PHYSICO-CHEMICAL CHARACTERISTICS AND MACROINVERTEBRATE COMMUNITIES OF THE CAHER RIVER

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ABSTRACT

A study of the physico-chemical characteristics of the Caher River, Co. Clare, was carried out at two sites between October 1999 and April 2000. The Caher is an alkaline system with pH values in excess of 8.0. Phosphate and nitrogen concentrations showed no evidence of eutrophication. Conductivity values were at the lower end of the range expected for a limestone region. Calcium concentrations were relatively high, and precipitation of calcium carbonate was evident for much of the lower course of the river. However, other ions such as magnesium and potassium were present in low concentrations when compared to other limestone areas. A total of 80 macroinvertebrate taxa were recorded. The upstream site (Site 1) supported a more diverse community. The compacted nature of the substratum at Site 2, located downstream of Site 1, would restrict habitat availability and preclude the establishment of some interstitial dwelling fauna. The macroinvertebrates recorded in the Caher were, for the most part, fairly typical of clean-water rivers in Ireland, being represented by taxa that are relatively common throughout the island. One noteworthy exception was the unusually high abundance of the plecopteran *Dinocras cephalotes*. This predatory species is uncommon in Ireland and, even where it occurs, the numbers present are generally low. The Caher River, with its excellent water quality, has high ecological status, deserving special protection as a biodiversity refuge.

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INTRODUCTION

Most of the precipitation that falls on the Burren quickly disappears underground through swallow holes to carve extensive subterranean channels, emerging only occasionally before reaching the sea (Daly *et al.* 2000). The area has several dry valleys, such as the Ballyvaughan and Turlough valleys, that once carried rivers (Feehan 1991). Only one river, the Caher, remains above ground for its entire length, flowing on extensive deposits of glacial till that lie over the permeable limestone bedrock.

This paper examines the physico-chemical character of the Caher River and presents an inventory of the macroinvertebrate species occurring in the river. It also evaluates the communities present in the context of those occurring elsewhere in Ireland. The sites examined are included as part of a larger investigation of the macroinvertebrate communities of clean-water reference sites throughout Ireland currently being undertaken by the Zoology Department, University College Dublin. The ecological integrity of the Caher River is also considered, based on the macroinvertebrate Environmental Protection Agency Q-value system (Flanagan and Toner 1972; McGarrigle and Lucey 1983) and the family-level British Biological Monitoring Working Party (BMWP) biotic index (as described in Extence *et al.* (1987)). Three sites located along the Caher have been sampled by the Environment Protection Agency since the 1980s.

MATERIALS AND METHODS

STUDY SITES

The Caher is a relatively short river, approximately 6.5km long. It rises 150m above sea level immediately south of Caherbullog (M171049), flows in a north-westerly direction and enters the sea at Fanore Strand. For most of its course the river has a relatively shallow gradient (1%). However, in the final 2km stretch the gradient is steeper (4%), and flow is visibly faster. The river has no tributary streams until it meets a short stream (approximately 1km long), which converges with the river near Fanore Bridge. Both continue to the sea as the Murroogh River.

Land cover for the catchment as a whole is shown in Table 1 (derived from CORINE

Landcover database). The catchment is just over 2000ha in area, and almost half of this comprises bare rock. Some 12% is devoted to grassland farming on improved pastures and another 33% comprises natural grassland, mixed agriculture and natural vegetation plus transitional woodland scrub that equates approximately to 'rough grazing' land. The catchment has a large number of hazel trees. Coniferous plantations in the catchment comprised *c*. 50ha when the 1989–90 CORINE Landcover database was compiled. This figure might be expected to have increased significantly since then if the catchment has followed the general national trend of increased afforestation. Smaller areas of wetland and beach sand are also included in the overall catchment statistics. The upper section of the catchment is included in the Caher Valley Nature Reserve. The catchment generally is both a National Heritage Area (NHA) and a Special Area of Conservation (SAC) as part of an extended Burren protected area under the auspices of the Department of the Environment, Heritage and Local Government.

