

HIGHLIGHTS FROM THE INSTITUTES

INSTITUTE OF FRESHWATER ECOLOGY

The Institute of Freshwater Ecology has operated from three sites during the past year: the Windermere Laboratory (Headquarters), the River Laboratory and the Edinburgh Laboratory. Collaboration between sites has been extensive and, therefore, this report will cover the Institute as a whole. The Institute's Mission is to conduct research of the highest quality and to develop integrated theory for the science and management of fresh and estuarine waters. The research scientists are organised into four Divisions, covering the following areas:



*Professor Alan Pickering,
Director IFE.*

FISH BIOLOGY

The primary objective is to understand the mechanisms underlying the dynamics of fish populations and to apply this knowledge to their management. The work of the Division covers a wide range of temporal and spatial scales, from long-term field studies of fish populations over many years, to short-term laboratory studies and investigations at the cellular and molecular level.

MICROBIAL ECOLOGY

The Division focuses on improving understanding of the diversity, dynamics and activities of micro-organisms and their genetic elements in natural and polluted fresh waters, on modelling the behaviour of natural microbial communities and on the cultivation and long-term preservation of key microbial freshwater groups. The IFE Algal Modelling Unit and the Culture Collection of Algae and Protozoa (CCAP) are integral components of this Division.

AQUATIC PROCESSES

The research interests of this Division have a particular emphasis on upland catchments and the impacts of changes in land use, atmospheric pollution and climate. The disciplinary approaches to the work include environmental chemistry and physics, remote sensing and limnology.

ECOSYSTEM MANAGEMENT

With a particular (but not exclusive) emphasis on the management of lowland chalk rivers, the research in this Division includes the relationships between water quality, quantity, habitat and river community structure. A further strength is the research programme on chemical processes in rivers, especially those involving nutrient and pesticide processes and fluxes.

Whilst the divisional structure is an important internal management tool, the science of the IFE contributes to all ten areas of the CEH Science Programme, with particular strengths in Programme 4 Freshwater Resources, Programme 5 Biodiversity and Population Processes, Programme 7 Pollution and Programme 10 Integrating Generic Science. The IFE output during 1998-99 has increased again over previous years, with over 160 publications in the international



scientific literature and some 120 reports delivered to customers for specific pieces of commissioned research. Extensive collaboration with all the other CEH Laboratories across the UK has been a feature of IFE science during the reporting year, with NERC Thematic Programmes, the CEH Integrating Fund and commissioned research all facilitating such activities. The new management structure, recommended by the SMA, must ensure that it continues to support the scientific synergism created by this type of collaboration. Additionally, mechanisms must be put in place to facilitate continued communication, exchange and co-operation between those three CEH sites that will have a significant freshwater ecology research capability post-April 2000 (Windermere, Winfrith and Bush). IFE scientists also actively collaborated with research organisations from 24 countries across the globe, including 26 UK and 6 overseas universities and formal teaching contributions were made to the courses of 12 universities. In a related area, the IFE provided training opportunities for 30 PhD students, 15 MSc students and 14 voluntary/work experience students during the year – the student population makes a vital contribution to the vitality and intellectual health of the Institute.

Involvement in the membership and management of Scientific and Professional Societies is an integral component of the workload of any active, publishing scientist and during the reporting year IFE staff were members of 38 societies, covering all scientific disciplines, and held organisational positions in 7 of these. In addition, Institute staff sat on the editorial/advisory boards of 25 journals and made similar commitments to the committees of NERC and other science management organisations.

1998-99 has also witnessed major developments within the Freshwater Biological Association. The FBA owns the Windermere Laboratory (which includes the Ferry House, headquarters of the FBA) and much of the River Laboratory. The FBA have been working closely with the IFE, CEH and NERC to manage the move of the IFE River Laboratory to the new Winfrith site in 2000. The appointment of a new Chief Executive, Dr Roger Sweeting, to manage the FBA provides an opportunity for planning in the longer term and good working relationships between both the IFE and FBA are essential if we are to provide the strongest infrastructure for the overall benefit of freshwater science. I am delighted to report that good lines of communication are established between the Director IFE and the Chief Executive FBA. Both organisations are now focusing attention on the best way to refurbish and extend the research facilities at the Windermere site.



Windermere Laboratory.

The strong performance of the IFE during the reporting year is based on the excellent work of the supporting staff and research staff alike. Team effort is essential if we are to push back the frontiers of science, exploit the best available technology and manage the organisation in an efficient, yet caring, manner. Such teamwork has been very evident during the past year and it is somewhat unfortunate, therefore, that the leading scientists tend to be the recipients of the accolades. Having said that, we are all proud of the personal achievements and the scientific recognition of the IFE staff. During the year, Jessica Winder achieved personal promotion, Iain Harris received the IdQ from the Natural History Museum, Kay Symes was awarded the degree of MSc from Bournemouth University, Mike Furse the degree of PhD from Reading and Patrick Armitage a DSc from the University of London. Bland Finlay was made an Adjunct Professor of Deakin University, Australia and, more recently, Roger Pickup was made an Honorary Professor of the University of Lancaster and a Visiting Professor of the University of Liverpool. At the end of the reporting year Malcolm Elliott was awarded the Ray Beverton Medal by the Fisheries Society of the British Isles for his personal research contribution to our understanding of the processes controlling freshwater fish populations.

Inevitably, in any active organisation there will be a degree of staff turnover. During the year we saw the retirements of Trevor Furnass, Eric Rigg, Colin Woof, Clive Pinder, Chris Moakes and Peter Cubby and the departure of Simon Harrison, Trevor Marsh, Michael Woolf, Kay Symes and Jerome Masters. We thank them all for the important contributions they have made in their individual ways and wish them all happiness and success for the future. During the year we welcomed Jane Managh, Esther Smith, Jane Gay, Keith Rodgers, Dawn Managh, Claire Shirley, Debbie Collier and Colin Vincent who joined the staff of the IFE and we wish them an interesting and enjoyable career within CEH.

