and Westwood**

2 specimens, Donegal Bay, 54°34.800'N 8°25.950'W, 6m, live maerl, Van Veen grab; 68 specimens, Mannin Bay, 53°26.720'N 10°04.700'W, 2m, *Zostera* on live maerl, Van Veen

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grab; 1 specimen, Kilkieran Bay, 1m, *Zostera* on live *Phymatolithon calcareum*, diver collecting; 1 specimen, Roaringwater Bay, 51°31.300'N 9°25.100'W, 4.5m, live *Lithothamnion corallioides*, Van Veen grab; 256 specimens, Roaringwater Bay, 51°31.800'N 9°24.820'W, 3.5m, live *Lithophyllum dentatum* on sandy mud, Van Veen grab.

***Ceradocus semiserratus* (Bate)**

15 specimens, Donegal Bay, 54°34.800'N 8°25.950'W, 6m, live maerl, Van Veen grab; 1 specimen, Inishbofin, 53°35.624'N 10°03.593'W, broken maerl, 16m, Van Essen grab; 1 specimen, Clifden Bay, 53°28.800'N 10°02.972'W, 2m, mud and live maerl, Van Veen grab; 10 specimens, Mannin Bay, 53°26.720'N 10°04.700'W, 2m, *Zostera* on live maerl, Van Veen grab; 5 specimens, Inner Galway Bay, 53°10.940'N 9°01.659'W, 8m, live maerl, Van Essen grab; 3 specimens, Kenmare River, 51°47.851'N 9°56.461'N, 10m, mud and minor amounts of broken maerl, Van Essen grab; 1 specimen, Kenmare River, 51°47.827'N 9°56.475'N, 10m, broken maerl, Van Essen grab; 1 specimen, Kenmare River, 51°47.851'N 9°56.461'N, 10m, mud and minor amounts of live maerl, Van Essen grab; 9 specimens, Bantry Bay, 51°39.400'N 9°46.400'W, 8m, live maerl, Van Veen grab; 4 specimens, Roaringwater Bay, 51°31.300'N 9°25.100'W, 4.5m, live *Lithothamnion corallioides*, Van Veen grab; 14 specimens, Roaringwater Bay, 51°31.300'N 9°25.100'W, 4.5m, live and broken *L. corallioides* on muddy sand, Van Veen grab; 104 specimens, Roaringwater Bay, 51°31.800'N 9°24.820'W, 3.5m, live *Lithophyllum dentatum* on sandy mud, Van Veen grab; 15 specimens, Roaringwater Bay, 51°31.800'N 9°24.820'W, 3.5m, sparse cover of live *L. dentatum* on mud, Van Veen grab; 12 specimens, Roaringwater Bay, 51°31.800'N 9°24.820'W, 3.5m, live *L. dentatum*, Van Veen grab.

***Cheirocrates sundevallii* (Rathke)**

53 specimens, Mannin Bay, 53°26.720'N 10°04.700'W, 2m, *Zostera* on live maerl, Van Veen grab; 1 specimen, Kilkieran Bay, 1m, *Zostera* on live *Phymatolithon calcareum*, diver collecting; 2 specimens, Roaringwater Bay, 51°31.300'N 9°25.100'W, 4.5m, live *Lithothamnion corallioides*, Van Veen grab; 4 specimens, Roaringwater Bay, 51°31.300'N 9°25.100'W, 4.5m, live and broken *L. corallioides* on muddy sand, Van Veen grab; 28 specimens, Roaringwater Bay, 51°31.800'N 9°24.820'W, 3.5m, live *Lithophyllum dentatum* on sandy mud, Van Veen grab; 12 specimens, Roaringwater Bay, 51°31.800'N 9°24.820'W,

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3.5m, sparse cover of live *L. dentatum* on mud, Van Veen grab; 13 specimens, Roaringwater Bay, 51°31.800'N 9°24.820'W, 3.5m, live *L. dentatum*, Van Veen grab.

***Colomastix pusilla* Grube**

2 specimens, Kilkieran Bay, 1m, *Zostera* on live *Lithothamnion glaciale*, diver collecting.

***Corophium acutum* Chevreux**

1 specimen, Bantry Bay, 51°38.800'N 9°47.250'W, 3m, live *Lithothamnion corallioides*, diver collecting.

***Corophium bonnellii* (H. Milne Edwards)**

4 specimens, Clifden Bay, 53°28.787'N 10°02.961'W, 3m, mud and broken maerl, Van Veen grab; 19 specimens, Mannin Bay, 53°26.720'N 10°04.700'W, 2m, *Zostera* on live maerl, Van Veen grab; 1 specimen, Kilkieran Bay, 1m, live maerl, diver collecting; 1 specimen, Kilkieran Bay, 1m, *Zostera* on live *Lithothamnion glaciale*, diver collecting; 3 specimens, Kilkieran Bay, 1m, *Zostera* on live *Phymatolithon calcareum*, diver collecting; 15 specimens, Inner Galway Bay, 53°10.940'N 9°01.659'W, 8m, live maerl, Van Essen grab; 1 specimen, Inner Galway Bay, 53°13.886'N 9°03.787'W, 5m, broken maerl and cobbles, Van Essen grab; 1 specimen, Kenmare River, 51°47.888'N 9°56.512'W, 11m, live maerl, Van Essen grab; 1 specimen, Kenmare River, 51°47.851'N 9°56.461'N, 10m, mud and minor amounts of live maerl, Van Essen grab; 1 specimen, Bantry Bay, 51°39.400'N 9°46.400'W, 8m, live maerl, Van Veen grab; 1 specimen, Roaringwater Bay, 51°31.300'N 9°25.100'W, 4.5m, live and broken *Lithothamnion corallioides* on muddy sand, Van Veen grab.

***Corophium crassicorne* Bruzelius**

67 specimens, Mannin Bay, 53°26.940'N 10°05.030'W, 15m, broken maerl and sand, Van Veen grab.

***Dexamine spinosa* (Montagu)**

8 specimens, Donegal Bay, 54°34.800'N 8°25.950'W, 6m, live maerl, Van Veen grab; 1 specimen, Clifden Bay, 53°28.800'N 10°02.972'W, 2m, mud and live maerl, Van Veen grab; 1 specimen, Clifden Bay, 53°28.787'N 10°02.961'W, 3m, mud and broken maerl, Van Veen grab; 6 specimens, Mannin Bay, 53°27.000'N 10°04.400'W, 1m, *Zostera* on live maerl, Van Veen grab; 1 specimen, Kilkieran Bay, 1m, *Zostera* on live *Phymatolithon calcareum*, diver collecting; 8 specimens, Inner Galway Bay, 53°09.172'N 9°09.474'W, 6m, mixture of live and

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broken maerl, Van Essen grab; 1 specimen, Roaringwater Bay, 51°31.300'N 9°25.100'W, 4.5m, live *Lithothamnion corallioides* on sandy mud, Van Veen grab; 6 specimens, Roaringwater Bay, 51°31.800'N 9°24.820'W, 3.5m, live *Lithophyllum dentatum* on sandy mud, Van Veen grab; 2 specimens, Roaringwater Bay, 51°31.800'N 9°24.820'W, 3.5m, live *L. dentatum*, Van Veen grab.

***Elasmopus rapax* Costa**

14 specimens, Donegal Bay, 54°34.800'N 8°25.950'W, 6m, live maerl, Van Veen grab; 2 specimens, Mannin Bay, 53°27.760'N 10°04.670'W, 15m, broken maerl and mud, Van Veen grab.

***Epimeria cornigera* (Fabricius)**

1 specimen, Mannin Bay, 53°27.000'N 10°04.400'W, 1m, *Zostera* on live maerl, Van Veen grab; 1 specimen, Kenmare River, 51°47.892'N 9°56.331'N, 10m, broken maerl, Van Essen grab.

***Erichthonius punctatus* (Bate)**

22 specimens, Mannin Bay, 53°26.670'N 10°04.470'W, 2m, *Zostera* on live maerl, Van Veen grab; 2 specimens, Kilkieran Bay, 1m, *Zostera* on live *Phymatolithon calcareum*, diver collecting; 2 specimens, Inner Galway Bay, 53°13.886'N 9°03.787'W, 5m, broken maerl and cobbles, Van Essen grab; 5 specimens, Bantry Bay, 51°38.800'N 9°47.250'W, 3m, live *Lithothamnion corallioides*, diver collecting.

***Gammarella fucicola* (Leach)**

3 specimens, Bantry Bay, 51°39.400'N 9°46.400'W, 8m, live maerl, Van Veen grab; 2 specimens, Roaringwater Bay, 51°31.300'N 9°25.100'W, 4.5m, live *Lithothamnion corallioides*, Van Veen grab; 1 specimen, Roaringwater Bay, 51°31.300'N 9°25.100'W, 4.5m, live *L. corallioides* and sandy mud, Van Veen grab; 6 specimens, Roaringwater Bay, 51°31.300'N 9°25.100'W, 4.5m, live and broken *L. corallioides* on muddy sand, Van Veen grab; 16 specimens, Roaringwater Bay, 51°31.800'N 9°24.820'W, 3.5m, live *Lithophyllum dentatum* on sandy mud, Van Veen grab; 10 specimens, Roaringwater Bay, 51°31.800'N 9°24.820'W, 3.5m, sparse cover of live *L. dentatum* on mud, Van Veen grab; 19 specimens, Roaringwater Bay, 51°31.800'N 9°24.820'W, 3.5m, live *L. dentatum*, Van Veen grab.

***Gammaropsis lobata* (Chevreux)**

5 specimens, Donegal Bay, 54°34.800'N 8°25.950'W, 6m, live maerl, Van Veen grab; 7 specimens, Clifden Bay, 53°28.787'N 10°02.961'W, 3m, mud and broken maerl, Van Veen grab; 1 specimen, Clifden Bay, 53°28.800'N 10°02.972'W, 3m, mud and live maerl, Van Veen grab; 3 specimens, Mannin Bay, 53°26.670'N 10°04.470'W, 2m, *Zostera* on live maerl, Van Veen grab; 1 specimen, Inner Galway Bay, 53°11.448'N 9°01.685'W, 7m, broken maerl, Van Essen grab. Previously recorded from maerl habitat in Kilkieran Bay (Myers and McGrath, 1982, 1983).

***Gammarus oceanicus* Segerstråle**

1 specimen, Donegal Bay, 54°34.800'N 8°25.950'W, 6m, live maerl, Van Veen grab.

***Gitana sarsi* Boeck**

1 specimen, Kilkieran Bay, 1m, *Zostera* on live *Phymatolithon calcareum*, diver collecting; 2 specimens, Inner Galway Bay, 53°10.940'N 9°01.659'W, 8m, live maerl, Van Essen grab; 2 specimens, Mannin Bay, 53°27.440'N 10°05.310'W, 6m, broken maerl, Van Veen grab; 1 specimen, Kenmare River, 51°48.089'N 9°55.803'W, 10m, broken maerl, Van Essen grab; 1 specimen, Kenmare River, 51°47.888'N 9°56.512'W, 11m, live maerl, Van Essen grab.

***Guernea coalita* (Norman)**

1 specimen, Mannin Bay, 53°27.000'N 10°04.400'W, 1m, *Zostera* on live maerl, Van Veen grab; 2 specimens, Mannin Bay, 53°26.670'N 10°04.470'W, 2m, *Zostera* on live maerl, Van Veen grab; 1 specimen, Mannin Bay, 53°27.590'N 10°05.260'W, 6m, live maerl banks, Van Veen grab. Previously recorded from maerl habitat in Kilkieran Bay (Myers and McGrath, 1983).

***Harpinia antennaria* Meinert**

1 specimen, Roaringwater Bay, 51°31.300'N 9°25.100'W, 4.5m, live *Lithothamnion corallioides* on sandy mud, Van Veen grab; 1 specimen, Roaringwater Bay, 51°31.800'N 9°24.820'W, 3.5m, live *Lithophyllum dentatum*, Van Veen grab.

***Iphimedia obesa* Rathke**

1 specimen, Donegal Bay, 54°34.800'N 8°25.950'W, 6m, live maerl, Van Veen grab; 2 specimens, Mannin Bay, 53°27.250'N 10°04.120'W, 9m, live maerl banks, Van Veen grab; 1 specimen, Kenmare River, 51°47.898'N 9°56.444'W, 8m, broken maerl, Van Essen grab.