Thus, the land use in the Caher catchment is quite unusual by Irish standards, with only 12% devoted to moderately intensive grassland farming. For the island of Ireland, a GIS-based analysis by the authors of the 1990 CORINE Landcover database shows that over 56% of the land surface is devoted to pasture and natural grasslands occupy a further 3%. The Caher catchment, as already mentioned, has a very low percentage of pasture (11.9%) and 27.8% natural grasslands (Table 1). Hydrometric area 28, Mal Bay in west Clare, which includes the Caher catchment, has 52.5% pasture and 6% natural grasslands. In contrast, Hydrometric area 24, located south of the Shannon Estuary has 91.5% of its area devoted to pasture, with 65% highly intensive grazing and a mere 0.7% classified as natural grassland.

Emergent and bankside plants included fool's watercress, *Apium nodiflorum*, water mint, *Mentha aquatica*, brooklime, *Veronica beccabunga*, and watercress, *Nasturtium aquaticum*, all of which are typical in Irish rivers in general. A nodular algal species, *Nostoc* sp., was present in the upper reaches of the river. It was, however, darker than the typical *Nostoc* and had quite a hard calcareous texture.

Two sites were chosen along the Caher River, located at approximately 2.5km (Site 1) and 5.0km (Site 2) from the river source. Site 1 was near Holywell, Co. Clare, (M173069) and was dominated by a loose cobble substratum with a relatively gentle flow of water. In contrast, Site 2, near Murroogh, (M153089) was boulder-strewn with a relatively fast flow. The substrate materials were compacted by deposits of calcium carbonate. The river at both sites was approximately 6m wide. At the time of sampling, water levels were low, averaging 15–20cm deep.

MACROINVERTEBRATE COLLECTION

Macroinvertebrate samples were collected using a three-minute multi-habitat kick sampling technique at each site in October 1999 and April 2000. Three replicate samples were taken at each site. The visible habitats, including riffles, glides, pools and margins, were sampled in proportion to their percentage occurrence at each site as described by Wright (1995). All macro-invertebrates were sorted and identified to the lowest possible taxon using Freshwater Biological Association taxonomic keys. Chironomid pupae and pupal exuviae were determined by reference to Langton (1991) and Sæther *et al.* (2000).

Table 1—Land cover in the Caher River catchment from the CORINE Landcover database (based on LANDSAT data from 1989–90).

CORINE Landcover code	*CORINE Landcover*	*Percentage of catchment*	*Area (ha)*
332	Bare rock	47.2	986
321	Natural grassland	27.8	580
231	Improved pasture	11.9	249
324	Transitional woodland–scrub	4.4	93
412	Peat bogs	2.3	48
312	Coniferous woodland	2.3	47
243	Mixed agriculture and natural vegetation	1.7	34
333	Sparsely vegetated areas	1.3	28
331	Beaches	0.9	20
322	Moors and heathlands	0.2	5
		100.0	2089

HYDROCHEMICAL COLLECTION

Water samples were also collected at each site in October 1999 and April 2000. The samples were analysed for a range of chemical parameters using the methods listed in Table 2. Estimates of non-marine ion concentrations were also calculated for calcium, magnesium, sodium, potassium and sulphate according to their ratio to the chloride concentration in the sample, using their ratio in seawater as a baseline (Allott *et al.* 1990). The average composition of seawater was taken from Davis (1977).

RESULTS

CHEMICAL CHARACTER

The Caher is an alkaline system with pH values in excess of 8.0 and medium alkalinity figures of 74–75mg l^{-1} $CaCO_3$ (Table 3). Phosphate and nitrogen concentrations indicated that both sites were clean with no evidence of eutrophication. Conductivity values were at the lower end of the range expected for a limestone region. Calcium concentrations were relatively high (38–57mg l^{-1} Ca) and precipitation of calcium carbonate was evident at Site 2 and for much of the lower course of this river. However, other ions such as magnesium (max. = 2.29mg l^{-1} Mg) and potassium (<1.0 mg l^{-1} K) were present in low concentrations when compared to other limestone areas. For example, the Unshin River, Co. Sligo, exhibits a similar conductivity range to the Caher, but its magnesium concentrations vary along a longitudinal gradient from 4mg l^{-1} to 6mg l^{-1} and its potassium concentrations are almost twice those recorded in the Caher (Bradley 2001). Furthermore, over 60% of the magnesium and 90% of both the sulphate and sodium in the Caher were marine derived (Table 4).