NEW SCIENTIFIC DEVELOPMENTS

SALMONID POPULATIONS AND MODELLING

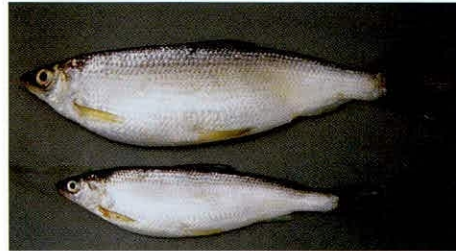
A new energetics model developed for the growth of brown trout has shown how the switch from a diet of invertebrates to one of piscivory radically alters not only the overall growth rate but also the optimum temperature for growth. Individual-based models have been developed to predict the time of emergence and initial size of larval fish when leaving the spawning redds. The time of emergence, which can vary by several weeks over the long-term period of the study, shows a marked correlation with the North Atlantic Oscillation (NAO). The genetic isolation of trout, possibly by the impacts of afforestation, in the upper Severn catchment has been demonstrated. This adds to the growing weight of evidence that salmonid stocks are normally composed of genetically distinct sub-groups. In this context the discovery of a relationship between the size of salmon parr in the River Frome and the flow category of the river may be of functional (and possibly genetic) significance. The 30 years collection of scale samples from the salmon in the River Frome is now an important resource for the resolution of such issues.



FISH CONSERVATION

The populations of two very rare coregonid species, the vendace in Bassenthwaite Lake and the schelly in Haweswater, are showing signs of poor recruitment and population decline. The key factors responsible for the decline of the vendace have been identified as enrichment, spawning site degradation and competition/predation from introduced fish species.

The schelly population is impacted by the effects of water abstraction, and more recently, by the potential impacts of predation by cormorants. Refuge populations of vendace have now been established in Scotland. A similar approach has been adopted for the schelly, but in this case with introductions to other water bodies within the Haweswater catchment.



Vendace.

ENVIRONMENTAL STRESS AND FISH

Clear evidence has been obtained that the magnitude of the stress response is under a degree of genetic control. New studies show that such physiological differences are accompanied by behavioural characteristics which could account for observed differences in performance. A comparative approach to the study of stress shows that the chub (hitherto unstudied in this respect) secrete extraordinarily high levels of the stress hormone cortisol that, in other species, would cause pathological damage. This could provide a unique opportunity to investigate the phenomenon of cortisol resistance.

AQUATIC MICROBIAL DIVERSITY

Achromatium oxaliferum is a large morphologically conspicuous unculturable bacterium associated with sulphide oxidation in freshwater sediments. Although once thought to be one species, sub-populations of *A. oxaliferum* have been distinguished by size. Further analysis revealed that these sub-populations were genetically distinct sub-species and each favoured different redox conditions in the sediment. This suggests that *Achromatium* populations have undergone adaptive radiation and divergent species occupy different niches in the sediment. In a related way, we have been able to show that different components of the lake ammonia oxidiser community are distinguishable on the basis of ammonium tolerance and possibly, on the basis of spatial separation in the sediment and water column. We have also shown that all species in the protozoan genus *Paraphysomonas* are probably globally ubiquitous. Intensive examination of one tenth of a square centimetre of pond sediment revealed 78% of the global number of species. Moreover, the pattern of relative abundance of species in the pond reflects the global pattern, supporting the idea that the rate of ubiquitous dispersal of microbes is a function of their absolute abundance.

WATER QUALITY ISSUES

It has been shown that tributaries of the River Duddon are now significantly less acid than they were 25-30 years ago. This is due to decreased atmospheric deposition of oxides of sulphur. The results add to previous evidence for acidification reversal in Cumbrian lakes. The Surface Chemical Assemblage Model for Particles (SCAMP) has been used to interpret metal chemistry in rivers entering the Humber Estuary. The significant roles of natural organic matter and the oxides of manganese and iron in controlling metal concentrations have been demonstrated.

A detailed analysis from vertical profiles through a complex plume of contaminants in a Triassic aquifer has shown that natural attenuation by biodegradation and dispersion is slow. Under present conditions the plume will grow despite the biodegradable nature of the organic pollutants and availability of suitable electron acceptors. On a more positive note, the continued improvement in the water quality of Windermere following phosphate stripping is visibly apparent in the reduction in biomass of *Cladophora* around the shore. Annual maxima can be predicted by the day of year at which the phosphate concentration falls below 1 milligram per cubic metre.



River Duddon.

AIRBORNE REMOTE SENSING OF WATER MOVEMENTS IN LAKES

Surveys of Esthwaite Water in Cumbria have shown that plumes of warm water periodically develop in the littoral zone and could have an important effect on the horizontal transfer of nutrients. Similar 'thermal siphons' have been recorded in other lake systems but their spatial dynamics had not previously been recorded by remote sensing

DATA MANAGEMENT

Over the past year, the IFE Data Centre has located, input and validated data for three substantial data sets under the NERC SEEDCORN project. These are the data for the River Ouse, the pike and perch populations in Windermere and the dace records for the River Frome. In addition, work is continuing on several other data sets, comprising significant progress in securing and making available long-term IFE / FBA data sets.

RIVER NUTRIENT PROCESSES

The efflux of dissolved silicon from river bed sediments is known to be an important process controlling the vernal growth of diatoms and a new method has been developed to estimate this efflux. Samples of sediment are used in experiments to measure the availability of silicon from diatom frustules and inorganic silicates. A diffusion-reaction model is used to predict the flux of silicon from bottom-sediments under different environmental conditions and the method has been validated in fluvium channel experiments.

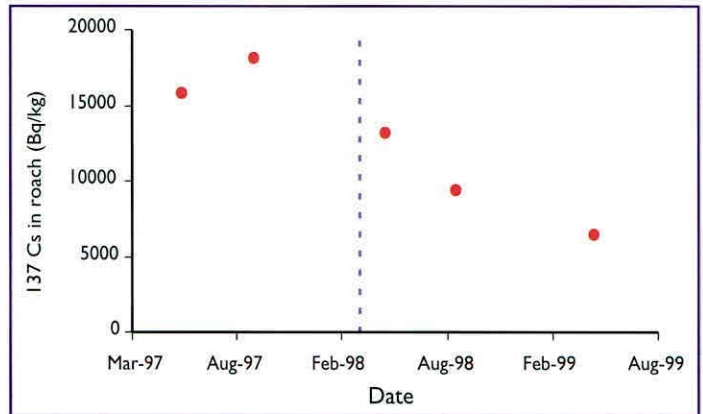


PESTICIDE MOVEMENTS IN RIVERS

A collaborative survey (with Reading University) of surface bed-sediments in the River Calder catchment in Yorkshire has revealed high concentrations of permethrin, a synthetic pyrethroid used in the formulation of sheep dip. The *cis-isomer* is more persistent and more toxic than the *trans-isomer* and the greatest retention time in the sediments was found to be between 103 and 125 days. The high concentrations are a serious threat to the benthic fauna of the river.

RADIONUCLIDE CONTAMINATION POST-CHERNOBYL

In a joint project with ITE, long-term predictions have been made (using models developed by the IFE) of radiocaesium concentrations in aquatic and terrestrial foodstuffs. These predictions suggest that restrictions on the consumption of fish in some lakes in the former Soviet Union will be required for 50 years and restrictions on sheep movements in the UK are likely to be required to continue for another 10 years. A multi-national project, co-ordinated by the IFE has shown that the addition of potassium to fresh waters recently contaminated by radiocaesium can significantly reduce the uptake of radiocaesium by fish.