***Lembos websteri* Bate**

3 specimens, Mannin Bay, 53°27.250'N 10°04.120'W, 9m, live maerl banks, Van Veen grab; 5 specimens, Kilkieran Bay, 1m, live maerl, diver collecting; 24 specimens, Kilkieran Bay, 1m, *Zostera* on live *Phymatolithon calcareum*, diver collecting; 7 specimens, Roaringwater Bay, 51°31.300'N 9°25.100'W, 4.5m, live *Lithothamnion corallioides*, Van Veen grab; 10 specimens, Roaringwater Bay, 51°31.800'N 9°24.820'W, 3.5m, live *Lithophyllum dentatum*, Van Veen grab.

***Leptocheirus hirsutimanus* (Bate)**

17 specimens, Mannin Bay, 53°26.720'N 10°04.700'W, 2m, *Zostera* on live maerl, Van Veen grab; 1 specimen, Mannin Bay, 53°27.590'N 10°05.260'W, 6m, live maerl banks, Van Veen grab. Previously recorded from maerl habitat in Kilkieran Bay (Myers and McGrath, 1983).

***Leptocheirus pectinatus* (Norman)**

1 specimen, Donegal Bay, 54°34.800'N 8°25.950'W, 6m, live maerl, Van Veen grab; 3 specimens, Kenmare River, 51°47.851'N 9°56.461'N, 10m, mud and minor amounts of broken maerl, Van Essen grab; 1 specimen, Kenmare River, 51°47.827'N 9°56.475'N, 10m, broken maerl, Van Essen grab; 1 specimen, Kenmare River, 51°47.851'N 9°56.461'N, 10m, mud and minor amounts of live maerl, Van Essen grab. Previously recorded from maerl habitat in Kilkieran Bay (Myers and McGrath, 1983).

***Leucothoe incisa* Robertson**

1 specimen, Donegal Bay, 54°34.800'N 8°25.950'W, 6m, live maerl, Van Veen grab; 28 specimens, Mannin Bay, 53°26.890'N 10°04.350'W, 11m, broken maerl and shell gravel, Van Veen grab.

***Leucothoe liljeborgi* Boeck**

1 specimen, Mannin Bay, 53°27.250'N 10°04.120'W, 9m, live maerl banks, Van Veen grab.

***Leucothoe spinicarpa* (Abildgaard)**

1 specimen, Kilkieran Bay, 1m, *Zostera* on live *Lithothamnion glaciale*, diver collecting; 1 specimen, Kilkieran Bay, 1m, *Zostera* on live *Phymatolithon calcareum*, diver collecting.

***Lysianassa ceratina* (Walker)**

8 specimens, Donegal Bay, 54°34.800'N 8°25.950'W, 6m, live maerl, Van Veen grab; 88 specimens, Mannin Bay, 53°26.720'N 10°04.700'W, 2m, *Zostera* on live maerl, Van Veen

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grab; 5 specimens, Kilkieran Bay, 1m, *Zostera* on live *Lithothamnion glaciale*, diver collecting; 10 specimens, Kilkieran Bay, 1m, live maerl, diver collecting; 25 specimens, Kilkieran Bay, 1m, *Zostera* on live *L. glaciale*, diver collecting; 150 specimens, Kilkieran Bay, 1m, *Zostera* on live *Phymatolithon calcareum*, diver collecting; 1 specimen, Inner Galway Bay, 53°13.886'N 9°03.787'W, 5m, broken maerl and cobbles, Van Essen grab; 1 specimen, Inner Galway Bay, 53°10.940'N 9°01.659'W, 8m, live maerl, Van Essen grab; 1 specimen, Inner Galway Bay, 53°13.680'N 9°03.393'W, 7m, shell gravel with 10% live maerl, Van Essen grab; 1 specimen, Inner Galway Bay, 53°11.448'N 9°01.685'W, 6m, broken maerl, Van Essen grab; 3 specimens, Roaringwater Bay, 51°31.300'N 9°25.100'W, 4.5m, live and broken *Lithothamnion corallioides* on muddy sand, Van Veen grab; 1 specimen, Roaringwater Bay, 51°31.300'N 9°25.100'W, 4.5m, live *L. corallioides*, Van Veen grab.

***Maera othonis* (H. Milne Edwards)**

2 specimens, Mannin Bay, 53°27.570'N 10°03.840'W, 6m, broken maerl and shell gravel, Van Veen grab; 3 specimens, Roaringwater Bay, 51°31.800'N 9°24.820'W, 3.5m, live *Lithophyllum dentatum* on sandy mud, Van Veen grab; 1 specimen, Roaringwater Bay, 51°31.800'N 9°24.820'W, 3.5m, sparse cover of live *L. dentatum* on mud, Van Veen grab; 1 specimen, Roaringwater Bay, 51°31.800'N 9°24.820'W, 3.5m, live *L. dentatum*, Van Veen grab. Previously recorded from maerl habitat in Kilkieran Bay (Myers and McGrath, 1983).

***Megamphopus cornutus* Norman**

5 specimens, Mannin Bay, 53°26.670'N 10°04.470'W, 2m, *Zostera* on live maerl, Van Veen grab; 8 specimens, Mannin Bay, 53°27.320'N 10°05.010'W, 10m, live maerl banks, Van Veen grab. Previously recorded from maerl habitat in Kilkieran Bay (Myers and McGrath, 1983).

***Microdeutopus anomalus* (Rathke)**

5 specimens, Kilkieran Bay, 1m, live maerl, diver collecting; 12 specimens, Kilkieran Bay, 1m, *Zostera* on live *Phymatolithon calcareum*, diver collecting.

***Microdeutopus versiculatus* (Bate)**

4 specimens, Donegal Bay, 54°34.800'N 8°25.950'W, 6m, live maerl, Van Veen grab; 30 specimens, Mannin Bay, 53°26.720'N 10°04.700'W, 2m, *Zostera* on live maerl, Van Veen grab; 1 specimen, Kilkieran Bay, 1m, *Zostera* on live *Lithothamnion glaciale*, diver collecting; 5 specimens, Kilkieran Bay, 1m, live maerl, diver collecting; 1 specimen, Inner Galway Bay,

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53°13.680'N 9°03.393'W, 7m, shell gravel with 10% live maerl, Van Essen grab; 6 specimens, Bantry Bay, 51°38.800'N 9°47.250'W, 3m, live *Lithothamnion corallioides*, diver collecting; 1 specimen, Inner Galway Bay, 53°09.172'N 9°09.474'W, 6m, mixture of live and broken maerl, Van Essen grab; 47 specimens, Roaringwater Bay, 51°31.300'N 9°25.100'W, 4.5m, live *L. corallioides*, Van Veen grab; 13 specimens, Roaringwater Bay, 51°31.300'N 9°25.100'W, 4.5m, live *L. corallioides* and sandy mud, Van Veen grab; 135 specimens, Roaringwater Bay, 51°31.300'N 9°25.100'W, 4.5m, live and broken *L. corallioides* on muddy sand, Van Veen grab; 289 specimens, Roaringwater Bay, 51°31.800'N 9°24.820'W, 3.5m, live *Lithophyllum dentatum* on sandy mud, Van Veen grab; 84 specimens, Roaringwater Bay, 51°31.800'N 9°24.820'W, 3.5m, live *L. dentatum*, Van Veen grab.

***Microprotopus maculatus* Norman**

15 specimens, Mannin Bay, 53°26.720'N 10°04.700'W, 2m, *Zostera* on live maerl, Van Veen grab; 2 specimens, Mannin Bay, 53°27.590'N 10°05.260'W, 6m, live maerl banks, Van Veen grab; 2 specimens, Inner Galway Bay, 53°09.060'N 9°09.741'W, 7m, broken maerl and cobbles, Van Essen grab.

***Parametaphoxus fultoni* (Scott)**

2 specimens, Donegal Bay, 54°34.800'N 8°25.950'W, 6m, live maerl, Van Veen grab; 5 specimens, Clifden Bay, 53°28.787'N 10°02.961'W, 3m, mud and broken maerl, Van Veen grab; 4 specimens, Clifden Bay, 53°28.800'N 10°02.972'W, 2m, mud and live maerl, Van Veen grab; 2 specimens, Mannin Bay, 53°26.720'N 10°04.700'W, 2m, *Zostera* on live maerl, Van Veen grab; 1 specimen, Inner Galway Bay, 53°13.680'N 9°03.393'W, 7m, shell gravel with 10% live maerl, Van Essen grab; 1 specimen, Inner Galway Bay, 53°14.577'N 9°03.116'W, 7m, live maerl, Van Essen grab; 1 specimen, Kenmare River, 51°47.892'N 9°56.331'W, 10m, broken maerl, Van Essen grab; 1 specimen, Kenmare River, 51°47.851'N 9°56.461'W, 10m, mud and minor amounts of broken maerl, Van Essen grab; 2 specimens, Kenmare River, 51°47.888'N 9°56.512'W, 11m, live maerl, Van Essen grab; 4 specimens, Kenmare River, 51°47.851'N 9°56.461'W, 10m, mud and minor amounts of live maerl, Van Essen grab; 10 specimens, Roaringwater Bay, 51°31.300'N 9°25.100'W, 4.5m, live *Lithothamnion corallioides*, Van Veen grab; 10 specimens, Roaringwater Bay, 51°31.300'N 9°25.100'W, 4.5m, live *L. corallioides* and sandy mud, Van Veen grab; 14 specimens,

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Roaringwater Bay, 51°31.300'N 9°25.100'W, 4.5m, live and broken *L. corallioides* on muddy sand, Van Veen grab; 52 specimens, Roaringwater Bay, 51°31.800'N 9°24.820'W, 3.5m, live *Lithophyllum dentatum* on sandy mud, Van Veen grab. Previously recorded from maerl habitat in Kilkieran Bay (Myers and McGrath, 1983).

***Peltocoxa brevirostris* (Scott and Scott)**

1 specimen, Mannin Bay, 53°27.590'N 10°05.260'W, 6m, live maerl banks, Van Veen grab.

***Phthisica marina* Slabber**

4 specimens, Clifden Bay, 53°28.800'N 10°02.972'W, 2m, mud and live maerl, Van Veen grab; 6 specimens, Mannin Bay, 53°27.590'N 10°05.260'W, 6m, live maerl banks, Van Veen grab; 1 specimen, Kilkieran Bay, 1m, *Zostera* on live *Phymatolithon calcareum*, diver collecting; 1 specimen, Inner Galway Bay, 53°10.940'N 9°01.659'W, 8m, live maerl, Van Essen grab; 1 specimen, Kenmare River, 51°47.851'N 9°56.461'N, 10m, mud and minor amounts of live maerl, Van Essen grab; 1 specimen, Roaringwater Bay, 51°31.300'N 9°25.100'W, 4.5m, live *Lithothamnion corallioides* and sandy mud, Van Veen grab; 9 specimens, Roaringwater Bay, 51°31.300'N 9°25.100'W, 4.5m, live and broken *L. corallioides*, Van Veen grab.

***Socarnes erythrophthalmus* Robertson**

26 specimens, Donegal Bay, 54°34.800'N 8°25.950'W, 6m, live maerl, Van Veen grab; 10 specimens, Clifden Bay, 53°28.787'N 10°02.961'W, 3m, mud and broken maerl, Van Veen grab; 11 specimens, Clifden Bay, 53°28.800'N 10°02.972'W, 2m, mud and live maerl, Van Veen grab; 2 specimens, Mannin Bay, 53°26.720'N 10°04.700'W, 2m, *Zostera* on live maerl, Van Veen grab; 18 specimens, Mannin Bay, 53°27.590'N 10°05.260'W, 6m, live maerl banks, Van Veen grab; 1 specimen, Inner Galway Bay, 53°11.448'N 9°01.685'W, 7m, broken maerl, Van Essen grab; 1 specimen, Inner Galway Bay, 53°01.307'N 9°11.841'W, 7m, broken maerl and live maerl (<5%), Van Essen grab; 1 specimen, Kenmare River, 51°47.851'N 9°56.461'N, 10m, mud and minor amounts of broken maerl, Van Essen grab; 1 specimen, Kenmare River, 51°47.827'N 9°56.475'N, 10m, broken maerl, Van Essen grab; 1 specimen, Kenmare River, 51°48.089'N 9°55.803'N, 10m, broken maerl, Van Essen grab; 5 specimens, Kenmare River, 51°47.851'N 9°56.461'N, 10m, mud and minor amounts of live maerl, Van Essen grab; 3 specimens, Bantry Bay, 51°39.400'N 9°46.400'W, 8m, live maerl, Van Veen

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grab; 1 specimen, Roaringwater Bay, 51°31.300'N 9°25.100'W, 4.5m, live and broken *Lithothamnion corallioides* on muddy sand, Van Veen grab; 2 specimens, Roaringwater Bay, 51°31.800'N 9°24.820'W, 3.5m, live *Lithophyllum dentatum* on sandy mud, Van Veen grab. Previously recorded from maerl habitat in Kilkieran Bay (Myers and McGrath, 1983).