MACROINVERTEBRATE COMMUNITIES

A total of 80 macroinvertebrate taxa were recorded (Table 5). Site 1 supported a more diverse community. The compacted nature of the substrate at Site 2 restricted habitat availability and precluded the establishment of some interstitial dwelling fauna. As expected, the April collection yielded a greater number of taxa than did the autumn samples. The difference was most pronounced at Site 1, where 58 taxa were encountered in April as opposed to 45 in October. A higher diversity of Trichoptera and Chironomidae in the spring largely accounted for these seasonal differences.

The community was dominated by insect larvae ($>88\%$) (Table 6). The paucity of fine-grained substrates at both sites and the occurrence of compacted substrates at Site 2 limited the abundance of the burrowing fauna. Epilithic chironomid larvae dominated this habitat with small numbers of Oligochaeta.

The ephemeropteran fauna was not particularly diverse, which is typical of river stretches with medium flow conditions (Kelly-Quinn and Bracken 2000). Six taxa were recorded, but *Baetis rhodani* (Pictet) predominated,

Table 2—Standard methods used for hydrochemical analysis.

Parameter	*Units*	*Method*
Temperature	°C	Thermistor
pH	pH	Electrometric
Conductivity	$\mu S\ cm^{-1}$ @25°C	Electrometric
Alkalinity	mg $CaCO_3$ l^{-1}	Acid titration method
Total hardness	mg $CaCO_3$ l^{-1}	Spectroscopy
Dissolved oxygen	mg l^{-1} O_2	Electrometric
Oxygen saturation	% Sat.	Electrometric
Chloride	mg Cl l^{-1}	Ion chromatography
Sulphate	mg SO_4 l^{-1}	Ion chromatography
Potassium	mg K l^{-1}	Atomic absorption
Sodium	mg Na l^{-1}	Atomic absorption
Calcium	mg Ca l^{-1}	Atomic absorption
Magnesium	mg Mg l^{-1}	Atomic absorption
Phosphate	µg P l^{-1}	Colorimetry
Ammonia	µg N l^{-1}	Colorimetry
Nitrate	mg N l^{-1}	Ion chromatography
Nitrite	µg N l^{-1}	Colorimetry

Table 3—Hydrochemical character of the Caher River.

Parameter	*Site 1*			*Site 2*		
	Mean	*Min.*	*Max.*	*Mean*	*Min.*	*Max.*
Temperature (°C)	11.4	11.1	11.7	11.2	11.2	11.2
pH (pH)	8.29	8.27	8.30	8.34	8.28	8.40
Conductivity (μS cm^{-1})	442	428	456	424	399	449
Alkalinity (mg l^{-1} $CaCO_3$)	74.8	74.8	74.8	75	75	75
Total hardness (mg l^{-1} $CaCO_3$)	105.18	91.52	118.83	142.38	133.00	151.75
Dissolved oxygen (mg l^{-1} O_2)	11.1	10.5	11.6	10.4	9.9	10.8
Oxygen saturation (%)	105.5	100.0	111.0	96.0	90.0	102.0
Chloride (mg l^{-1} Cl)	12.16	12.16	12.16	17.83	17.83	17.83
Sulphate (mg l^{-1} SO_4)	2.29	2.29	2.29	2.67	2.67	2.67
Potassium (mg l^{-1} K)	0.84	0.80	0.89	0.84	0.82	0.87
Sodium (mg l^{-1} Na)	11.54	11.30	11.77	13.18	12.63	13.73
Calcium (mg l^{-1} Ca)	38.95	33.85	44.05	53.75	50.50	56.99
Magnesium (mg l^{-1} Mg)	1.92	1.70	2.15	2.00	1.70	2.30
Phosphate (μg P l^{-1})	—	<10	<10	—	<10	<10
Nitrite (μg N l^{-1})	—	<1	<1	—	<1	<1
Nitrate (mg N l^{-1})	—	1.4	—	—	2.0	—
Ammonia (μg N l^{-1})	—	<10	<10	—	<10	<10

together with small numbers of the flat-bodied Heptageniidae (*Ecdyonurus venosus* Fabricius) and Caeniidae (*Caenis rivulorum* Eaton). The group was numerically more abundant at Site 1.