Addition of potassium fertiliser to a lake contaminated by the Chernobyl accident reduces radiocaesium activity concentrations in fish. The dotted line shows the time of fertiliser application.

RIVER INVERTEBRATE PREDICTION AND CLASSIFICATION SYSTEM (RIVPACS)

More than 22 years of research into the use of freshwater invertebrates to assess the quality of waters has been compiled into a book entitled "Assessing the biological quality of freshwaters: RIVPACS and similar approaches". It outlines the latest developments and describes a number of methods used in other countries, which use the fundamental RIVPACS principle of reference sites. Analysis of the Environment Agency's surveys of invertebrates in rivers for 1990 and 1995 has demonstrated the value of these data beyond their simple application to national water quality statistics. Links have been made between the taxa gains and losses and the associated environmental changes. This is a fundamental precursor of future attempts to develop a dynamic RIVPACS that will allow predictions to be made of the effect of changing environmental conditions on the invertebrate fauna.

RIVER HABITAT SURVEY

The collection of additional data by surveyors in the major national River Habitat Survey (RHS) for the Environment Agency has allowed us to quantify the wide-scale vulnerability of bank-side habitats to invasion by aggressive invasive plants, such as Japanese knot-weed. These plants reduce plant diversity and increase seasonal bank erosion. The combined database has also helped clarify the habitat requirements for aquatic and riparian plants, which can be used as indicators of quality of water and physical habitat.

It has been another excellent year for hydrological research and IH staff have made significant progress in four major areas of hydrology:

- ◆ Processes affecting surface water quality
- ◆ Processes controlling the mass transfer of water in the terrestrial hydrological cycle
- ◆ Estimation of hydrological risks (for floods and droughts) and their impacts
- ◆ Water resource assessment, environmental impacts and hydrological data



*Professor Jim Wallace,
Director IH.*

New projects in water quality research have linked processes controlling the transfer of pollutants such as nutrients and pesticides to aquifers and rivers. This work is being developed in collaboration with IVEM to identify the microbial processes that degrade these chemicals. This is important in assessing the ultimate impact on water resources and helps identify potential means for remediation. IH's progress in water quality research has been greatly enhanced by large investments in new analytical chemistry equipment, funded by the CEH central budget.

Research into the biophysical processes that control energy and gas exchange at the land surface continues to explore important new areas. Much of this work is carried out in collaboration with the Hadley Centre and a key achievement has been the development of a new 'analogue' CO₂ model. This allows much faster computation of the impacts of different CO₂ emission scenarios on vegetation growth, climate and carbon sequestration.

The successor to the 1975 Flood Studies Report, a major revision of UK flood design practice, has now been completed by IH. The new scheme called the Flood Estimation Handbook (FEH) and accompanying software and digital catchment data includes many novel aspects, including new methods for estimating river flow peaks. The FEH has also entered into new territory by providing a method in which flood data are pooled according to catchment similarity rather than geographical position. This approach should revolutionise regional flood frequency analysis. IH was pleased to host a visit on 14 July 1999 by Elliott Morley, Minister for Fisheries and the Countryside at MAFF, who came to Wallingford to hear at first hand about recent and ongoing flood research commissioned by his Department. This includes the new FEH and research into flood forecasting, continuous simulation of runoff and climate change.



To capitalise on the rainfall-runoff modelling expertise in IH, and the rainfall modelling expertise in the UK Met Office, a new Joint Centre for Hydro-Meteorological Research at Wallingford has recently been formed. The JCHMR will bring key staff from the Met Office together with counterparts from IH to produce world leading rainfall and flood forecasting capability.

It has also been an important year for catchment research at IH. Historical data from 30 years of observations at the Plynlimon catchments in Wales are being relocated to Wallingford to exploit the availability of modern data base technology. Key results from these data have been brought together in a Special Issue of Hydrology and Earth Systems Science and in a brochure for distribution to a wider audience with more general interests in water. IH's commitment to catchment research throughout the UK continues. Large investments are being made in the equipment monitoring the Plynlimon catchments and new funds have now been agreed for more hydrological infrastructures and research in lowland catchments, through the NERC LOCAR (Lowland Catchment Research) Thematic Programme, within which CEH scientists continue to play a major role.

The collation, quality control and dissemination of hydrological data also remain a central remit of IH. The past year has seen the co-location of the IH National River Flow Archive with the BGS Groundwater Archive. This puts all the key paper and electronic records in one tailor-made location and brings IH and BGS staff responsible for the archives closer together. Furthering our aim to extend access to research data and information as widely as possible, the year under review saw the publication of an innovative Land Ocean Interaction Study (LOIS) Data Viewer on CD, complete with tutorial help and sample data. This was a joint IH and Plymouth Marine Laboratory production for the Lois Data Centres and is the first-ever effective welding of land and sea-based geographic and time-stamped data.

Finally, access to hydrological information at Wallingford has been greatly enhanced by the opening of the new National Hydro-Sciences Library. This modern and well equipped library holds the largest collection of hydrological research material in the UK. The facility is open to IH, CEH and BGS staff as well as the rest of the UK research community.

The new extension to IH at Wallingford completed in Spring 1999 as part of NERC's Rationalisation & Restructuring Programme.