***Stenothoe monoculoides* (Montagu)**

2 specimens, Mannin Bay, 53°27.000'N 10°04.400'W, 1m, *Zostera* on live maerl, Van Veen grab; 2 specimens, Kilkieran Bay, 1m, *Zostera* on live *Phymatolithon calcareum*, diver collecting; 1 specimen, Kenmare River, 51°47.827'N 9°56.475'N, 10m, broken maerl, Van Essen grab; 1 specimen, Kenmare River, 51°48.089'N 9°55.803'N, 10m, broken maerl, Van Essen grab.

***Synchelidium maculatum* Stebbing**

2 specimens, Mannin Bay, 53°27.390'N 10°04.390'W, 4m, broken maerl and sand, Van Veen grab.

***Tryphosella horingi* (Boeck)**

3 specimens, Mannin Bay, 53°26.720'N 10°04.700'W, 2m, *Zostera* on live maerl, Van Veen grab; 1 specimen, Kilkieran Bay, 1m, *Zostera* on live *Phymatolithon calcareum*, diver collecting.

***Urothoe elegans* (Bate)**

5 specimens, Mannin Bay, 53°27.520'N 10°04.510'W, 6m, broken maerl and sand, Van Veen grab; 2 specimens, Inner Galway Bay, 53°10.940'N 9°01.659'W, 8m, live maerl, Van Essen grab.

***Urothoe marina* (Bate)**

17 specimens, Mannin Bay, 53°27.390'N 10°05.390'W, 12m, broken maerl and sandy mud, Van Veen grab.

CUMACEA

***Cumella pygmaea* Sars**

1 specimen, Mannin Bay, 53°26.720'N 10°04.700'W, 2m, *Zostera* on live maerl, Van Veen grab; 5 specimens, Mannin Bay, 53°27.000'N 10°04.400'W, 1m, *Zostera* on live maerl, Van Veen grab; 1 specimen, Kilkieran Bay, 1m, *Zostera* on live *Phymatolithon calcareum*, diver collecting.

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***Nannastacus brevicaudatus* Calman**

1 specimen, Mannin Bay, 53°27.590'N 10°04.140'W, 2m, broken maerl and filamentous algae, Van Veen grab.

***Vaunthompsonia cristata* Bate**

4 specimens, Clifden Bay, 53°28.787'N 10°02.961'W, 3m, mud and broken maerl, Van Veen grab; 15 specimens, Clifden Bay, 53°28.800'N 10°02.972'W, 2m, mud and live maerl, Van Veen grab; 1 specimen, Mannin Bay, 53°27.290'N 10°03.880'W, 6m, live maerl banks, Van Veen grab; 2 specimens, Roaringwater Bay, 51°31.300'N 9°25.100'W, 4.5m, live

Lithothamnion corallioides, Van Veen grab; 2 specimens, Roaringwater Bay, 51°31.300'N 9°25.100'W, 4.5m, live *L. corallioides* and sandy mud, Van Veen grab; 7 specimens, Roaringwater Bay, 51°31.300'N 9°25.100'W, 4.5m, live and broken *L. corallioides* on muddy sand, Van Veen grab; 12 specimens, Roaringwater Bay, 51°31.800'N 9°24.820'W, 3.5m, live *Lithophyllum dentatum* on sandy mud, Van Veen grab; 9 specimens, Roaringwater Bay, 51°31.800'N 9°24.820'W, 3.5m, sparse cover of live *L. dentatum* on mud, Van Veen grab; 8 specimens, Roaringwater Bay, 51°31.800'N 9°24.820'W, 3.5m, live *L. dentatum*, Van Veen grab.

TANAIDACEA

***Apseudes talpa* (Montagu)**

2 specimens, Mannin Bay, 53°27.000'N 10°04.400'W, 1m, *Zostera* on live maerl, Van Veen grab; 7 specimens, Roaringwater Bay, 51°31.300'N 9°25.100'W, 4.5m, live and broken *Lithothamnion corallioides* on muddy sand, Van Veen grab.

***Pseudoparatanaïs batei* (Sars)**

1 specimen, Mannin Bay, 53°26.670'N 10°04.470'W, 2m, *Zostera* on live maerl, Van Veen grab; 5 specimens, Roaringwater Bay, 51°31.300'N 9°25.100'W, 4.5m, live *Lithothamnion corallioides* and sandy mud, Van Veen grab; 7 specimens, Roaringwater Bay, 51°31.800'N 9°24.820'W, 3.5m, sparse cover of live *Lithophyllum dentatum* on mud, Van Veen grab.

***Tanaopsis graciloides* (Lilljeborg)**

1 specimen, Kenmare River, 51°47.888'N 9°56.512'W, 12m, broken maerl and mud, Van Essen grab; 1 specimen, Roaringwater Bay, 51°31.300'N 9°25.100'W, 4.5m, live and broken *Lithothamnion corallioides* on muddy sand, Van Veen grab; 12 specimens, Roaringwater Bay,

51°31.800'N 9°24.820'W, 3.5m, live *Lithophyllum dentatum* on sandy mud, Van Veen grab; 3 specimens, Roaringwater Bay, 51°31.800'N 9°24.820'W, 3.5m, live *L. dentatum*, Van Veen grab.

Discussion

A total number of 89 species of Crustacea were recorded during the present investigation. This number is divided as follows across the various groups: Decapoda Anomura 6 species, Decapoda Caridea 7 species, Decapoda Brachyura 14 species, Amphipoda Gammaridea 45 species, Amphipoda Caprellidea 3 species, Isopoda 8 species, Tanaidacea 3 species and Cumacea 3 species. Of this total number, 66 species are recorded for the first time as occurring in maerl bed habitats.

Although most species are widespread in Irish waters and occur in a variety of subtidal habitats, some species are of interest. The amphipod *Gammaropsis lobata* was until now only known from maerl habitats in Kilkieran Bay and gravel deposits in Barloge Creek, near Lough Hyne (Costello *et al.*, 1990). The present records indicate this species to be relatively widespread in Irish waters. The record of *Gammarus oceanicus* confirms the presence of this arctic-boreal species in Irish waters, previously only known from an unsubstantiated record in Briggs (1982) from Lough Foyle. The isopod *Munna limicola* is, within Ireland, known only from Lough Hyne (Sloane *et al.*, 1961; De Grave and Holmes, 1998).

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DISCOVERY OF *TRICHOGRAMMA CACOEZIAE* MARCHAL (HYMENOPTERA: TRICHOGRAMMATIDAE) NEW TO ENGLAND, AT CHELSEA PHYSIC GARDEN, LONDON

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The family Trichogrammatidae includes small parasitic wasps which are exclusively egg-parasitoids of various insects. Many species of this family, especially belonging to the genus *Trichogramma*, are important biological control agents in integrated pest management systems.

Trichogramma species are widely used for pest control, but the taxonomic status of some has not been yet correctly determined. These species have to be revised and redescribed. For example, the redescription of the type of *Trichogramma evanescens* Westwood was made by Sugonyaev (1985) and Kostadinov and Pintureau (1991). These authors examined the type specimen from the Hope Entomological Collection, Oxford University Museum (England). The type specimen is a female mounted in Canada balsam on a glass slide with the label "Type O.U.M., Hym. 99(5)". But this research was insufficient to solve all the questions concerning *T. evanescens*. The determination of the species of *Trichogramma* is mainly based on the structure of the male genitalia. Since *T. evanescens* was described from a female, males needed to be collected in the type locality for the exact identification of the species, and to designate a male specimen as topotype.

J. O. Westwood described *T. evanescens* from one female from "Chelsea, June 11, 1828" (Westwood, 1833). In that area of Central London there is the famous, beautiful and well-known Chelsea Physic Garden, founded in 1673. Westwood probably collected the insect not far from the Garden in Chelsea over 160 years ago and it was chosen as a possible place to find *T. evanescens*.

In May-June 1991, young cabbage shoots (*Brassica oleracea*) were planted in the Garden. Under natural conditions, this plant can attract the adults of the cabbage armyworm *Mamestra*

brassicae (L.) (Lepidoptera) and the cabbage white *Pieris brassicae* (L.) (Lepidoptera), and their eggs can attract egg-parasitoids belonging to *Trichogramma*. More than one species of parasitoids can be attracted.

It was planned to use for the experiment fresh eggs of *Mamestra brassicae* from laboratory culture. Twenty five living pupae of *M. brassicae* were received from Dr M. Furlong (Imperial College, Silwood Park, Ascot) and were kept in a glass jar. After the emergence of the first moths, all the pupae were put in a large cardboard box. Many separate ribbed strips of paper were attached to the walls. Periodically the moths were fed with a water and honey mixture. The emerged moths laid eggs intensively on the ribbed paper. The pieces of ribbed paper with fresh eggs were then removed for the experiment at the Garden.

During three weeks in July-August 1991, the eggs of *M. brassicae* from the laboratory culture were exposed on the leaves of cabbage at Chelsea Physic Garden. About 2000 eggs of *M. brassicae* were attached to the cabbage plants by means of wooden sticks. Then, each two or three days, the eggs were checked and a new series of strips with fresh eggs were attached. It was noted that *Pieris brassicae* frequently laid eggs on the cabbage during this time, and about 200 eggs of *P. brassicae* were collected. No eggs of *P. brassicae* were parasitized. On the other hand, on 15 July 1991, three parasitized eggs of *M. brassicae* were collected and three females of *Trichogramma* emerged from them on 26 July. These females parasitized fresh eggs of *Mamestra* and 18 females of the next generation emerged on 7 August. At the laboratory, females of this unknown species of *Trichogramma* were bred on the eggs of two moths, *M. brassicae* and *Plodia interpunctella* (Hübner) (Lepidoptera).

The living specimens of *Trichogramma* were reared and maintained in the laboratory. Only one species of *Trichogramma* was identified in the sample. All insects of the first and second generations were females. Therefore, the reproductive mode was thelytokous parthenogenesis which can be induced by symbiotic bacteria belonging to the genus *Wolbachia* (Stouthamer *et al.*, 1990; Louis *et al.*, 1993). Some females were fed with a mixture of water, honey and tetracycline to revert thelytoky to arrhenothoky. The attempts to use antibiotics (Stouthamer, 1991) were unsuccessful in the present case. Only females of *Trichogramma* were obtained.

The culture of *Trichogramma* was moved to Kiev, Ukraine, in September 1991 to continue the study. In the Ukraine, five generations of the English strain of *Trichogramma* were reared

on the eggs of *Sitotroga cerearella* (Olivier) (Lepidoptera). We hoped to get males of *Trichogramma* on this host but had no success (at laboratories in Kiev, Ukraine, and in Saint-Petersburg, Russia).

In the French laboratory of INRA-INSA the same strain of *Trichogramma* was treated at high temperature (30°C throughout the cycle) (Pintureau, 1993) for seven generations. Only females were observed among the numerous individuals in each generation studied. As a result, the strain showed a thelytokous mode of reproduction which was not caused by the *Wolbachia* symbionts. Only one species, *T. cacoeciae* Marchal, is known to have such a character (Pintureau, 1997).

The esterases of the strain of *Trichogramma* were stained after electrophoresis. All the eight studied homogenates (20 females taken at random constituted one homogenate) were similar, with no polymorphism. Five bands (positions: 0.07, 0.24, 0.45, 0.48 and 0.51) corresponding to four alleles at four loci were identified: Est 1-0.07, Est 2-0.24, Est 5-0.45-0.48 and Est 6-0.51.

It was shown that the esterase pattern of the strain from Chelsea corresponds to that of *T. cacoeciae* (Pintureau, 1993). This determination confirms the preliminary diagnosis inferred from the absence of *Wolbachia*. This species is an addition to the English fauna.