A total of seventeen possible trichopteran taxa, representing eleven families, were recorded between the two sites (Table 5). *Hydropsyche siltalai* Dohler, *Lepidostoma hirtum* (Fabricius), *Metalype fragilis* (Pictet), *Sericostoma personatum* (Spence) and *Ithytrichia* spp were the most common larvae present. All but one of these occurred at Site 1. The diversity of Trichoptera and the number of individuals was greater at Site 1 during both sampling seasons. Only ten species were recorded at Site 2 from the combined seasonal data. The seven species absent from this site included *Philopotamus montanus* (Donovan), *Plectrocnemia conspersa* (Curtis), *Lype reducta* (Hagen) and *Agapetus fuscipes* Curtis. The other three were limnephilid larvae, *Chaetopteryx villosa* (Fabricius), *Halesus radiatus* (Curtis) and *Potamophylax cingulatus* (Stephens), which all prefer stony and weedy substrata (Wallace *et al*. 1990). *Rhyacophila munda* McLachlan, however, was present only at Site 2 in the spring.

The Plecoptera were represented by eight species from five families over the spring and autumn sampling periods (Table 5). Seven of these were common to both areas. The number of plecopteran individuals was again greater at Site 1. *Amphinemura sulcicollis* (Stephens) was the most abundant stonefly present at both sites on both sampling occasions. Others such as *Leuctra hippopus* Kempny, *Leuctra inermis* Kempny, and *Isoperla grammatica* (Poda) were found at both sites. *Chloroperla tripunctata* (Scopoli), an infrequent stonefly found in stony streams, also occurred in fair numbers at both sites (Costello 1988). *Siphlonoperla torrentium* (Pictet), which is often abundant in stony streams and has a preference for soft oligotrophic waters (Costello *et al*. 1984), was found in small numbers only at Site 1 in the

Table 4—Mean values for the non-marine ion content.

Mean values	*Site 1*	*Site 2*
Non-marine K (mg l^{-1})	0.65	0.46
(%)	72.88	56.57
Non-marine Na (mg l^{-1})	4.59	3.89
(%)	40.61	28.33
Non-marine Ca (mg l^{-1})	33.60	50.13
(%)	99.25	99.26
Non-marine Mg (mg l^{-1})	0.90	0.52
(%)	52.67	30.61
Non-marine SO_4 (mg l^{-1})	0.60	0.19
(%)	26.23	7.24
Non-marine hardness (mg l^{-1})	87.58	127.31
(%)	95.69	95.65

Table 5—Taxa recorded at Sites 1 and 2 of the Caher River.

			Site 1 27 Oct 1999	*Site 1* 29 Apr 2000	*Site 2* 27 Oct 1999	*Site 2* 29 Apr 2000
Gastropoda	Hydrobiidae	*Potamopyrgus antipodarum* (Gray)	0	0	0	1
	Planorbidae	*Gyraulus albus* (Muller)	1	0	0	0
	Lymneaidae	*Lymnaea peregra* (Muller)	5	3	1	0
	Zonitidae	Zonitidae indet.	0	3	0	0
Bivalvia	Sphaeriidae	Sphaeriidae indet.	0	5	0	0
Annelida	Oligochaeta	Oligochaeta indet.	28	75	35	134
Hirudinea	Glossiphoniidae	*Helobdella stagnalis* (L.)	4	3	0	0
Aranea	Acari	Hydracarina indet.	0	3	0	0
Crustacea	Gammariidae	*Gammarus duebeni* Lilljeborg	217	441	24	133
		Gammarus spp	14	3	0	2
Insecta		Collembola indet.	0	0	0	1
Ephemeroptera	Ephemerellidae	*Ephemerella ignita* (Poda)	0	15	1	40
	Baetidae	*Baetis rhodani* (Pictet)	344	744	133	236
		Baetis muticus (L.)	1	761	2	334
		Centroptilum luteolum (Muller)	0	3	0	0
	Heptageniidae	*Ecdyonurus venosus* (Fabricius)	3	11	0	4
		Ecdyonurus spp	26	63	5	22
	Caenidae	*Caenis rivulorum* Eaton	33	277	0	60
Plecoptera	Nemouridae	*Amphinemura sulcicollis* (Stephens)	270	485	73	148
		Protonemura meyeri (Pictet)	0	0	3	0
	Leuctridae	*Leuctra hippopus* Kempny	9	2	8	8
		Leuctra inermis Kempny	2	4	0	29
		Leuctra spp	0	3	0	1
	Perlodidae	*Isoperla grammatica* (Poda)	2	59	17	63
	Perlidae	*Dinocras cephalotes* (Curtis)	169	164	13	8
		Perlidae indet.	5	0	4	0
	Chloroperlidae	*Chloroperla tripunctata* (Scopoli)	0	41	0	31
		Siphlonoperla torrentium (Pictet)	3	0	0	0
		Chloroperlidae indet.	2	0	3	0
		Plecoptera indet.	0	1	0	0
Hemiptera	Velidae	*Velia* spp	0	1	0	0
Coleoptera	Elmidae	*Esolus parallelepipedus* (Muller)	6	12	7	104
		Elmis aenea (Muller)	563	734	698	1103
		Oulimnius tuberculatus (Muller)	0	0	17	11
		Limnius volckmari (Panzer)	3	5	0	12
	Hydraenidae	*Hydraena gracilis* Germar	5	10	8	23
	Gyrinidae	*Orectochilus villosus* (Muller)	4	5	0	0
	Helophoridae	*Helophorus* spp	1	0	0	0
	Scirtidae	*Elodes* spp	0	0	1	0
Trichoptera	Rhyacophilidae	*Rhyacophila dorsalis* (Curtis)	9	14	8	9
		Rhyacophila munda McLachan	0	0	0	1
		Rhyacophila spp	2	4	3	2
	Philopotamidae	*Philopotamus montanus* (Donovan)	6	0	0	0
	Polycentropodidae	*Plectrocnemia conspersa* (Curtis)	0	3	0	0
		Plectrocnemia spp	0	1	0	0
		Polycentropus flavomaculatus (Pictet)	7	2	0	4
		Polycentropus spp	3	0	0	0
		Polycentropodidae indet.	0	4	0	2