CROSS CENTRE-SURVEY COLLABORATION

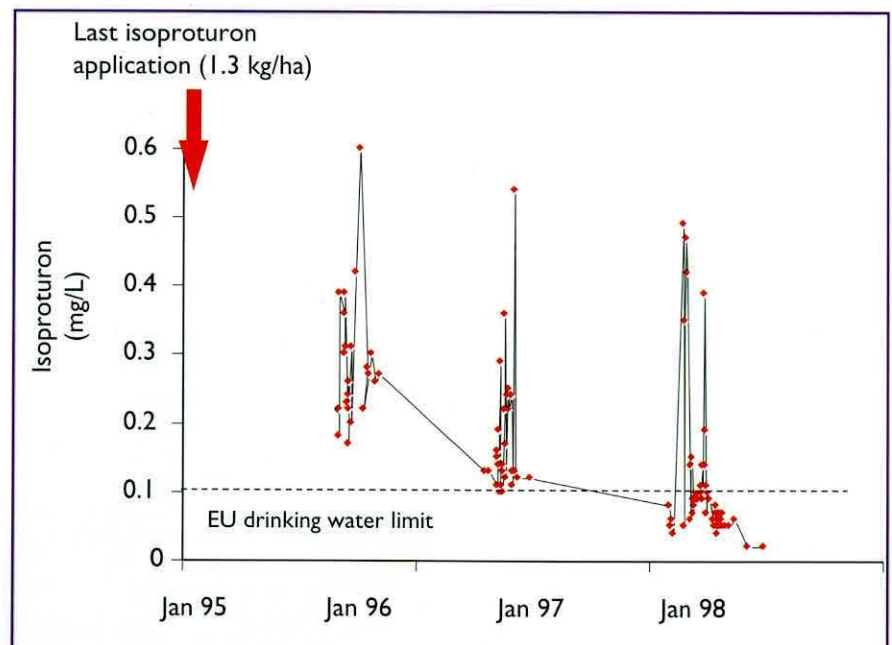
Approximately 30% of the UK's drinking water is provided by groundwater drawn from aquifers whose surface outcrops are in regions of intense agricultural production. These aquifers occur in consolidated sedimentary formations and have the potential, therefore, for the transport of pesticides (and other pollutants) through both the rock matrix itself and through fractures. The latter route can permit very rapid transport to the water table. In such aquifers, both routes for contaminant transport need to be characterised as a matter of urgency so that the rate of new treatment and control actions can be planned. IH has just completed a joint research initiative with colleagues from the Hydrogeology Group in the British Geological Survey, to establish the importance of the routes of transport and processes of pesticide behaviour in the chalk aquifer, and to examine and quantify the factors that control pesticide fate and behaviour. The main period of field monitoring was between 1994 and 1998 on the Hampshire Chalk. Specific objectives were:

- ◆ to study the mechanisms of groundwater recharge and to establish the importance of different flow routes;
- ◆ to measure pesticide residues in the soil and in the unsaturated and saturated zones;
- ◆ to assess and measure the potential for degradation and sorption in the soil and in the underlying regions.

The field results demonstrated that groundwater could become contaminated by herbicides as a result of normal agricultural practice. At the fieldsite this contamination was associated at a point where the watertable was relatively shallow (5 metres below the surface) and by-pass flow occurred. Groundwater contamination by the pesticide isoproturon was still occurring 3 years after its last application.

Both temporal and spatial variation in the ability of groundwater samples to degrade isoproturon was noted. This illustrates the complexity of subsurface microbial ecology. The factors which influence the presence or absence of a degrading potential in groundwater is now the subject of a new Integrating Fund project.

Isoproturon monitored in groundwater in borehole WON 5 over a 3 year period.





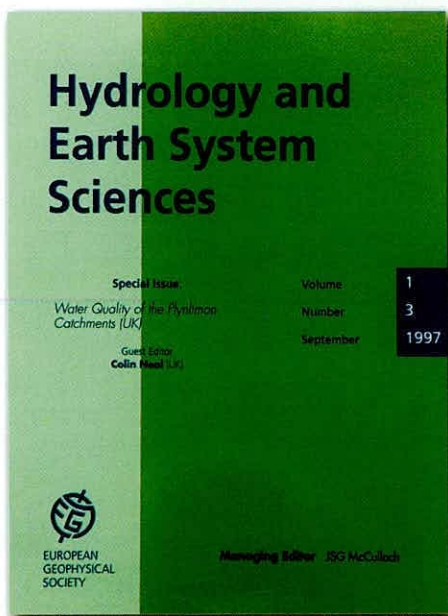
LONG TERM ENVIRONMENTAL MONITORING AT PLYNLIMON

There can be few research hydrologists - both national and international - who have not heard of the Institute of Hydrology's experimental catchments on the eastern slopes of Plynlimon in the uplands of mid-Wales. The original aim of the research programme was to collect measurements to resolve questions on the water use of conifer forests. This year is a milestone, marking 30 years of catchment operation and an unbroken dataset in excess of 30 years.

The Plynlimon instrument network combines the best elements of traditional manual observation and state-of-the-art technology, and thus has provided an outdoor laboratory for the exposure of new instruments and techniques to severe field conditions. Much of what is now taken for granted in environmental instrumentation was either new or did not exist and had to be invented when the network was first established in 1967. This was a time of development: the 'Wallingford' neutron soil water probe, early Automatic Weather Stations, steep stream flumes capable of measuring flows in channels with Froude numbers well in excess of unity all had prototypes sited there. Other challenges were the large sediment loads, the high proportion of winter precipitation occurring as snow and the absence of reliable data loggers with which to record vital environmental variables.

The story of Plynlimon parallels the development of British hydrology in many ways. The early years were spent ensuring accurate measurements as a sound foundation for the later work. The hydrological studies were originally concerned solely with water quantity. In time this work widened considerably to tackle other issues since the catchments, their hydrometric network and the accumulated data provide an ideal base for other studies of upland water quality and freshwater ecology. New work in the 1980s included investigations into surface water acidification, as well as systematic routine monitoring of water quality, which is now providing valuable information on long-term water chemistry trends. The catchment data set from Plynlimon is unique in the UK and has served as a foundation and an inspiration for the development of whole families of hydrological models which have gone on to have wide application in the UK and overseas.

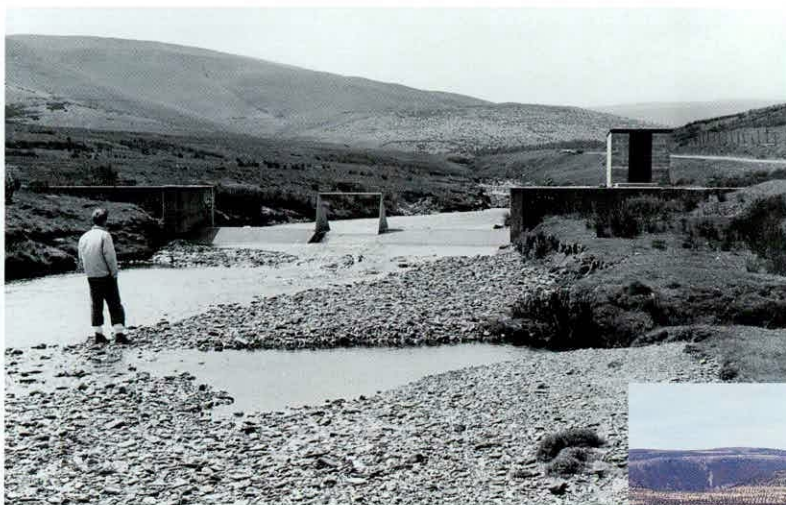
In recent years there has been increasing recognition of the importance of 'integrated' or holistic catchment studies. The results from Plynlimon are now recognised as having great potential in understanding effects arising from climate change and also from rapid changes in land use such as forest clear-felling and moorland set-aside. At this point in its history it is timely that so much of the current research has recently been published in a special issue of *Hydrology and Earth System Sciences** and we are able to take pride in the remarkable achievements based on the first quarter-century of Plynlimon data.