Finally, it is important to mention that males of *T. evanescens* have not yet been found in the topotypic locality. Hopefully, future experiments in this type locality will provide new valuable material for taxonomists.

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RECOLONISATION BY STAPHYLINIDAE (COLEOPTERA) OF LEAD MINE TAILINGS AT SILVERMINES, CO. TIPPERARY, IRELAND

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Summary

Thirty-four species of staphylinid were recorded from naturally revegetated old lead mine tailings at Shallee, near Silvermines. The numbers of typical old grassland species in three abundance classes from a mossy grass sward were comparable to samples from non-metalliferous old grasslands in four other Irish counties, and the number of typical species from *Molinia caerulea* tussocks was also comparable to non-metalliferous sites. *Ocalea rivularis* Miller is recorded new to Ireland from Co. Sligo and Co. Wicklow.

Introduction

The Silvermines area of North Tipperary has an extensive history of metal mining (Cowman, 1988; Russell, 1990). One of the more recent mining operations was the lead mine at Shallee, which last operated between 1955 and 1958 (Russell, 1990). This mine exploited an Old Red Sandstone lead barite vein deposit, with relatively low zinc and pyrite content (Taylor, 1984). The Shallee mine produced a large quantity of sandy textured tailings (waste milled rock after ore extraction), which was dumped in benches on either side of the Newport to Silvermines road (L 182). Much of the tailings on the northern side of the road has been naturally colonised by vegetation since the mine closed. This area, of c. 0.75ha in extent, consists predominantly of *Calluna vulgaris* (L.) (Hull.) heath, with areas of mossy grassland and *Salix* scrub on the lower bench to the north-west. A sandy heath fauna occurs on the tailings, including high densities of burrowing bees (*Colletes* sp.), large numbers of tiger beetles (*Cicindela campestris* L.), and a colony of sand martins (*Riparia riparia* (L.)) nesting in an exposed face of the tailings.

Large metalliferous tailings deposits are a permanent landscape feature of modern metal

mining in Ireland. The natural colonisation of soil fauna of old tailings deposits may provide useful data on how soil development could proceed on these more recent sites. Colonisation by soil staphylinid beetles of old copper mine tailings was reported by Good and Butler (1999). Their recolonisation of the lead mine tailings at Shallee is reported here.

Methods

The area with the most diverse vegetation cover at Shallee tailings (R806715) was sampled as follows: (1) Mossy grassland (including *Holcus lanatus* L., *Cirsium palustre* (L.) Scop., *Anthoxanthum odoratum* L., *Festuca* sp., and *Boletus* sp.) near the edge of a stand of *Salix* sp. on fine sandy soil saturated at c. 200mm depth, sampled using plastic cup pitfall traps with ethylene glycol preservative (21 June - 10 July 1991, n = 4 traps) and a Stihl® BR400 suction apparatus ('S-vac'; see Good and Butler, 1998) modified as a suction sampler (4 May 1993, c. 2m²); (2) *Molinia caerulea* (L.) Moench tussocks in the same area as above, sampled using pitfall traps (as above).

Several other sites with *Molinia caerulea* tussocks were sampled with pitfall traps (as above) for comparison with the Shallee site: (1) near Caim, Co. Wexford (S884408), on Pb tailings, clearing in conifer plantation, 16 June - 10 July 1991; (2) Knocknamadree, Co. Cork (V790308), mountain wet pasture, grazed by sheep, Old Red Sandstone ridge, 20 June - 13 July 1991; (3) near Riverstick, Co. Cork (W667585), drained marsh on gley soil, cattle pasture, 13 August - 2 September 1991; (4) Lough Carrowabanny, Co. Sligo (G556225), lake shore, 26 June - 20 July 1991; (5) near Cloghoge, Co. Wicklow (O110069), rough pasture on peat near conifer plantation, 23 June - 17 July 1991.

Species were selected as typical of old grasslands if they: (1) occurred frequently in old grasslands; and, (2) were absent or occurred only sporadically, and at most as single (and likely vagrant) individuals in combined pitfall trap and suction samples, from recently cultivated or nutrient-amended soils (data from Good and Giller, 1990; 1991; Good and Butler, 1996; Horion, 1963-67; see also Good and Wistow, 1997). Voucher specimens of *Ocalea rivularis* Miller have been deposited in the National Museum of Ireland, and *Stenus palustris* Erichson and several other species have been retained in the author's collection. Soil elemental analysis of tailings soil from Caim, Co. Wexford, was undertaken by OMAC Laboratories, Loughrea,

using aqua regia extraction.

Results

In total 34 species of staphylinid were recorded from the Shallee tailings, of which 16 species are characteristic of old grassland (Table 1). Although the dominant species (the myrmecophilous *Drusilla canaliculata* (Fabr.)) is associated with dry grassy and heathy habitats, most other abundant typical old grassland species recorded were characteristic of mesic or wet environments.

The Shallee sample from mossy grassland had higher than average numbers of species in each of three abundance classes, when compared to six other old grassland sites, sampled using the same techniques and procedure (Table 2). Similarly, the pitfall trap sample from *Molinia* tussocks had a higher number of (a) total species, and (b) typical grassland species, compared to four other sites with *Molinia* sampled in the same season and year (Table 1, cf. Table 3). In contrast, *Molinia* tussocks on lead mine tailings at Caim (Co. Wexford) had the lowest total number of species of the six *Molinia* sites (Tables 1 and 3), although the number of typical old grassland species was similar to the average of the six samples. The tailings site at Caim was drained and planted with coniferous forestry, and apparently experienced drier soil conditions than any of the other five sites. The tailings soil (upper 50mm) in which *Molinia* was growing at Caim had, like Shallee, highly elevated lead concentrations (As: < 30mg/kg; Cd: 0.3mg/kg; Cu: 226mg/kg; Pb: 3520mg/kg; Zn: 184mg/kg).

Three males of *Stenus palustris* occurred in the suction sample from Shallee. *S. palustris* has been recorded from Ireland only twice previously (Good, 1989; Owen, 1997), and is a local species in Britain (but common in northern Scandinavia), restricted to wetlands (especially reed-beds, fens and carr) (Renkonen, 1934; Horion, 1963; Hyman and Parsons, 1994). The tailings surface does not contain these types of wetland, and this combined with the fact that the three individuals were males, and that the sample was taken in early May, suggests that they were dispersing through the site, rather than breeding in it.

There are several species worth noting from the *Molinia* tussock samples. The first is *Ocalea rivularis* Miller, a species not previously recorded from Ireland (Anderson *et al.*, 1997). This species occurred on the shore of Lough Carrownabanny, Co. Sligo, and in a *Molinia* sward

with flushes near Clohoge, Co. Wicklow (Table 3). *O. rivularis* occurs on banks of streams, and to a lesser extent, banks of rivers, lakes and springs (Horion, 1967). The species was distinguished on the basis of the key and aedeagal and spermathecal illustrations in Lohse (1974).

Lathrobium brunnipes (Fabr.) was the species most associated with *Molinia caerulea* tussocks, occurring at all six sites (Tables 1 and 3). The microhabitat of decomposing, straw-like tussock litter in wet soils appears to favour this species; it has been recorded from rotting straw at field barns, for instance (Horion, 1965). It is a common species in Ireland (Johnson and Halbert, 1902), and would be expected to have an important predatory role in *Molinia* tussock communities.

Two females of the *Atheta crassicornis*-group were taken from near Clohoge, Co. Wicklow. They are referable to *fungicola* (Thomson), *crassicornis* (Fabr.), *paracrassicornis* Brundin or *britanniae* Bernhauer and Scheerpeltz (nomenclature of Lohse and Lucht, 1989; Hansen, 1996) on external characters and spermathecal shape; of these only *A. fungicola* and *A. britanniae* are on the Irish list (Anderson *et al.*, 1997; anonymous referee, pers. comm.). I have not been able to reliably distinguish *A. fungicola* from the other species on the key character of relative antennal segment dimensions (see Palm, 1970), so the possible occurrence of a new Irish species in this group will have to await expert opinion on these specimens, or discovery of a male.

Discussion

The relative abundance of old grassland species of staphylinid occurring in the naturally revegetated tailings at Shallee indicates the development of a mature arthropod soil fauna and a self-sustaining ecosystem (see Good, 1995). Lead and cadmium are present in the Shallee tailings in concentrations which exceed trigger concentrations (concentrations above which phytotoxicity and zootoxicity may occur in mine wastes (ICRCL, 1990)), whereas zinc and copper are not (Pb: 3000mg/kg; Cd: 5mg/kg; Zn: 500mg/kg; Cu: 60mg/kg (pH 5.0 - 7.3); data from J. P. Timpson and P. Tierney, pers. comm.).

The cadmium concentration is less than twice the trigger concentration (3mg/kg), whereas lead is ten times the trigger concentration (300mg/kg). A range of grasses and other vascular

plants, albeit with reduced growth, can tolerate inorganic lead concentrations of this level in soils, especially where soil humus has accumulated (Jeffrey *et al.*, 1975; Davies, 1995). Unlike some other potentially toxic metals, lead does not easily concentrate in food chains (Hopkin, 1989), and lead is much less biologically available in solid mine waste compared to roadside and smelter-contaminated soils (Davis *et al.*, 1992). Furthermore, Staphylinidae are not as inhibited by high soil metal levels compared to other soil invertebrates such as earthworms and isopods (Hopkin, 1989). It is, then, perhaps not surprising that elevated lead concentrations have not restricted colonisation of this site by staphylinids and other soil arthropods.

Staphylinid beetles, however, are sensitive to low humidity and have low diversity in dry soils (Good and Wistow, 1997; see also Good and Butler, 1999), and drought is also often a problem for plant colonization of sandy textured soils. This does not appear to be a limiting factor in the sampled tailings soil at Shallee. A high relative diversity of staphylinids, extensive moss growth, and the occurrence of plant species like *Molinia caerulea* and *Salix* sp. indicate that the sampled tailings mound can retain moisture and has a high water table. This contrasts with the apparently drier lead tailings at Caim, which had lower numbers of staphylinid species (Table 1), although a similar set of total metal concentrations to Shallee.

The Shallee site is small, and, as indicated by the presence of *Stenus palustris*, the sampled area may be readily colonised from surrounding intact habitat. The question must be raised, therefore, of the extent to which the fauna is regularly augmented by colonising individuals, as opposed to representing a set of genuine self-sustaining breeding populations. Ma and Eijsackers (1989) pointed out the importance of reproduction as a critical test of the ability of soil invertebrates to maintain sustainable populations where heavy metal concentrations in the soil are elevated but not acutely toxic to adults. However, many of the species typical of old grasslands take several years to build up their populations after initial colonisation (e.g. Good and Wistow, 1997), and the relative abundance and number of these species recorded from the Shallee tailings are greater than would be expected from annual recruitment only.

The results from Shallee show that a typical grassland staphylinid fauna, indicating a self-sustaining ecosystem, can develop on metalliferous mine tailings. Although the site lacks the biologically more challenging soil chemical conditions of other tailings sites (elevated Zn, Cu, and As and high pyrite concentrations), it nonetheless appears to have a favourable

hydrological regime which facilitates ecosystem development. Old mine sites often have biological conservation values (e.g. Johnson *et al.*, 1978) and, given the apparent ecological quality of its developing soil, the conservation of this site could be recommended (if downstream water quality is adequate, or can be adequately controlled). A detailed soil physico-chemical, hydrological and biological characterisation of the Shallee tailings would be very worthwhile.

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TABLE 1. Staphylinidae recorded from naturally revegetated lead mine tailings at Shallee near Silvermines, Co. Tipperary, and Caim, Co. Wexford. Grass/moss area sampled by S-vac + pitfall traps, *Molinia* tussocks by pitfall traps only. Nomenclature follows Anderson *et al.* (1997). Species associated with old grasslands, and not with disturbed or nutrient-amended soil, are marked with an asterisk. *Sepedophilus nigripennis* (Stephens) is in this category, but is excluded because it is associated with accumulations of undecomposed litter.