Table 5—(Continued).

			Site 1	Site 1	Site 2	Site 2
			27 Oct 1999	*29 Apr 2000*	*27 Oct 1999*	*29 Apr 2000*
	Psychomyiidae	*Metalype fragilis* (Pictet.)	78	103	3	1
		Lype reducta (Hagen)	0	1	0	0
	Hydropsychidae	*Hydropsyche siltalai* Dohler	56	88	62	46
		Hydropsychidae indet.	12	0	10	0
	Glossosomatidae	*Agapetus fuscipes* Curtis	16	35	0	0
	Goeridae	*Silo pallipes* (Fabricius)	0	11	0	6
		Goeridae indet.	0	1	0	0
	Hydroptilidae	*Ithytrichia* spp	58	174	7	4
		Hydroptilla spp	4	83	12	20
	Lepidostomatidae	*Lepidostoma hirtum* (Fabricius)	20	242	5	26
	Limnephilidae	*Chaetopteryx villosa* (Fabricius)	3	1	0	0
		Ecclisopteryx guttulata (Pictet)	0	0	0	0
		Halesus radiatus (Curtis)	0	1	0	0
		Potamophylax cingulatus (Stephens)	4	0	0	0
		Limnephilidae indet.	3	0	0	0
Trichoptera	Sericostomatidae	*Sericostoma personatum* (Spence)	27	125	3	13
		Trich. Indet. (Pupae)	24	0	0	0
Lepidoptera		Lepidoptera indet.	0	0	2	0
Diptera	Tipulidae	*Hexatoma* spp	1	1	0	0
		Pediciidae indet.	89	1	67	0
		Dicranota spp	0	24	0	2
		Antocha spp	87	156	1	3
	Dixidae	*Dixa* spp	0	0	1	0
	Ceratopogonidae	Ceratopogonidae	0	0	2	0
	Psychodidae	Psychodidae	70	80	0	63
	Stratiomyidae	Stratiomyidae	0	1	0	0
	Muscidae	Muscidae	28	25	24	7
	Empididae	Empididae	0	1	0	2
	Simuliidae	*Prosimulium latimucro* (Enderlein)	0	1	0	0
		Simulium spp	1	1	9	5
		Simuliidae Indent.	0	0	17	0
	Chironomidae	Tanypodinae indet.	19	48	6	48
		Potthastia gaedii (Meigen)	0	0	1	0
		Diamesinae indet.	2	0	0	0
		Prodiamesa spp	0	2	0	0
		Cricotopus (Cricotopus) trifascia Edwards	0	0	1	2
		Cricotopus (Isocladius) ? brevipalpis Kieffier	0	1	0	0
		Eukiefferiella coerulescens (Kieffier)	0	0	0	1
		Eukiefferiella dittmari Lehmann	5	0	0	1
		Eukiefferiella gracei (Edwards)	0	1	0	2
		Eukiefferiella spp	0	3	0	0
		Eukiefferiella Pe2 (Langton 1991)	0	0	0	1
		Orthocladius (Euorthocladius) rivicola Kieffier	0	0	13	0
		Orthocladius (Orthocladius) frigidus (Zetterstedt)	0	0	1	0
		Orthocladius (Orthocladius) rubicundus (Meigen)	4	4	6	3
		Parametriocnemus stylatus (Kieffier)	5	4	0	8
		Tvetenia calvescens (Edwards)	5	8	6	1
		Orthocladinae indet.	64	551	86	258