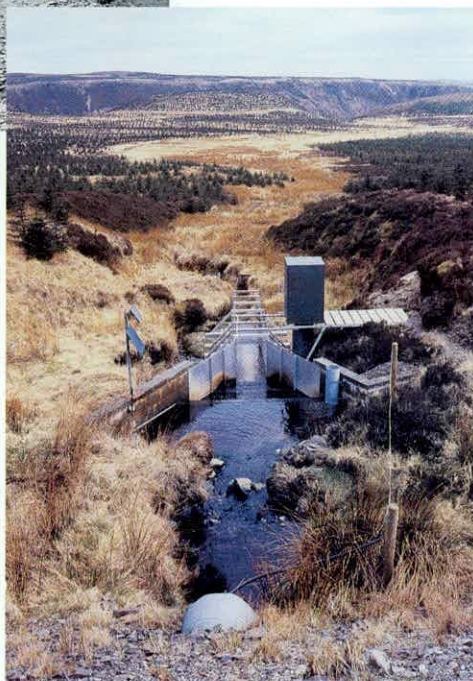
Restructuring within CEH has allowed the opportunity to modernise the basic hydrometric networks at Plynlimon. The staffed office at Staylitttle will close in late 1999. In future, the hydrometry network will be maintained from the CEH site at Bangor. Water quantity and quality data will continue to appear in the National Surface Water Archive. This database is at Wallingford, from where requests for data by outside researchers will be serviced.

Upland hydrology remains an important research topic, with many challenging aspects still to be studied. These include, for example, investigations into the changing pattern of evaporation losses over the life-span of a commercial forest plantation, as well as the question of why the streams in some acidic forest catchments can sustain trout populations whilst others are devoid of this valuable and environmentally-indicative game fish.

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Experimental divide piers in operation on Cefn Brwyn weir on the River Wye at Plynlimon c.1968, following alteration of the original design from a simple triangular profile (Crump) style to one of compound design with crests at two different heights. This was done to enable accurate measurement of a wide range of flows in this steep upland catchment as part of a high precision water balance experiment.



A prefabricated, duralumin steep stream 'Plynlimon' type flume, measuring flow from a small, recently-afforested, peat catchment at Llanbrynmair in mid-Wales. In tandem with a similar installation at the outflow of the basin wetland, seen downstream of the flume, this was used to estimate fluxes and storage of water, chemicals and sediment in the wetland to assess its effectiveness as an environmental, particularly chemical, buffer.





Over the past year the Institute of Terrestrial Ecology has continued to develop long-term multi-disciplinary research to advance the science of terrestrial ecology. Priority has been placed on developing and applying knowledge in the following areas:

- ◆ the factors that determine the composition, structure, and processes of terrestrial ecosystems and the characteristics of individual plant and animal species.
- ◆ the dynamics of interactions between atmospheric processes, terrestrial ecosystems, soil properties and surface water quality.
- ◆ the development of a sound scientific basis for monitoring, modelling and predicting environmental trends to assess past, present and future effects of natural and man-made change.
- ◆ the securing, expansion and dissemination of ecological data to further scientific research.



Professor Mike Roberts,
Director ITE.

The Institute has continued to draw upon the geographical distribution of its six Research Stations to deliver strategic research of national importance. The past year saw the involvement of all sites in the fourth Countryside Survey of England, Wales, Scotland and N. Ireland. The report on land use change from the field survey and a land cover map produced from remote sensing will be delivered to 8 government departments and agencies in autumn 2000. This project is indicative of the growing importance of ITE's capability to deliver independent research outputs to government departments and the public in support of environmental protection and conservation of biodiversity. The

geographical capability and scientific credibility of ITE were key factors in securing commissioned research to assess the effects of herbicide-tolerant genetically-modified crops on biodiversity in national farm-scale trials.

Whilst there has been a dynamic turnover of research contracts and grants, the overall financial position has remained in balance. Similarly, the turnover of staff has been higher than expected in some disciplines although the overall output of publications and contract reports continues to improve. A particularly notable feature of the scientific publications is the fact that co-authorship with staff outside ITE now exceeds 50% of all papers. This reflects the growing emphasis on collaborative research with the university sector and research organisations overseas.



Using GPS and pen-computer technology to collect map data during fieldwork, for the Countryside Survey 2000.

ITE has played a major role in developing the 10 Science Programmes in CEH and actively participates in NERC's Thematic Programmes and Non-Thematic projects. All sites have extensive collaborative links with universities, some with formal Memoranda of Understanding, and a buoyant customer base. Each ITE station contributes a number of unique, but complementary, science disciplines to CEH. Some of the scientific developments and highlights of the last year are summarised below.

MONKS WOOD

Research at Monks Wood concentrates on the integration of large-scale and long-term databases with field-based process studies to understand the structure and function of intensively managed landscapes.

Monks Wood currently hosts the Directorate of the Institute of Terrestrial Ecology, the office of the NERC Head of Earth Observation and staff of NERC Satellite Laser Ranging Facility. The research at ITE Monks Wood is organised in five Sections:

- ◆ Pollution and Ecotoxicology
- ◆ Ecological Processes and Management
- ◆ Animal Ecology
- ◆ Earth Observation
- ◆ Environmental Information Centre (EIC)

NEW SCIENTIFIC DEVELOPMENTS

Biological Records Centre and the National Biodiversity Network.

The National Biodiversity Network (NBN) is being promoted by a consortium of conservation bodies, including ITE. The NBN is working towards creating and managing a national network of biodiversity information, driven by the need for more accessible, reliable and accurate data about the nation's species and habitats. The Biological Records Centre (BRC), within the Environmental Information Centre at Monks Wood, is an important component of this network. NERC and the Joint Nature Conservation Committee have established a new Partnership, implementing a six-year Development Plan for BRC. National scale data about the occurrence of species from the BRC Database will be used to give wider and easier access to the existing data resources. The BRC will also work with National Biological Societies and specialist Recording Schemes to develop and improve their unique role in contributing biodiversity data to the network.