Species	Grass/moss		<i>Molinia</i> tussocks (traps only)	
	Shallee	Shallee	Caim	
<i>Aloconota gregaria</i> (Erichson)	1	-	-	
<i>Amischa analis</i> (Gravenhorst)	3	1	-	
<i>Anotylus rugosus</i> (Fabr.)	2	6	-	
<i>Astenus lyonessius</i> (Joy)*	2	-	-	
<i>Atheta amplicollis</i> (Mulsant & Rey)	1	-	-	
<i>Atheta fungi</i> (Gravenhorst)	4	3	-	
<i>Drusilla canaliculata</i> (Fabr.)*	55	33	1	
<i>Geostiba circellaris</i> (Gravenhorst)*	2	8	1	
<i>Gabrius trossulus</i> (Nordmann)*	3	1	-	
<i>Lesteva sicula</i> Erichson*	1	-	-	
<i>Megarthritis denticollis</i> (Beck)	1	-	-	
<i>Mycetoporus splendidus</i> (Gravenhorst)	6	2	-	
<i>Ocypus aeneocephalus</i> (DeGeer)	2	1	-	
<i>Quedius tristis</i> (Gravenhorst)	1	1	-	
<i>Rugilus erichsoni</i> (Fauvel)*	6	1	-	
<i>Sepedophilus marshami</i> (Stephens)*	1	-	-	
<i>Sepedophilus nigripennis</i> (Stephens)	3	1	1	
<i>Staphylinus erythropterus</i> L.*	1	-	-	
<i>Stenus brunripes</i> Stephens*	1	2	-	
<i>Stenus cicindeloides</i> (Schaller)*	5	-	-	

TABLE 1 (continued)

Species	Grass/moss	<i>Molinia</i> tussocks (traps only)	
	Shallee	Shallee	Caim
<i>Stenus clavicornis</i> (Scopoli)	10	-	-
<i>Stenus fulvicornis</i> Stephens*	25	1	-
<i>Stenus impressus</i> Germar*	3	1	1
<i>Stenus nanus</i> Stephens	1	-	-
<i>Stenus ossium</i> Stephens	10	-	-
<i>Stenus palustris</i> Erichson	3	-	-
<i>Stenus picipes</i> Stephens	2	-	-
<i>Stenus similis</i> (Herbst)*	8	-	-
<i>Tachinus laticollis</i> Gravenhorst	1	-	-
<i>Tachyporus dispar</i> (Paykull)	18	-	-
<i>Xantholinus longiventris</i> Heer	6	4	-
<i>Atheta eremita</i> (Rye)*	-	1	-
<i>Lathrobium brunnipes</i> (Fabr.)*	-	1	5
<i>Othius punctulatus</i> (Goeze)*	-	1	-
<i>Atheta triangulum</i> (Kr.)	-	-	1
<i>Bolitobius cingulatus</i> Mannerheim	-	-	1
<i>Quedius curtipennis</i> Bernhauer*	-	-	1
No. species	31	18	8
No. old grassland species	13	10	5
No. individuals	188	69	12

TABLE 2. The number of old pasture/wet grassland species in different abundance classes from old grassland sites in Ireland; compared to Shallee tailings. Sampling effort is equivalent for each site (4 pitfall traps, *circa* 2m² suction samples).

Site	Abundance classes (total no.)			Source
	11-100	2-10	1	
Shallee tailings	2	7	6	Table 1
Curragh, Co. Kildare	1	5	2	Good and Butler (1996)
Glandore, Co. Cork	3	4	2	Good and Giller (1990)
Galley Head, Co. Cork	2	4	3	Good (in preparation)
Luska Point, Co. Tipperary	0	7	6	Good (in preparation)
Muckross, Co. Kerry	3	8	1	Good and Giller (1990)
Mullagh Mór, Co. Clare	1	5	5	Good (in preparation)
Mean of old grasslands	1.5	5.5	3.2	

TABLE 3. Staphylinidae recorded from pitfall traps in *Molinia caerulea* tussocks on shallow organic soils from four sites: Knocknamadree, Co. Cork; Lough Carrownabanny, Co. Sligo; near Riverstick, Co. Cork; near Cloghoge, Co. Wicklow. Nomenclature follows Anderson *et al.* (1997). Species associated with old grasslands and wetlands, and not with disturbed or nutrient-amended soil are marked with an asterisk. *Sepedophilus nigripennis* is in this category, but is excluded because it is associated with accumulations of undecomposed litter.

Species	Knocknamadree	Carrownabanny	Riverstick	Cloghoge
<i>Amischa analis</i> (Gravenhorst)	1	-	-	-
<i>Atheta fungi</i> (Gravenhorst)	3	-	5	-
<i>Geostiba circellaris</i> (Gravenhorst)*	1	-	25	1
<i>Lathrobium brunnipes</i> (Fabr.)*	3	1	1	1
<i>Mycetoporus splendidus</i> (Gravenhorst)	2	1	-	-
<i>Quedius fumatus</i> (Stephens)*	1	-	-	-
<i>Sepedophilus nigripennis</i> (Stephens)	1	-	5	-
<i>Staphylinus erythropterus</i> L.*	1	-	-	-
<i>Stenus impressus</i> Germar*	1	2	-	-
<i>Tachinus signatus</i> Gravenhorst	2	1	3	137
<i>Tachyporus pallidus</i> Sharp*	1	-	-	-
<i>Anotylus rugosus</i> (Fabr.)	-	1	3	-
<i>Atheta orbata</i> (Erichson)*	-	1	-	1
<i>Mycetoporus longulus</i> Mannerheim	-	1	-	-
<i>Ocalea rivularis</i> Miller*	-	5	-	4
<i>Quedius aridulus</i> Jansson / <i>boops</i> (Gravenhorst)*	-	1	-	-
<i>Quedius curtipennis</i> Bernhauer / <i>fuliginosus</i> (Gravenhorst)	-	1	1	-
<i>Xantholinus linearis</i> (Olivier)	-	2	-	2

TABLE 3 (continued)

Species	Knocknamadree	Carrownabanny	Riverstick	Cloghoge
<i>Aloconota gregaria</i> (Erichson)	-	-	8	-
<i>Dinaraea angustula</i> (Gyllenhal)	-	-	1	1
<i>Drusilla canaliculata</i> (Fabr.)*	-	-	1	-
<i>Stenus bimaculatus</i> Gyllenhal*	-	-	1	-
<i>Stenus flavipes</i> Stephens*	-	-	1	-
<i>Atheta crassicornis</i> -group	-	-	-	2
<i>Atheta graminicola</i> (Gravenhorst)	-	-	-	1
<i>Atheta hypnorum</i> (Kiesenwetter)	-	-	-	1
<i>Othius punctulatus</i> (Goeze)*	-	-	-	3
<i>Quedius molochinus</i> (Gravenhorst)	-	-	-	1
<i>Tachyporus dispar</i> (Paykull)	-	-	-	1
No. species	11	11	12	13
No. old grassland species	6	5	5	6
No. individuals	17	17	55	153

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**PSEUDONYCHOCAMPTUS CARTHUI HAMOND (CRUSTACEA: COPEPODA:
HARPACTICOIDA) NEW TO IRELAND**

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The marine polychaete worm *Serpula vermicularis* L. secretes a calcareous tube around itself. Aggregates of these tubes can form sublittoral reefs. These are often abundant in lagoons, inlets, fjords and natural harbours on the west and south coasts of Britain and Ireland (Hayward and Ryland, 1990). The reefs can in turn support a rich and diverse epifauna, by providing a firm substrate in an otherwise sometimes unconsolidated and muddy environment.

As part of an ongoing study of the epifauna of *Serpula* reefs, samples were taken in Ardbear Lough, Co. Galway, and in Killary Harbour on the Galway Mayo boundary (Minchin, 1987). One such sample, taken in May 1984 near the ferry pier on the south (County Galway) side of Killary Harbour (L8362), in *circa* 4m depth of water, yielded an interesting collection of epifaunal crustaceans. One of the copepods found was a single female specimen of the laophontid harpacticoid *Pseudonychocamptus carthui* Hamond, 1968, a species new to Ireland.

Pseudonychocamptus carthui is otherwise known only from a single female specimen collected by Hamond at Hunstanton, Norfolk, on the east coast of England, in April 1957. The site conditions were described by Hamond as "stones and lumps of concrete which lie scattered in little shallow pools" under a pier.

Nothing is known about the life-style of *P. carthui*, other than that it lives in shallow marine water, although Hamond (1968) suggested a possible link with the hydroid *Hartlaubella gelatinosa* (Pallas) (as *Laomedea gelatinosa*), which was growing in thick colonies at the Norfolk site. The conditions under which the Killary specimen was found were similar, in that it was shallow marine water. There is no suggestion that *P. carthui* is positively associated with *Serpula*, but it could be associated with any component of the rich and diverse epi-fauna living

on the reef.

Other crustaceans encountered in the same collection were the amphipod *Corophium bonnellii* (Milne Edwards), the tanaid *Pseudoparatanais batei* (Sars) and the copepods *Pseudanthessius gracilis* Claus, *Acontiophorus scutatus* (Brady and Robertson) and *Dermatomyzon nigripes* (Brady and Robertson).

The Irish specimen of *P. carthyi* has been deposited in the National Museum of Ireland.

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A CHRONOLOGICAL ACCOUNT OF THE CRAYFISH *AUSTROPOTAMOBIOUS PALLIPES* (LEREBoulLET) IN IRELAND

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"In Ireland, on the other hand, they occur in many localities; but the question whether their diffusion, and even their introduction into this island, has or has not been affected by artificial means, is involved in some obscurity". From '*The Crayfish*' by T. H. Huxley, 1880.

Although the freshwater crayfish *Austropotamobius pallipes* (Lereboullet) has, for some time, been under suspicion of having been introduced into Ireland, no reference or proof positive has, up until now, been cited to the effect. Some of the 19th-century writers on natural history *did* seem to point to a tradition of it having been introduced by artificial means, i.e. by man. More modern workers on the Irish fauna in general (e.g. Praeger, 1950) as well as those on crayfish in particular (e.g. Moriarty, 1973; Reynolds, 1982; Lucey and McGarrigle, 1987; Reynolds *et al.*, 1990; Byrne and Bracken, 1995), however, believed or presumed the species to be an old native, i.e. to have colonized naturally in the interim following the retreat of the ice in the wake of the last glaciation some 10,000 years ago.¹ Some of these authors did not rule out the possibility of introduction by human agency and the most recent biogeographic considerations suggested that it is not indigenous (Reynolds, 1997). Nonetheless whether the arrival of crayfish in Ireland was by natural or artificial means has remained *vexata quaestio*.

In the following review, which is based on a comprehensive literature survey, a chronology of crayfish in Ireland will be presented, from which it will be evident that the origin and diffusion

¹Most of Ireland's invertebrates are species that occur in Britain's fauna which is in turn largely composed of species common in north-western Europe. Opinion has remained divided as to whether the entire flora and fauna was obliterated by the Pleistocene glaciations or if some elements represent relict populations which survived from interstadial, interglacial or even Tertiary times, in southern or maritime refugia (McCarthy, 1986). Any unglaciated areas, however, would have been very cold and it is likely that the fish fauna, and by extension crayfish, then occurring was destroyed (Varley, 1967).

of this decapod crustacean has indeed been effected by man.

The known distribution of crayfish in Ireland in the 20th century is well documented (Reynolds, 1982; Lucey and McGarrigle, 1987) so it need not concern present purposes and only those records of any interest from the 19th century and before will be used. The earliest reference to crayfish in Ireland, found during the search, was in a 17th-century topographical manuscript work wherein the English schoolmaster, traveller and antiquary Thomas Dingley (1680), also called Dyneley (Hayman, 1856-1857) and Dineley (Shirley, 1862), states unequivocally that they only then occurred in places to which they had been introduced from England:

The rivers, Pools called Loughs, & Ponds were never known to have these English Fish unless they were at times brought over, as Carpe, Tench, Gugeon, Perche nor Crayfish.

This reference, which has not hitherto been cited in the debate, is the single most important statement regarding the origin of crayfish in Ireland.

The next known references to crayfish are apparently not until the 18th century. The first of these, an entry in the diary/autobiography of Pole Cosby of Stradbally, refers to them having been introduced into ponds on his estate in Laois from another in Offaly in 1740 (Cosby, 1906-1908):²

The 10 of May 1740 Laurance Parsons Esq. Grandson to Sir Willm Parsons Baronet of Birr in the King's County sent me a present of 12 brace of fresh water craw fish, 3 brace of 'em died on y^e way, ye other nine brace I put into the Ponds of Grutnegoe.

We do not know when, nor from where, the crayfish were introduced into Birr Castle Demesne as there is no mention of them in the surviving Rosse MSS (Countess of Rosse, personal communication).