Table 5—(Continued).

		Site 1 27 Oct 1999	Site 1 29 Apr 2000	Site 2 27 Oct 1999	Site 2 29 Apr 2000
Chironomidae contd	Tribe *Chironomini* (indet. sp.)	0	1	0	0
	Polypedilum spp	0	1	0	1
	Micropsectra atrofasciata (Kieffier)	4	6	1	5
	Micropsectra spp	0	5	0	0
	Rheotanytarsus curtistylus (Goetghebuer)	0	1	0	0
	Chironominae indet.	45	50	6	12
	Chironomidae indet.	3	0	8	0
	Diptera indet.	4	15	12	29
Total no. of individuals		2482	5810	1435	3095
Total no. of taxa		45	58	39	47
Q-rating		Q_5	Q_5	Q_5	Q_5
BMWP score		174	186	149	168
ASPT score		6.44	6.64	6.77	7.00

autumn. *Protonemura meyeri* (Pictet), a widespread species in Ireland, was present only at Site 2 in the autumn. The most striking feature of the plecopteran fauna in the Caher was the high abundance of *Dinocras cephalotes* (Curtis), an uncommon perlid in Irish waters. This species constituted 38% of the plecopteran fauna in the autumn at the upstream site.

Aquatic beetles were poorly represented in the Caher sites. With the exception of *Elmis aenea*, numbers were low with average occurrence of less than fifty specimens in any one sample. The Elmidae predominated in the samples. *Orectochilus villosus* is the only species of this genus to occur in running water in Europe. Larvae, but no adults, were recorded from the Caher sites. This is not unusual because the adults are nocturnal and generally rest beneath stones or logs above the water in the daytime (Nilsson 1996). The larvae live under stones or in cushions of algae, gravel or mud but do not swim. They are carnivorous, and their preferred prey include chironomid larvae and oligochaetes. *Hydraena gracilis* was the only representative of the Hydraenidae. Most aquatic hydraenids prefer eutrophic waters with abundant vegetation (Hansen 1996). Species with a preference for running water are primarily found in the genus Hydraena spp.

Dipteran larvae were more abundant and diverse, particularly the Limnoniinae and Psychodidae (Table 5). Based on exuviae or mature pupae obtained, sixteen chironomid taxa were recognised in the material examined. They were dominated by representatives of the subfamily Orthocladiinae, typically regarded as rheophilic species. With the exception of a single specimen identified as *Eukiefferiella* pe2 from Langton (1991), all species recorded in this study have been previously found in Ireland (Ashe *et al*. 1998). Additional material is required to confirm the record of *Eukiefferiella* pe2, which is known from a stream in the Czech Republic (Langton 1991). Some species, such as *Eukiefferiella dittmari* and *Orthocladius frigidus* are more typical of upland headwaters, but others, such as *O. rubicundus*, are known to exhibit a wide adaptability, occurring from the krenal to potamal regions of lotic waters. The data obtained are too limited to infer seasonal or longitudinal distribution patterns.

Despite the high calcium content and relative abundance of aquatic plants, molluscs were scarce at both sites, with fewer than three taxa recorded and no more than five individuals of each present. The remainder of the fauna was represented by small numbers of annelids, mainly Oligochaeta and three specimens of the Hydracarina. Leeches were uncommon, and *Helobdella stagnalis* (L.) was the only species recorded (Site 1).