*Monitoring a
genetically-modified
oilseed rape crop.*



Genetically-Modified Crops. A consortium led by ITE was recently awarded three contracts by the Department of the Environment, Transport and the Regions (DETR), to carry out farm-scale experiments to determine the effects on wildlife of genetically-modified (GM) crops. The crops are maize, and spring-sown and winter-sown oilseed rape that have been manipulated to introduce resistance to herbicides. The assessment of GM maize is being led from Monks Wood. The research will collect scientific evidence to determine whether the management of genetically-modified herbicide-tolerant crops could induce changes in farmland wildlife. Pilot studies are being conducted in 1999, leading to a programme of full-scale experiments to be carried out between 2000 and 2002.



Applications of Liquid Chromatography-Mass Spectrometry in

Ecotoxicology. The analytical chemical facilities within the Pollution and Ecotoxicology Section at Monks Wood have recently been significantly enhanced with a liquid chromatography-mass spectrometer (LC-MS). The LC-MS permits quantification of polar contaminants that was previously impossible. Current studies using the LC-MS include:

- ◆ characterisation of substituted poly-aromatic hydrocarbons (PAHs)
- ◆ analysis of rodenticides
- ◆ following the metabolism of arsenic in plant-soil systems
- ◆ metabolism of PAHs and poly-chlorinated biphenyls (PCBs) in animal tissues

EDINBURGH

The focus of research at Edinburgh is on the flux of pollutant and greenhouse gases, the modelling of ecosystem processes at a range of scales and the sustainable management of tropical forests.

The Station is also host to a Section of the Institute of Freshwater Ecology (IFE). CEH's presence in Scotland has become increasingly important since the Scottish Parliament was established in 1999. Research at ITE Edinburgh is organised in three Sections:

- ◆ Trace Gas and Air Pollution
- ◆ Ecosystem Process Modelling
- ◆ Tropical Forestry

NEW SCIENTIFIC DEVELOPMENTS



Site of field studies on tropical biodiversity of rainforests.

Air Pollution. New work has begun on the fate and effects of urban aerosols, within the NERC URGENT Thematic Programme, based at a site on Carlton Hill in central Edinburgh. Work for the Global Atmosphere Division of DETR has expanded to include the UK terrestrial carbon inventory, participation in post-Kyoto IPCC activities, boundary-layer measurement of UK greenhouse gas emissions using aircraft, and the development of a set of climate change indicators for the UK.

Earth System Modelling. A new initiative to develop Earth System Models of intermediate complexity has started, associated with the development of new NERC initiatives in this area. Scientists are working on the global carbon cycle and are developing contacts with the Potsdam Institute for Climate Impact Research (PIK).

Tropical Biodiversity. Molecular studies on tropical tree diversity have expanded to include timber and fruit trees in central America and Africa, revealing centres of diversity and effects of logging.

Facilities. Major field facilities have been established locally at Auchencorth Moss, to continuously monitor fluctuations in concentrations of a range of trace gases, and at Deepsykehead, to expose mature forest trees to acid deposition. State-of-the-art equipment has been acquired recently to measure over 10 trace gases, organic solvents, ions in precipitation, aerosols and heavy metals.

FURZEBROOK

Research at Furzebrook has focused on the ecology of habitats and species of conservation importance in the lowlands and the coastal zone. In recent years, there has been an expansion of research to support the risk assessment of genetically-modified crops. Research at Furzebrook is organised in three Sections:

- ◆ Coastal Zone Ecology
- ◆ Biodiversity and Conservation Management
- ◆ Genetics & Molecular Ecology



Restored chalk downland.

NEW SCIENTIFIC DEVELOPMENTS

Conservation. Analysis of the first six years of colonisation by spiders of restored chalk downland close to the M3 Motorway at Twyford Down has revealed clear temporal patterns with characteristic functional groups, or guilds, replacing one another. There has been convergence in areas with initially different restoration methods towards similar communities of recognised high conservation value. Other long-term studies of variation in sediment accretion patterns in east coast saltmarshes and mudflats are highlighting the importance to vegetation succession of inter-annual variation in sediment supply, providing a basis for predictive models.

Molecular Ecology. Research underpinning risk assessment for the release of genetically-modified crops is focusing on the potential long-term impacts, with strategic studies on the role of herbivores and plant viruses in regulating natural populations of crop relatives.

NEW DORSET SITE

In April 2000, ITE Furzebrook will be combined with IFE East Stoke at a new well-found laboratory on the nearby Winfrith Technology Centre. This move and merger is part of the NERC Rationalisation and Restructuring Programme instigated several years ago and will provide CEH with a centre of excellence in population and community ecology supported by first-class facilities.

The mission of the CEH Dorset Laboratory will be to conduct high-quality, long-term research to understand the processes controlling the functioning of freshwater, terrestrial and estuarine ecosystems, the abundance, diversity and persistence of species' populations, and the composition and dynamics of terrestrial and freshwater communities. It will aim especially to produce science that is predictive and can be applied directly to the management, conservation and restoration of biodiversity.



BANGOR

Research is focused on the effects of air pollution and climate change on upland ecosystems with particular emphasis on biogeochemical cycles. The Bangor Research Unit provides a strong link to the environmental and conservation agencies in Wales and to the University of Wales. Research at Bangor is organised in two Sections:

- ◆ Biogeochemistry and Land Use
- ◆ Pollution and Climate Change

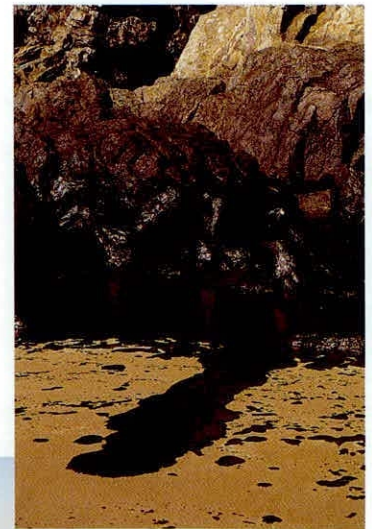
NEW SCIENTIFIC DEVELOPMENTS

Atmospheric Pollution. The monitoring of the Plynlimon catchment will operate from Bangor in future. This will strengthen the collaboration between CEH hydrologists and freshwater ecologists on catchment water quality and modelling.

International collaboration within the European Union NITREX project on nitrogen exceedance in forests led to the publication of a letter to Nature suggesting that anthropogenic nitrogen deposition makes only a minor contribution to enhancing carbon sequestration in temperate forests. Work is continuing to compare nitrogen critical loads exceedance in conifer plantations with that in native broadleaved woodlands.

Land Use. Bangor continues to research land use change issues in Wales. During the year we also completed a three-year survey for the Countryside Council for Wales (CCW) of the impacts of the Sea Empress oil spill on salt marsh vegetation in Southwest Wales, and a three-year study for MAFF of factors affecting coastal heathland regeneration in Wales.