John Ruddy (1772) mentions their occurrence in Dublin, in ornamental ponds and in the Tolka River, to which, he says, they were introduced from Munster:

²This record was first brought to the author's notice through John Feehan's book on Laois (Feehan, 1983).

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It has been sometimes found in this County, chiefly in Gentlemen's ponds, and lately in the river near Finglass; but said to have been brought thither from Munster.

Towards the end of the century crayfish were evidently well established in the Nore and some of its tributaries in County Laois. For Edward Ledwich (1796), the then vicar of Aghaboe, writing on the Nore, Erkenny (now known as Erkina) and Gully noted, with no hint as to their having been introduced, that:

All these rivers abound in eel, trout, pike and crayfish.

We know that crayfish were in the Barrow and some of its tributaries by the beginning of the 19th century (Tighe, 1802):

The crawfish, *cancer astacus*, also lives in the Barrow and in some streams.

Crayfish were also well established in another tributary of the Barrow, the River Greese, in County Kildare by 1817 as a correspondent of William Thompson (1856), Dr Robert Ball who had been a schoolboy at Ballitore at the time, remembered:

When at school at Ballitore, in 1817, and in pursuit of fresh-water cray-fish, I many times captured what we (boys) called 'lamper eels';

The crayfish was obviously unknown to some in northern parts in the first quarter of the 19th century as the following evinces (Stephenson, 1825):

The lady of the late Arthur Upton introduced a stranger into our river, called crawfish; crefish; by the French crevice; by some, the fresh-water lobster; and by Linnæus, *astacus*. It was put into the brook in Templepatrick; it descended into the Sixmile Water, where it found a situation perfectly suited to its nature - deep water and banks of loam, which they excavate as lodgings for themselves and their young. They have increased to a very great multitude.

Thompson (1843a), however, says that he was reliably informed that they were present,

further upstream, in the same river at Templepatrick in 1794.

Humphreys (1845) recorded crayfish for Cork in the mid-19th century but gives no precise location; since then they have been reported from just one river in that county: the Awbeg, a tributary of the Blackwater (Reynolds, 1982; Lucey and McGarrigle, 1987).

In a treatise on European crayfish Gerstfeldt, writing in 1859, alluded to their having recently been brought into Ireland:

In Grossbritannien ist *Ast. fluv.* nicht sehr häufig, obwohl er in manchen Gegenden beobachtet wird und nach Irland ist er erst in neuerer Zeit eingeführt worden.³

What the author meant by recent times is perhaps open to question and could be construed as hundreds rather than just years for he cited, or else misinterpreted, Thompson (1843a) as his authority.⁴ Another German writer Ernst Friedel, writing from Berlin some twenty years later in 1878, however, speculated that crayfish were introduced at the end of the 18th century and had spread through the whole island before long:

Auch *Astacus fluviatilis* ist in Irland erst eingeführt, vermuthlich gegen Ende des vorigen Jahrhunderts, und daher noch lange nicht über die ganze Insel verbreitet, obwohl stellenweis nicht selten.

Patterson (1872) stated, apparently on the authority of Thompson, that:

The Cray-fish inhabits rivers in many parts of Ireland, but is generally stated to have been introduced.

What Thompson (1856) wrote on the matter, it appears, may have been misconstrued by

³This has been interpreted by Albrecht (1983) as meaning the beginning of the 19th century, viz. 'Nach GERSTFELDT (1859) wurden diese Flußkrebse in Irland zu Beginn des 19. Jahrhunderts ausgesetzt', which, as can be seen from what has gone before, is patently absurd.

⁴In relation to Great Britain, Gerstfeldt quotes Merrett (1667) as his source; this writer, however, gives no information on distribution of the 'crey fish' which he calls *Astacus fluviatilis*, thus predating the 'binominal nomenclature' of Linnaeus by almost a century.

others also (e.g. Praeger, 1950) because he meant by introduced into its 'recorded haunts from other quarters', other parts of the country:

A. fluviatilis, Edw.,

Inhabits the rivers in many parts of Ireland, but generally stated to have been introduced to its recorded haunts from other quarters. Thus, Ruddy in his Natural History of Dublin remarks, "It has been sometimes found in this country, chiefly in gentlemen's ponds, and lately in the river near Finglass; but said to have been brought thither from Munster".

He goes on to relate how he had witnessed the introduction of crayfish, from Kildare, into a pond near Belfast in 1840 and that they had been introduced to a part of Fermanagh from Laois. In his report to the British Association he uses four quarters N[orth], S[outh], E[ast] & W[est] (Thompson, 1843b) to describe the then known invertebrate fauna, including crayfish, distribution.

Knox (1875) writing on Down noted the absence of crayfish from that county:

The Cray Fish (*Astacus Fluviatilis*) is found in the rivers, in various parts of the Kingdom but I have not seen any account of its occurrence in this county.

In England, as well as the nobility and gentry who stocked the waters on their property, it was the fashion for Victorian naturalists also to release crayfish into local streams and ponds (Tattersall, 1920):

It seems to have been a regular custom of the local naturalists of this district some forty to fifty years ago to purchase living crayfish in the Manchester Market and turn them loose in the ponds, canals and reservoirs in the surrounding districts.

It is likely that a similar practice aided their diffusion in Ireland. In this context it is interesting to note that references to introductions from one part of the country to another, seem all to be from southern parts northwards: Munster to Dublin (Ruddy, 1772); Laois to Fermanagh and Kildare to Antrim (Thompson, 1856). In Britain the same pattern of dissemination is also apparent; for example, from southern England to Yorkshire in the 17th and 18th centuries (Fuller, 1662; Thomas and Ingle, 1971).

By the end of the 19th century crayfish were known to be present in the following 17 counties: Antrim (Stephenson, 1825), Cavan (Thompson, 1856), Clare (Phillips, 1908), Cork (Humphreys, 1845), Donegal (NMI 216.1895, J. M. C. Holmes, personal communication), Dublin (Scharff, 1895), Fermanagh, September 1897 (NMI, J. M. C. Holmes, personal communication), Kildare (Thompson, 1856), Kilkenny (Tighe, 1802), Laois (Ledwich, 1796), Limerick (O'Brien, 1909), Longford (BM 1876.21, R. Ingle, personal communication), Monaghan (Templeton, 1836), Offaly (Cosby, 1906-08), Tipperary (Kendall, 1909), Tyrone (Thompson, 1856) and Wicklow (Phillips, 1908). In the twentieth century this has increased to a total of 27 counties (Reynolds, 1982; Lucey and McGarrigle, 1987).

There appears to be no specific word in the Irish language for crayfish and the earlier dictionaries make no mention of them. For example, in an Irish-English Dictionary (*Focloir Gaoidheilge-Shagsonach*) contained in his *Archæologia Britannica*, Edward Lhuyd (1707) includes words, *Gliomach* and *Gliomag*, for lobster but not for the crayfish. Names such as *crúbóg* (O'Hanlon and O'Leary, 1907) and *gliomach fionnuisce* (An Roinn Oideachais, 1978) that have been applied literally mean crab (or crab-fish) and freshwater lobster respectively; many rural people in Ireland still refer to crayfish as crabs or lobsters! Scharff (1916), in his survey of Irish names for invertebrates, found words applying to the marine crawfish (which is sometimes called the crayfish) but not to the freshwater crayfish. Gaelicized variations on crayfish, such as *crefish* (Stephenson, 1825) and *cráifisc* (de Bhaldráithe, 1959) have been used in the past and phonetically resemble the Old French words for crayfish, *crevisse* and *crevice*. Reynolds (1996) observed that while it appears to be native to Ireland or at least a long-standing resident, it is little known to most country people, and does not appear to figure in Irish folklore. Such factors merely serve to add to the evidence regarding its non-native status.

The most likely date for the first introduction of crayfish into Ireland is sometime in the 400-year period between the 13th and 16th centuries with the most probable date later rather than sooner. If crayfish were to have been brought by the Norman conquerors then it would be imagined, a priori, that the more delicate-tasting species *Astacus astacus* (L.) now used for food in, among other places, France and some of the countries of Scandinavia, would have been preferred; it appears, however, that *A. astacus* may have only been introduced into France relatively recently (Albrecht, 1983). When Henry II came to Ireland, in 1171, he entertained

some of the native nobles at a banquet in Dublin that Christmas 'with all the ostentation for which the luxurious Normans were remarkable. Among the foreign dishes said to have been here used for the first time in Ireland, special mention is made of crane's flesh, which, as well as that of peacocks, herons, swans, and wild geese, was then esteemed a choice luxury in France' (Gilbert, 1865). Crayfish may not have been used as a food item by the Anglo-Normans but some type of crayfish was, evidently, eaten in later times such as at the lavish feast held at Kenilworth Castle, in 1575, to honour Queen Elizabeth (Furnivall, 1890).⁵

It is about this time or shortly thereafter that crayfish were most likely to have been introduced to Ireland. The two countries were then very closely linked, through the intercourse between the larger island and its colony, by the constant traffic of officials, soldiers and settlers. In the south, for example, Walter Raleigh (1554-1618) had fought, as a captain, in the wars in Munster (1579-1583) and owned a house in Youghal and a castle at Lismore on the River Blackwater. He settled his lands and adjoining areas with people from the English west country and undoubtedly first introduced the potato into Ireland, from Virginia, about the year 1601 or 1602 when he planted it in his garden at Youghal⁶ from whence it gradually spread over the entire country (Anon., 1854); he also planted myrtles, bays and arbutus in the same garden (Hayman, 1856-1857). He owned the salmon fisheries of the Blackwater and introduced cherry trees, walnuts (Freeman, 1950) and other exotic species, including a yellow wallflower from the Azores (Winton, 1975), to his Lismore estate. It is interesting to note that the Awbeg, a tributary of the Blackwater, is the only river in Cork known to contain crayfish; many rivers in that county are deficient in lime and thus incapable of supporting a species with a high demand for calcium carbonate to replace an exoskeleton that must be shed and rebuilt often to

⁵A contemporary account, by Robert Laneham, of the entertainments at Kenilworth lists, 'Coonger, Burt, Mullet, fresh Herring, Oysters, Samon, Crevis, and such like, from Neptunus, God of the Sea', as being served up. The crayfish mentioned here, however, may as the writer indicates have referred to the marine species, i.e. the crawfish.

⁶In the arbour of the same garden he is said to have smoked the first tobacco brought into Ireland (Townshend, 1904).

attain growth. Edmund Spenser (1552-1599),⁷ who lived at Kilcolman Castle near Buttevant, writes about the river, which he calls Mulla⁸ in his poetry and which he derived from Kilnemullah (or more correctly *Cill-na-mullach*) the old name for Buttevant (Joyce, 1911). Spenser and Raleigh were in Ireland during the same time and visited each other discussing their poetry and apparently walked together along the River Blackwater in such conversations (Winton, 1975). In the 18th century we are told, by Ruttly (1772), that crayfish were introduced into the Dublin area (River Tolka) from Munster and it could be that they came from this river. Another Elizabethan adventurer, Richard Boyle, who purchased Raleigh's estates for £1,000 in 1602 (Williams, 1988), is said to have first introduced carp into Ireland (Went, 1950) and we know from one of his letters, written from Dublin in 1634, that this fish was among the food taken on special occasions, such as Christmas, at his country home, Lismore Castle (Townshend, 1904). It would not be unreasonable to conjecture that crayfish may have been introduced into Ireland about the same time as carp, perhaps also for the table but most likely primarily for stocking in ornamental ponds. If crayfish were introduced, or escaped from a pond, into the Blackwater they might have gravitated to the Awbeg which appears to be one of the few suitable habitats for the crayfish's ecological requirements within the catchment. They could, of course, have been introduced directly into the Awbeg or found their way there from a pond on the Kilcolman Castle estate which is all merely conjecture and is given here to provide circumstantial evidence for the case. The foregoing is only one of a number of possible hypotheses regarding the implanting of crayfish in Ireland. Many people, known or unknown to us through history, could have brought crayfish and another possible candidate, who falls into the former category, is Barnabe Googe or Goche (1540-1594) the English poet and translator who was in Ireland from 1574 to 1585. He would have been aware of river crayfish, for in his translation of Kirchmayer's *Popish Kingdome* they are mentioned (Googe, 1570):

⁷Spenser came to Dublin in 1580, as secretary to the newly appointed Governor, and moved to Munster about eight years later (Berger, 1968).