Application of EPA and BMWP bioindicator criteria to the faunal data yielded high quality ratings (Table 5). The Q-value (Q_5) and BMWP scores (149–186) clearly indicated a clean-water system. Water quality has always been excellent (Q_5), with pollution-sensitive taxa such as *Dinocras* and *Ecdyonurus* present in good numbers in all samples taken. Again, the presence of *Dinocras* has been the most striking element of the invertebrate fauna in all samples examined by the EPA since 1988.

DISCUSSION

The hydrochemical results highlight the major influence of the dissolution of calcium carbonate from the limestone on the chemical composition of the Caher River. The water is dominated by calcium ions and has surprisingly low concentrations of other ions such as magnesium and potassium. The waters of the Caher thus stand in marked contrast to other limestone rivers. The relatively thin soil overburden may be a factor limiting the availability of these ions. Calcification of the substratum was noticeable, with significant encrustations on the stones on the river bed. The substratum of rocks, stones and gravel was characterised by dramatic white calcareous deposits, with the result that the invertebrates are generally very pale-coloured. *Gammarus* and *Baetis* are particularly noticeable in this respect. The water is extremely clear with no obvious peat-staining. The perlid *Dinocras* specimens, however, were quite black in contrast, although frequently found with calcareous encrustations adhering to their exoskeleton.

Many of the rivers in the karst limestone area of south Galway and north Clare are temporary rivers with extended dry periods during the summer months. These rivers have a very limited fauna as a result and are typically characterised by Chironomidae and Simuliidae or other winged insects with short life cycles. The Caher River, however, is different in that it appears to have at least some water flowing even in relatively dry summers. Only once, in 1988, was there any indication that this lower section of the river may have come close to drying up completely: this was suggested by the macroinvertebrate diversity at Fanore Bridge (located downstream of Site 2).

In the present study, we found that the fauna and flora were diverse, relatively abundant and more characteristic of a permanent river. Indeed, the macroinvertebrates recorded in the Caher were for the most part fairly typical of clean-water rivers in Ireland, being represented by taxa that are relatively common throughout the island. One noteworthy exception was the unusually high abundance of *Dinocras cephalotes*. This predatory species is uncommon in Ireland—even where it occurs the numbers present are generally low. For example, it occurs in sections of the rivers Nier (Co. Waterford), Tar (Co. Waterford) and Owenmore (Co. Kerry). A maximum of 26 individuals of *D. cephalotes* were taken from three multi-habitat samples at these sites (Kelly-Quinn, unpublished data). At Site 1, in the Caher, over 50 individuals of this species could be encountered in one sample. In Britain *D. cephalotes* is also a relatively uncommon species, mainly found in May and June in rivers with stable rocky and stony substrata (Hynes 1993).

In general, the species assemblages of the Caher were fairly typical of the middle reaches of alkaline rivers in Ireland, where stony or cobble substrates predominate and medium conductivity values occur. Taxa such as *Rhithrogena semicolorata* (Curtis), typical of similar altitudinal locations in high gradient rivers (Kelly-Quinn and Bracken 2000), were absent. In terms of the Trichoptera, all species present are widespread in Ireland, with the exception of *Metalype fragilis* (Pictet) and *Lype reducta* (Hagen), both of the family Psychomyiidae. Their occurrence in the Caher is worth highlighting as both have limited records presently in Ireland (O'Connor 1987). Psychomyiids are usually scarce or absent in streams with soft or acidic waters (Edington and Hildrew 1995). The

Table 6—Percentage representation of the major taxonomic groups on the Caher River Sites 1 and 2 in October 1999 and April 2000.

	Site 1			*Site 2*			*Site 1*			*Site 2*		
	27 Oct 1999			*29 April 2000*			*27 Oct 1999*			*29 April 2000*		
	Total	*Mean*	*SD*	*Total*	*Mean*	*SD*	*Total*	*Mean*	*SD*	*Total*	*Mean*	*SD*
% Non insects	9.20	9.72	6.65	8.80	8.55	1.34	10.83	10.73	3.36	4.21	4.21	0.90
% Insects	90.73	90.47	6.55	92.11	92.48	1.80	89.33	89.43	3.20	96.63	96.71	1.72
% Ephemeroptera	32.17	32.44	3.23	22.69	21.59	4.72	16.38	16.06	6.76	9.90	12.81	7.60
% Plecoptera	13.03	12.72	3.63	9.39	9.30	1.56	18.60	18.62	5.50	8.50	6.62	4.87
% Hemiptera	0.02	0.02	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
% Coleoptera	13.15	13.15	2.76	40.85	41.62	3.22	23.43	22.87	9.46	51.33	53.31	8.14
% Trichoptera	15.33	15.14	2.89	4.37	4.58	0.87	13.37	13.35	1.94	7.94	7.35	1.69
% Diptera	17.03	17.00	2.69	14.80	15.40	4.08	17.55	18.53	17.03	18.82	16.53	10.05

hard water of the Caher may provide a more favourable environment.