Facilities. The solardome glasshouse facility for climate change studies has been completely refurbished, including new compartmentalised subsurface root chambers. A major new field 'roof' facility, enabling study of the effects of drought and elevated temperature on the pools and fluxes of carbon and nutrients in moorland ecosystems, has been established as part of an EU-funded collaborative trans-European experiment (CLIMOOR). A misting facility for exposing vegetation to simulated atmospheric aerosols has also been uprated, with improved mist generation and airflow.



Oil on rock at Tenby Beach.



Clean-up after the Sea Empress oil spill. Saundersfoot, Feb 1996

MERLEWOOD

The focus of research at the Merlewood Research Station is on large-scale studies of land use change and pollution impacts as well as long-term studies of environmental change. Research at Merlewood is organised into five Sections:

- ◆ Land Use
- ◆ Soil Ecology
- ◆ Environmental Change
- ◆ Radioecology
- ◆ Environmental Chemistry

NEW SCIENTIFIC DEVELOPMENTS

Countryside Survey 2000. The latest of the CEH's surveys of the British countryside, Countryside Survey 2000 (CS 2000), was carried out in 1998 managed by the Land Use Section. The survey is jointly funded by NERC and eight government departments and agencies. It involved field survey of 520 x 1 km sample squares distributed throughout GB, with the recording of land cover, landscape features and up to 50 vegetation plots in each square. Soil samples were also collected and will be used to assess changes in pH and carbon content since 1978, and to provide a national data set on the occurrence of soil mesofauna and functional microbial groups. Data analysis began in summer 1999 and results will be reported in autumn 2000.

The previous Countryside Survey, CS 1990, was followed by a major programme of research to investigate the causes of detected changes in vegetation and landscape features. A new vegetation classification system, the Countryside Vegetation System (CVS) was developed during this research programme and a description published in 1999.

Soil Biodiversity. The NERC Soil Biodiversity Thematic Programme, which is managed from Merlewood, began in the last year. The research is focused on a site at the Sourhope Research Farm in the Cheviot Hills. The Soil Ecology Section is involved in four of the projects and has developed a mobile laboratory for the introduction of pulsed ¹³C labelled CO₂ and gaseous nitrogen into the grassland system at the field site, and the continuous monitoring of CO₂ effluxes with funding from the Programme.

Environmental Change Network. The Environmental Change Network (ECN) is leading an international team on a European Commission funded project called NoLIMITS – Networking of Long-term Integrated Monitoring In Terrestrial Systems. The project will prepare a user-driven implementation plan for a European network of long-term integrated monitoring sites. The highlight of the past year was the NoLIMITS Workshop (Oxford, March 1999) attended by 90 stakeholders from 24 European countries.

Radioecology. Large areas of the former Soviet Union (FSU), were contaminated by radioactivity following accidents at nuclear facilities and the testing of nuclear weapons. In collaboration with research institutes in the FSU, the Radioecology Section has identified and quantified pathways of this radioactive contamination and developed predictive models to identify areas producing food with elevated levels of radioactive contamination. Practical countermeasures, which allow people living in contaminated areas to minimise



their dose, are being developed and implemented in collaboration with local village committees.

Stable Isotope Facility. During the last year the Stable Isotope Facility has been expanded with the installation of a new gas chromatography-combustion-isotope ratio mass spectrometer (GC-C-IRMS). This instrument gives increased sensitivity for ¹⁵N and ¹³C analyses and also enables compound specific work to be carried out.

BANCHORY

The focus of research at Banchory is on the dynamics of plant and animal communities in upland and montane ecosystems and, more recently, on arctic ecology. This past year we have consolidated from three sections to two:

- ◆ Community Ecology (formerly the Applied Ecology & Upland Ecology Sections).
- ◆ Population Ecology

NEW SCIENTIFIC DEVELOPMENTS

Arctic Initiative. Banchory is leading the recent CEH Arctic Initiative to exploit the opportunities for studying the role of water (in solid and liquid form) in ecosystem processes, the impact of anthropogenic change on these processes, and the likely feedback into global climate change.

Banchory is also a partner in a bid led by the University of Aberdeen to the Joint Infrastructure Fund. The aim is to develop the world's first suite of chambers that permit replicated simulation of freeze-thaw actions in soil cores on soil processes, energy fluxes and the fate of pollutants many a times a year.

UK Environmental Change Network - New terrestrial site in Cairngorms. A new terrestrial site, the most northerly and highest in the ECN network, has been established to monitor the impact of anthropogenic pollution, climate and land use change in the Cairngorms mountains, the most extensive tract of subarctic montane habitat in the UK.

Insect herbivory and tropical forest regeneration. Banchory is studying the effects of insect herbivores on the regeneration of tropical forest trees, particularly mahogany species in Costa Rica and Sri Lanka, and dipterocarps in Malaysia. Research on mahogany, in collaboration with the Tropical Agronomic Centre for Research and Education (CATIE) and the Universities of Edinburgh and Peradeniya, focuses on the management of these important species to reduce the impact of shoot borers.



Loch Avon, from the summit of the Cairngorms

INSTITUTE OF VIROLOGY & ENVIRONMENTAL MICROBIOLOGY

During the last year, the Institute of Virology and Environmental Microbiology (IVEM) has been involved in some notable events, in particular:

- ◆ the contained release of a genetically modified baculovirus to assess the fitness consequences of removing a specific gene.
- ◆ the production of two reports for HSE, on gene transfer from genetically engineered micro-organisms and plant virus transgenes.
- ◆ the establishment of Evolutec Ltd, a spin-off from IVEM's research on ticks and tick-borne diseases.

These highlights illustrate IVEM's continued commitment to understanding the functional roles of viruses and micro-organisms in the environment. In particular, IVEM is contributing to the important debate on the risks and benefits of genetically modified organisms through committee membership and contract research. Advice has been provided on the impact of horizontal gene flow and the development of genetically modified organisms for biocontrol and bioremediation. With the aim of developing novel biopharmaceuticals from tick saliva, the recently established spin-out company, Evolutec Ltd, is fully in-line with the Baker Report that encourages appropriate commercialisation of research discoveries.

Of the 10 Science Programmes in CEH, major contributions have been made by IVEM to 5 Programmes (Soil, Biodiversity, Biocontrol, Pollution and Biotechnology Development). Collaborations with other CEH Institutes have continued through Integrating Projects and NERC Non-Thematic Projects. The NERC EDGE (Ecological Dynamics of Genes in the Environment) Thematic Programme is managed by Dr Rosie Hails at IVEM, and IVEM scientists are involved in 4 projects in the Programme. A project has been initiated in the NERC Soil Biodiversity Programme on the development of molecular tools to assess ecosystem function.