⁸While he refers to trout and pike in the Awbeg (Mulla), in *Epithalamion* (Stanza 4, lines 2-3), Spenser makes no mention of crayfish in his poetry.

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Through which some pleasant river ranne, or goodly streame did passe
That stoared with divers daintie fishe, and full of Crevis was,

He does not, however, mention them in relation to Ireland in his correspondence⁹ with William Cecil (i.e. Lord Burghley, the Lord Treasurer of England) by whom he was employed as Provost Marshal of the Presidency Court of Connaught.

We know that crayfish were in ponds, the lake or Little Brosna River in the grounds of Birr Castle in the first half of the 18th century but cannot be sure when, by whom and from where they were introduced. Regarding the latter, however, somewhere in Munster is the most likely source: the Dublin crayfish were said by Ruty to have come from there in the same century. There is a link between the Parsons' family of Birr and Walter Raleigh's former house in Youghal when owned by Richard Boyle. When Sir Laurence Parsons, Attorney-General for the province of Munster, was appointed Recorder for Youghal in 1616 he took this house from the Earl of Cork for a residence. It was known afterwards as Sir Laurence Parsons' House even after it was conveyed to another in 1661 by his grandson of the same name (Hayman, 1856-1857).

Crayfish, so far as the present writer could ascertain, appear not to be mentioned in writings on Ireland prior to the 17th century. For instance, Giraldus Cambrensis, who visited Ireland in 1185 and who although liable to make fabulous statements regarding Irish people and places is generally reliable regarding its fish and other fauna, makes no mention of crayfish (e.g. Dimock, 1867; O'Meara, 1951). From letters patent issued in 1375,¹⁰ in the reign of Edward III, we know that Norman families in Kilkenny bought lampreys as food during the 14th century (Ledwich, 1781); these people were really of Anglo-Norman descent who evidently

⁹Some of which were preserved among the *State Papers* (Hamilton, 1867). Commenting on the lack of information in his letters, compared with that of other correspondents, Pinkerton (1863) has observed: 'Mere rude soldiers write to him [i.e. Cecil] of the natural aspects and productions of Ireland - the customs and family history of its people; yet Googe alludes to none of these. Many of his letters, however, have not been preserved, and those may have been the most interesting'.

¹⁰These list an inventory of food sold with the tolls, for upkeep of the city walls in Kilkenny, levied on each item.

maintained aspects of their traditional cuisine which also included the purchase of leeks for their *porrée*. There is no evidence that crayfish, unlike the lampreys, were readily available from the rivers at that time and there appears to be no trace of a culinary fashion for crayfish in Ireland until a much later date. In the late 19th century, for example, they were 'occasionally imported from abroad to be ground down for the famous "*soupe d'ecrevisses*" a dish greatly esteemed by connoisseurs' (Scharff, 1895). Earlier in the same century Stephenson (1825) intimated that crayfish were then eaten in Ireland, viz. 'By some it is preferred to the common crab'. Thompson (1856) also mentions them having been brought from Dublin to be eaten in the north, in Antrim, in the middle of that century. It is likely that they were exploited, by the poorer people, during the Famine (1845-1852) when rivers and lakes were intensively fished for food (McHugh, 1994).

There is no evidence to suggest that crayfish were present in pre-Norman Ireland. They could, of course, have been introduced by the monastic orders but there appears to be no literary reference to them before the 17th century. Apart from that of Dingley (1680) references to crayfish in other 17th-century works, particularly those relating to natural history in Ireland, are either very rare or do not exist and were not discovered in the study. Philip O'Sullivan Beare (*circa* 1630), for example, does not include crayfish, or indeed crawfish, in his list of fauna while other crustaceans such as lobster and crab are cited.¹¹ Neither are they mentioned in the surviving MSS among the Molyneux Papers¹² (1680s) nor other 17th-century manuscripts relating to the natural history of Ireland¹³ (e.g. Anon., *circa* 1710). Whereas other elements of the freshwater biota, such as mussels and lampreys, feature among the papers or minutes of the

¹¹Philip O'Sullivan Beare left his native area, the Bantry and Beara region of west Cork, where crayfish are not found, at an early age. After the defeat of the Irish armies at Kinsale he, like many of the Gaelic order, was sent to Spain in 1602 when aged about 12 years. Because he never returned his first-hand knowledge of the Irish fauna would be very limited and his list is likely to have been compiled with the help of family and teachers who later joined him in exile.

¹²Thomas and William Molyneux were founders of the Dublin Philosophical Society and the latter its first secretary in 1683.

¹³The Molyneux Papers as well as other 17th-century works relating to natural history in Ireland were transcribed about 1710.

Dublin Philosophical Society (1683-87) crayfish do not. In this connection it is worth noting that one species of each of these was at that time exploited respectively for pearls and food. If crayfish had been used as a food item in Ireland in the 17th century then, almost certainly, they would have received more attention from contemporary writers. While some fish species are mentioned in accounts which have traced the food of the ancient or early Irish, crayfish most definitely are not (e.g. Anon., 1854; Sullivan, 1873; Joyce, 1903; Lucas, 1960).

Dr Robert Scharff (1907), who was Keeper of the then Natural History Collections in the Dublin Museum of Science and Art, gave his theory of the origin of European and Irish crayfish as follows:

It seems to me that the original European form was not *Potamobius pallipes* but *P. torrentium* found in the Alps. This may have sent an offshoot into France when the Alpine area became connected with that country, and thus have developed the characters of our western *P. pallipes*. The latter extended its range from there westward to Spain and Ireland and southward to Italy, Dalmatia and Greece.

Scharff's account of the crayfish's *fons et origo* appears to be loosely based upon, and therefore repeating, a theory put forward by Thomas Huxley (1880) in his classic work on the crayfish more than a quarter of a century earlier. The only criticism that might be levelled at Huxley's biogeographical reasoning is that, because of the lack of direct evidence, he would not countenance that they had been purposely introduced by human agency 'but existed in Britain while it was still continuous with western Europe'.

According to Huxley (1880) there was no proof of the occurrence of British crayfish in the fossil state and he makes no mention of the *Astacus? multicavatus* cited by Woodward (1877) as found, in Speeton clay, at Speeton in Yorkshire. At the British Association meeting, held in Dublin during August 1835, an interesting notice titled 'On British Fossil Astacidae' by J. Phillips appeared; the notice informs the reader that 'Results will be given in the next volume of Transactions' (British Association, 1836) but never subsequently appeared. This, had it been published, would surely have shed some light on the antiquity of crayfish in the British Isles although the reason for its omission, from the published proceedings, is likely to have been due to lack of information because of the absence of crayfish from the fossil record.

Apparently crayfish were absent from many parts of Europe, including the British Isles,

immediately post-Pleistocene (Albrecht, 1983). Mitochondrial DNA (mtDNA) studies, which provide greater resolution than protein electrophoresis, have shown no genetic difference between British and French populations of *A. pallipes*. This absence of detected genetic differentiation supports the hypothesis that British stock had a French origin and that sufficient time had not elapsed to affect homogeneity thus possibly indicating that the former may have been introduced from the latter relatively recently (Grandjean *et al.*, 1997). Albrecht (1983) does not rule out the possibility that *A. pallipes* could have reached England naturally through a post-glacial stream connection with France. A low level of genetic heterozygosity, based on enzymatic polymorphism, has also been found between a north-eastern French and Irish population (Attard and Vianet, 1985); the genetic distance found in the study distinguished these from a southern population group (south-eastern France and Corsica).

The fact that the word crevice, as well as crayfish, was still in use in England in the 16th century,¹⁴ e.g. William Harrison refers to both crevices [*sic*] and crayfish (Holinshed, 1587), would indicate that they did originate in France in the then not too distant past. The two names were still in use down to the late 17th century as can be seen from Plot (1686) referring to them by crevice. It would appear that the modern English name is derived from the Old French *crevice*¹⁵ or *crevisse*, of which the modern designation is *écrevisse* (Anon., 1932; Mansion, 1980), despite Huxley (1880) patriotically, albeit vainly, attempting to make a case for its Anglo-Saxon etymology.¹⁶ In fact the evolution of the word can be seen in the literature: from *crevis* (Russell, *circa* 1460), in the 15th century, to *crevisse* (Levins, 1570) or *crevice* (Holinshed, 1587), in the 16th century, through *crevish* (Fuller, 1662) and then *crey fish* (Merrett, 1667), in the 17th century, to *crayfish* thereafter. The second syllable had obviously been confused with *vish* ⇒ fish, thus giving the modern appellation.

The earliest reference to crayfish in Ireland is, as we have seen, in the 1675-80 period, during a tour undertaken by Thomas Dingley (1680). It could be inferred from his comments that they

¹⁴Peter Levins (1570) lists *crevisse*, but not *crayfish*, in his rhyming English dictionary.

¹⁵According to the *Oxford English Dictionary* (Fowler and Fowler, 1959) this was also a Middle English (1200-1500) word, i.e. in use after the Norman Conquest.

¹⁶No Anglo-Saxon word apparently existed for the *crayfish* (e.g. Toller and Cambell, 1980).

were not introduced in living memory which would bring us to the late 16th century.

Holinshed's Chronicles were published about that time and those relating to Ireland, compiled mainly by Richard Stanyhurst, make no mention of crayfish (Holinshed, 1577, 1587) while the English ones, contributed to by William Harrison do, wherein it is said they were plentiful (Holinshed, 1587):¹⁷

As for the little crayfishes they are not taken in the sea, but plentifulle in our fresh rivers in banks, and under stones, where they keep themselves in most secret maner, and oft, by likenesse of colour with the stones among which they lie, deceive even the skilfull takers of them except they use great diligence.

Thus it would appear that they were well established in southern English rivers by the last quarter of the 16th century. The present study would point to a date of introduction of crayfish to Ireland sometime in the 100-year period between the 1560s and the 1660s. Because of what is implicit in Dingley's remarks,¹⁸ during his tour of 1675-80, this can be narrowed down even more and a time-frame of somewhere in the period *circa* 1580-1620 may be deduced. They might have first been brought into Munster, during the wars or shortly afterwards in the plantation of that province (*post* 1585), for use in 'gentlemen's ponds' from which they may have spread to rivers and other water bodies aided in their subsequent diffusion by man. There can be little doubt that the the recently completed canals greatly facilitated their rapid dispersal early in the 19th century.

¹⁷Although these chronicle historical affairs, in the main, they also contain descriptions of England, Ireland and Scotland. Stanyhurst is somewhat disappointing in his description of the country's flora and fauna which lacks Harrison's detail regarding England. As Lennon (1981) points out there is no systematic arrangement in his account of the species of birds, animals and plants which he had seen in Ireland but rather a haphazard and impressionistic order which is surprising since he later achieved a reputation for his scientific pursuits.

¹⁸It is interesting to note that Dingley (1680) does not include pike among the fish that had been brought over from England. They had by then apparently been resident for at least some 200 years as they are mentioned as having been exported from Ireland in the late 15th and early 16th centuries (Longfield, 1929).

From the foregoing we have direct evidence, from a reliable 17th-century source, of the introduction of crayfish into Ireland but cannot arrive at a definite date although the circumstantial evidence would point to a particular period. Thus, the sequence of events in the chronology of crayfish in Ireland, may be summarized as having been introduced in the late 16th or early 17th century, by the colonial gentry, for stocking in ornamental ponds and perhaps also for cultivation as a food item, spreading thereafter by artificial and natural means culminating in their present wide distribution in the 400-year interval. On the evidence presented here it would appear that crayfish were first introduced into England, from French stock, whose progeny were later implanted in Ireland. Thus, it might be concluded that like a proportion of its human population Ireland's crayfish could be said to be of Anglo-Norman descent.