The beetle species in the Caher also commonly occur in Irish rivers (Anderson *et al.* 1997). However, the aquatic beetles present have a number of characteristics in common: they cannot swim or are poor swimmers, and they are generally classified as clingers and crawlers (Klausnitzer 1996). Six of the seven aquatic species have a preference for the slow-flow conditions found in deep rivers and are typical around well-oxygenated river gravels and riffles (Foster *et al.* 1992). With the exception of the single specimen of Chironomidae identified as *Eukiefferiella pe2*, which warrants further study, all of the remaining taxa have been found elsewhere in Ireland.

Grazers and shredders were the principal feeding guilds of the macroinvertebrates recorded. Predators were represented by the Elmidae, Perlidae and Chloroperlidae. Filter feeders were poorly represented. Despite the fair abundance of aquatic flora, total macroinvertebrate numbers were lower than for other Irish limestone rivers. The compaction of the substrata by precipitation of calcium carbonate in the lower reaches may limit the production potential of the Caher.

Overall the aquatic community was indicative of clean-water conditions because of the high abundance of sensitive plecopteran and ephemeropteran species present. This translated into the high scores for both the EPA Q-value and BMWP index systems. These scores are based largely on family-level identification. The indicator potential of species has not been adequately explored for most taxonomic groups. The indicator value of chironomid taxa in lake typology has been long recognised. Their use as indicators of river water quality has not received the same detailed study. The increasing availability of taxonomic determination keys, which facilitates recognition of species level taxa based on pupal exuviae, will soon overcome this problem. The work by Moog (1995) is a significant advance in the effort to use individual species as indicators. However, the applicability of valency values presented by Moog for saprobity, biocoenotic regions and functional feeding guilds in Austrian waters has not yet been tested in Irish freshwater systems. It is striking that all of the chironomid species thus far identified from the Caher River may be assigned to the intermediate beta meso-saprobic category of Moog (1995) with known tolerances to slight or moderate enrichment, in contrast to the ecological assessment based on the EPA Q-value and BMWP scores indicating clean waters. None of the chironomid taxa recorded are unique to pristine waters. Clearly, the autecology of species in Ireland requires further attention.

The potential threat to the clean-water status of the Caher River is eutrophication. The EPA surveys have noted that, despite the relatively low flow rates, dissolved oxygen values have generally been high during daytime with supersaturation noted on every occasion, ranging from 104% to 113%. The saturation value of 113% was noted in August 2000 at a water temperature of 22°C. The night-time oxygen values are not known but may drop to a certain extent due to plant respiration. The presence of *Dinocras* and *Ecdyonurus*, however, suggests that nocturnal depletion in oxygen concentrations is never serious. Overall, the oxygen supersaturation figures suggest that the system is perhaps naturally quite rich in terms of plant productivity. It is likely that the oxygen production is primarily driven by the encrusting nodular photosynthetic cyanobacterial species *Nostoc*. This is also a nitrogen-fixing organism typical of wet depressions in the Burren (B. Osborne, pers. comm). It is unusually abundant in the upper reaches of the Caher and probably contributes significantly to the nutrient budget of the system. Interestingly, the nutrient levels were low in the water samples, perhaps indicating tight or finely balanced recycling processes. The system would, however, be particularly vulnerable to eutrophication. Further expansion of conifer plantations would not be recommended for a sensitive catchment such as the Caher nor, indeed, would increased intensification of agriculture, particularly if this was accompanied by drainage and application of nitrogen and phosphorus fertilisers.

Although no rare taxa and few uncommon species have been recorded to date in the Caher River, the value of the system lies in its diverse assemblage of common, clean-water species. With an ever-diminishing number of high-quality river sites remaining in Ireland and western Europe generally, the Caher River is something special—a river with the excellent water quality and high ecological status of a biodiversity refuge. As such it deserves extraordinary protection measures.

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