The extensive links of IVEM with universities continues. In its membership of the Oxford Centre for Environmental Biotechnology (OCEB), IVEM works closely with scientists of the University of Oxford's Departments of Engineering Science and Plant Sciences. Recently awarded grants from BBSRC and EPSRC for research on biocatalysis development, functional diagnostics for land quality and soil electrokinesis, bring together Oxford University engineers and IVEM microbial ecologists, promoting true interdisciplinary research. Links with the University of Oxford's Biochemistry Department have been recognised for their excellence through a Wellcome Trust Programme grant awarded to Professor Polly Roy. Furthermore, Professor Roy has for 10 years co-ordinated an EC project grant which recently received the highest score in the biotechnology/vaccinology programme.



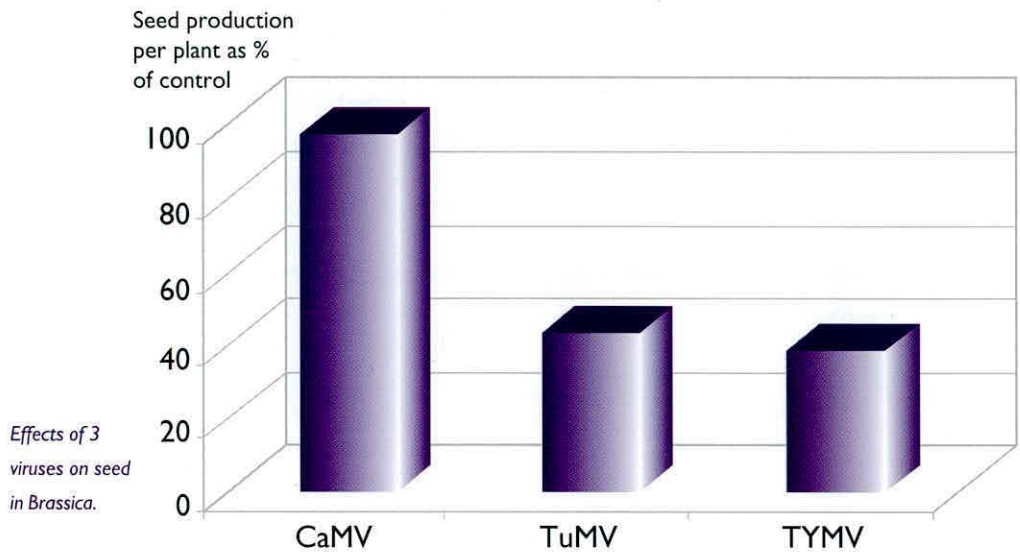
*Professor Pat Nuttall,
Director IVEM.*



NEW SCIENTIFIC DEVELOPMENTS

VIRUSES IN WILD PLANTS

Viruses cause economic losses in agricultural plants, that are recognised by changes in the shape or colour of infected leaves or fruit. Wild plants act as reservoirs of viruses that threaten crop production but the impacts of the viruses on wild plant performance are unknown. Studies in collaboration with ITE Furzebrook are focusing on wild *Brassica* species. Symptomless virus infections were detected in about half of the seedlings of one species, *Brassica nigra*. More importantly, infected plants contributed fewer seeds to the seed bank in soil and hence contributed less to future biodiversity of the species than their uninfected counterparts. These studies provide information that is important to assessing the risks of gene flow between genetically modified horticultural *Brassic*as and their wild relatives.



GENETICALLY MODIFIED BACULOVIRUSES

Baculoviruses have long been considered as biocontrol agents owing to their highly infectious nature and restriction for invertebrates. Genetic modification (GM) has been used to increase their speed of kill and make them more effective biocontrol agents. A consequence of adding the predatory mite toxin to the baculovirus is that the resulting GM virus produced only 5% of the expected number of new virus particles. To investigate how effectively the GM virus competes with the unmodified virus, molecular methods were developed to distinguish modified and wild type virus in killed insects. Surprisingly, infections with GM virus alone were more common than with the wild type virus alone, and mixed infections were rare even at high virus concentrations. These findings have important implications for understanding the dynamics of GM virus infections in field populations.

COMPLEMENT INHIBITORS IN TICK SALIVA

Complement is a key component of the innate immune system of vertebrates. In last year's Annual Report, research was described demonstrating the important role of serum complement in the ecology of the tick-transmitted bacterium that causes Lyme disease. Further work of Charles Lawrie at IVEM, in collaboration with the University of Oxford's MRC Immunochemistry Unit, has now shown that ticks produce inhibitors of complement. Comparison of anti-complement activity of three tick species showed a striking correlation with host preference. For example, the hedgehog tick, *Ixodes hexagonus*, had high activity against hedgehog complement and no activity against pheasant or pigeon complement. By inhibiting host complement, ticks can promote the transmission of the Lyme disease agent. Thus differential inhibition of host complement will contribute to the pathogenesis and ecology of Lyme disease.

INSECT-TRANSMITTED ORBIVIRUSES

Orbiviruses are transmitted to mammals and birds by blood-sucking arthropods (gnats, mosquitoes and ticks), replicating in both their vertebrate and invertebrate hosts. The spread of their arthropod vectors, from endemic to non-endemic regions of the world, poses a threat to countries currently free from these viruses. A major focus of research at IVEM is to understand how orbiviruses enter, replicate, and spread from cell to cell in such a wide range of hosts. Viral proteins have been identified that perform each of these major functions in the virus life cycle. The characterisation of these proteins will enable development of custom-designed antiviral agents. This research topic has been particularly rewarding in providing training opportunities for young scientists. Indeed, in the past year, five students submitted their doctoral theses and the three examined to date passed with flying colours.

RABBIT HAEMORRHAGIC DISEASE

During the past 30 years, rabbit haemorrhagic disease virus (RHDV) has ravaged European and Asian rabbits. The origin of this virus is unknown, but it appears to have spread into Asia from Germany. IVEM scientists are collaborating with Professor Peter Hudson (University of Stirling) and Dr Roger Trout to investigate the molecular epizootiology of this disease, funded by MAFF. A genetically engineered diagnostic probe has been produced using a recombinant baculovirus expressing the major surface protein of RHDV. This facilitates rapid screening of rabbit sera for antibodies to RHDV that provide evidence of infection. In addition, molecular methods have been developed for detecting and sequencing RHDV present in the marrow of rabbit bones collected up to 5 days after death. These tools enable detailed field studies to determine the epizootiology, dispersal and evolution of RHDV in the UK.



Rabbit infected with rabbit haemorrhagic disease (RHDV). Studies are currently underway to investigate the epidemiology of RHDV in the UK.