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OBITUARY: CARMEL F. HUMPHRIES PH.D., D.SC., R.I.A. (1909-1986)

A native of Waterford, Carmel Humphries entered the Faculty of Science at University College Dublin in 1929. She graduated in 1932 with a B.Sc honours degree in Botany and Zoology, having won several scholarships in her undergraduate years. In 1933 she gained the M.Sc. degree and was awarded the prestigious Travelling Studentship in Zoology from the National University of Ireland. She then commenced research on the benthic fauna of lakes in the English Lake District, in the laboratories of the Freshwater Biological Association at Wray Castle, Ambleside, on the shores of Lake Windermere. Working with Winifred Frost, T. T. Macan and H. P. Moon, she developed an interest in the taxonomically difficult group of dipteran insects, the Chironomidae, which was to dominate her later research life. She subsequently pursued research in Germany under the guidance of August Thienemann at the Hydrobiologische Anstalt der Kaiser Wilhelm Gesellschaft, Plön, in Schleswig Holstein. At Thienemann's suggestion, Carmel Humphries undertook the first comprehensive work based on collections of pupal exuviae on the community composition and emergence periods of the Chironomidae of the Grosser Plöner See. While in Plön, she had regular contact with other doyens of limnology and chironomid research including Lenz, Uttermohl, Ohle and Goetghebuer. This period immediately prior to the Second World War had a profound influence on Carmel Humphries. In later years she often reminisced (to DM in whom she instilled an enthusiasm for Chironomidae) as she sat at the microscope with a cigarette at one corner of her lip, about how she would row across the flat calm lake in early morning mists towing a plankton net behind the boat skimming the lake surface to collect exuviae of the insects which had emerged during the previous night. It was obvious that this was a formative period in her career, which she relished with enthusiasm. She admired and spoke fondly of Thienemann, that he would marvel at her almost photographic memory and ability to recognise and retain special taxonomic features - a gift she retained for many years. Strangely, like Thienemann, she did not study the adult Chironomidae but concentrated on the larval and pupal stages. Adults were always sent either to Goetghebuer in Ghent or to F. W. Edwards in the British Museum (Natural History), London. On her return to Ireland, she worked with Winifred Frost on the fauna of the River Liffey and was awarded the Ph.D. degree on published work in 1938. She

gained the D.Sc. in 1952. She lectured in the Queen's University Belfast and in University College Galway before her appointment as Assistant in the Department of Zoology in University College Dublin in 1947. In 1957, she succeeded Professor James Bayley-Butler to the Chair of Zoology at University College Dublin. She was elected member of the Royal Irish Academy in 1950 and served on several of its committees and those of the Royal Dublin Society. She was also a member of the Board of Visitors of the National Museum of Ireland, representing the Royal Dublin Society. Professor Humphries was the last zoologist to be appointed to this Board. She was very interested in the Natural History Museum and its collections. Indeed, the then Keeper, Dr Colm E. O'Riordan, had studied under her and JPOC became the Museum's entomologist on her advice. She had a high prominence in the U.C.D. Womens Graduates' Association.

While Professor at U.C.D., she initiated studies on the Irish Chironomidae and was actively involved in directing postgraduate students in a number of research projects. She also encouraged ecological and taxonomic work on freshwater Trichoptera, Ephemeroptera, Acari, and groundwater niphargid Crustacea and on the Irish Marine Fauna. Under her direction, the Department of Zoology produced a steady line of graduates, including the authors. She was a formidable figure while lecturing and enjoyed greatly the foot stamping and cheering from her Agricultural and Science students which, not infrequently, resounded through the College of Science (now Government Buildings) following some of her very pertinent biological quips. She boasted about being ambidextrous but it was often difficult for students to decipher what she had written on the blackboard with either hand! She was a member and Irish National Representative of *Societas Internationalis Limnologiae*. She oversaw the move of the Zoology Department from the College of Science, Merrion Street, to Belfield in the mid 1960's and the establishment of an active Limnology Unit. Carmel Humphries retired in 1979, 50 years after she first entered UCD. Failing health and eyesight hindered her enjoyment of retirement and she died in 1986.

One of her lasting achievements was her genuine interest in promoting taxonomy and entomology. As a token of esteem, her name was given to the chironomid species *Zalutschia humphriesiae* Dowling et Murray, by two of her former students.

Carmel Humphries endured diabetes throughout her life. Occasional unpredictable behaviour

and volatility antagonised a number of her peers and students, from time to time creating stormy scenes which, however, disguised her basically kind and generous nature and were usually followed by an apology. A short bibliography of her chironomid work is given below.

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**A CATALOGUE OF THE IRISH BRACONIDAE (HYMENOPTERA:
ICHNEUMONOIDEA):** for further details please see overleaf.

**A CATALOGUE OF THE IRISH BRACONIDAE
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A CATALOGUE OF THE IRISH BRACONIDAE

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Occasional publication of the Irish Biogeographical Society, number 4. Published 21 May 1999. 123 pages. Four colour plates. ISBN 0-9511514-3-6. Price £5.00 (Sterling or Irish Pounds, including postage). Copies of this publication may be obtained by writing to:- The Irish Biogeographical Society, c/o Dr J. P. O'Connor, National Museum of Ireland, Kildare Street, Dublin 2, Ireland.

The Braconidae is one of the largest families in the Hymenoptera and there are at least 40,000 described species worldwide. The majority are small, active, inconspicuous insects, black brown or orangish in colour. Virtually, all are primary parasitoids of other insects. The Irish braconid fauna is reviewed in the catalogue and a checklist provided. A total of 529 species are reported from Ireland, including nineteen new to the island. The present work provides detailed information on the Irish fauna and is a contribution towards a future checklist of the Irish Hymenoptera (Nash, O'Connor *et alia*, in preparation).

Previous to the compilation of the present catalogue, the literature on the Irish Braconidae was so scattered that it was very difficult to study this important group of Irish insects. Based mainly on the published literature, full data are given where available for each species including distributions, flight periods and hosts. Synonyms are included. There is a comprehensive index. The work also contains superb figures of braconids by Dr C. van Achterberg and four colour plates of braconids reproduced from *British Entomology* (1823-1840) by John Curtis. It is dedicated to the memory of Ireland's greatest braconid expert: Alexander Henry Haliday (1806-1870).

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BOOK REVIEW

PLANT CRIB 1998 by T. C. G. Rich and A. C. Jermy. Published by the Botanical Society of the British Isles. 1998. ISBN 0 901 158 28 3. Price £20.50 Sterling (including postage and packing). Softback. 400 pages (A4). Available from BSBI Publications, Green Acre, Wood Lane, Oundle, Peterborough, PE8 5TP, England.

Plant Crib 1998 is intended as a guide to the identification and recording of plants for the BSBI Atlas 2000 project. This said, it is an indispensable addition to the library of any serious field botanist, who will already be familiar with its predecessors i.e. *Plant Crib* by Rich and Rich (1988) and *Guide to the Identification of some Difficult Plant Groups* by Wigginton and Graham (1981). *Plant Crib 1998*, while incorporating the information in the aforesaid, also contains much additional new information.

Plant Crib 1998 does not cover the complete Irish and British flora. Rather it is intended to augment Stace's *New Flora of the British Isles* (1991, 1997), Webb *et al.* *An Irish Flora* (1996) and BSBI Handbooks on plant identification. The authorship changes throughout the text, the individual plant accounts being compiled by experts in the particular plant group. Some 325 taxonomic groups are covered in all, with contributions by nearly 150 different authors. These accounts concentrate on the elucidation of distinguishing features between species, and their hybrids and subspecies, of difficult taxonomic groups. These features are often presented in tabular form. Keys, where included, are generally dichotomous, but there is some treatment by multivariant access. Clear line diagrams of salient features are much in evidence, with occasional use of silhouette illustrations. The accounts include notes on field features required for identification, and the collecting and preservation methods necessary for expert determination by the panel of BSBI referees. References to previously published material are given after each account. The text is self-contained i.e. the index does not send the user on a trail to other publications as did its predecessor, *Plant Crib*. Nomenclature throughout follows Stace.

There is no question but that this publication is an indispensable guide to the identification of difficult plant groups. It also plays the important role of heightening ones awareness of the existence of hybrids, subspecies and their distinguishing features. While not all identification

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problems are immediately solvable, this book goes a long way towards doing so. And where expert advice is necessary, there are clear guidelines as to material required. It is very much a book to be used, and I look forward to doing so while recording for Atlas 2000 during the coming field season.

MARGARET NORTON

BOOK NOTICES

Recent publications from Gem Publishing Company, Brightwood, Brightwell, Wallingford, Oxon OX10 0QD, England.

1. *The butterflies of Morocco, Algeria and Tunisia* by John Tennent.

This book is the first comprehensive work on the butterflies of the Maghreb since the turn of the century. The area is of great zoogeographic interest and supports a number of endemic butterflies.

282 x 210mm. 253pp including colour plates. Hardback with full colour dust jacket. ISBN 0 906802 05 9. Price £77.00 Sterling, overseas postage and packing £5.00 Sterling.

2. *Butterflies on British and Irish offshore islands* by Roger Dennis and Tim Shreeve.

This book presents a detailed treatment on the butterflies of Britain's and Ireland's offshore islands.

235 x 156mm. 143pp. Laminated limp colour cover. ISBN 0 906802 06 7. Price £16.00 Sterling, postage and packing in the United Kingdom - £1.00 Sterling, overseas - £1.60 Sterling.

3. *The moths and butterflies of Cornwall and the Isles of Scilly* by F. H. N. Smith.

The systematic list gives details of localities, dates and provenance for over 1500 species. 235 x 156mm. 448pp + 32pp colour photographs. Hardback colour cover. ISBN 0 906802 07 5. Price £44.00 Sterling, postage and packing in the United Kingdom - £3.00 Sterling, overseas - £4.50 Sterling.

4. *Handbook of Palearctic Macrolepidoptera. Volume I. Sesiidae - clearwing moths.*

The first volume covers all 309 species of this family presently known from the Palearctic region. The text has been prepared by an international team of five authors. Most species are illustrated by superb water-colour illustrations.

592pp, 487 colour illustrations. Casebound with colour jacket. ISBN 0 906802 08 3. Price £120.00 Sterling.

INSTRUCTIONS TO CONTRIBUTORS

1. Manuscripts should follow the format of articles in this *Bulletin*.
2. Manuscripts should be submitted as typed copy on A4 paper, using double-spacing and 2.5cm (1 inch) margins. Whenever possible, also submit the text on diskette. Wordperfect 5.1 is preferred.
3. Figures should be submitted in a size suitable for reduction to A5 without any loss of detail.
4. Records: please ensure that, when possible, the following information is incorporated in each record included in a manuscript:-
 - (a) latin name of organism.
 - (b) statement of reference work used as the source of nomenclature employed in the text. The describer's name should be also given when a zoological species is first mentioned in the text.
 - (c) locality details including at least a four figure Irish grid reference (e.g. N3946), county, vice-county number and some ecological data about the collection site, plus date of capture.
 - (d) collector's name and determiner's name (where different from collector's name), and
 - (e) altitude data should be included where relevant.
- (5). Manuscripts should be submitted to the Editor, Dr J. P. O'Connor, at the following address:- National Museum of Ireland, Kildare Street, Dublin 2, IRELAND.

NOTICES

**ROYAL IRISH ACADEMY
PRAEGER COMMITTEE FOR FIELD NATURAL HISTORY**
Millenium Grant Scheme

The Praeger Committee is pleased to announce a special Millenium Scheme of grants, up to a maximum of IR£1000 each for field work relevant to the natural history of Ireland, in the year 2000. Grantees need not be based in Ireland. Grantees need not be based in Ireland.

Applications are particularly welcome from amateur natural historians. Grants could be considered as a contribution to the cost of the project. Awards cannot be made in support of undergraduate or postgraduate student programmes, for school projects or for any part of the applicants' professional work.

Applicants should ensure that the proposed work, or work closely resembling the proposal, has not already been carried out in the same geographical area. A catalogue of previous Praeger reports can be accessed through the Academy Library.

A representative set of any material collected must be deposited in the National Museum, Dublin, or the National Herbarium, Dublin, or the Ulster Museum, Belfast or any other recognised institution in Ireland.

Application forms, which should be returned by **15th February**, are now available from:

*Sara Whelan,
Praeger Committee,
Royal Irish Academy,
19 Dawson Street,
Dublin 2,
IRELAND*



**IRISH
NATURALISTS' JOURNAL**

The *Irish Naturalists' Journal*, successor to the *Irish Naturalist*, commenced publication in 1925. The quarterly issues publish papers on all aspects of Irish natural history, including botany, ecology, geography, geology and zoology. The *Journal* also publishes distribution records, principally for cetaceans, fish, insects and plants, together with short notes and book reviews.

Current subscription rates for four issues (including postage) are – £IR15.00 (£14.00stg). Further details may be obtained from Ms Catherine Tyrie, Ulster Museum, Botanic Gardens, Belfast BT9 5AB.

