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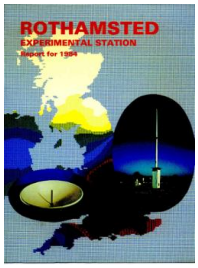
ROTHAMSTED RESEARCH

Rothamsted Experimental Station Report for 1984



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Biomathematics Division

J. C. Gower

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INTRODUCTION

The Division comprises the Computing Unit (RESCU) and the Statistics Department. RESCU manages and operates the Station's local computing network, itself a part of the AFRS-wide network run by the AFRC Computing Centre. The local network is growing fast and now handles all the Station's computing, except for file archiving which is managed centrally by the AFRCCC. An increasingly important part of the work of RESCU is concerned with providing interfaces between the computer network and laboratory equipment, including automatic data collection. RESCU also writes software for instrumentation and advises on the availability of applications software; it has an important instructional role to play in programming and use of equipment.

The Statistics Department offers a service on many aspects of statistics arising from planning the collection, and subsequent analysis, of observational and experimental data. These aspects include field studies, surveys, laboratory and field experiments. The

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service operates at several levels. Straightforward problems are handled by a weekly rota of statisticians; several departments have a senior statistician assigned to them on a liaison basis; all Commodity Group committees include one or two statisticians. A routine statistical computing and data preparation service remains popular, especially with occasional users of statistics whose time would be very inefficiently used if they were obliged to 'do it yourself'. A substantial amount of work is done for ADAS and a small unit funded by ODA handles the design and analysis of overseas agricultural work.

The essential underpinning of this service depends on our development of statistical computing software (now in its 30th year in the Department) that enables us to handle efficiently a great variety of problems; the programs developed have an international following. General statistical programs imply the generalization and unification of statistical methodology and this is an important part of the work of the Department. Other methodological research arises naturally from novel consulting problems and new areas of scientific research in the Station.

COMPUTING UNIT

This, the Unit's second full year has been a very active one seeing the final move of users from the ICL System 4 machines to the new VAX service, an additional VAX system being installed, cabling provided for the local network and much activity on the automation of laboratory equipment.

The VAX systems. The DEC VAX 11/750 computer installed in 1983 was upgraded by 1 Mbyte of memory, 16 asynchronous terminal lines, a synchronous communication line connecting the Statistics Department Jacquard system, and a 480 Mbyte Winchester disc. An additional VAX system was installed in June 1984 comprising an 11/750 cpu, 2 Mbyte memory, two 250 Mbyte exchangeable disc drives, 24 asynchronous terminal lines and a 300 1pm graphics-printer. Both VAX systems are connected for file transfer and for interactive traffic to other systems connected to AGRENET and to the British Telecom Packet Switch Stream (PSS). Broom's Barn joined AGRENET in August and normally accesses the RES VAX systems.

The VAX systems provide a general purpose computing environment with over 98% serviceability. The system is accessed from 37 VDUs dispersed throughout the station, from elsewhere within AGRENET, and from other sites by direct dialling and the PSS. The local network also supports microcomputers, two Calcomp flat-bed plotters, a Benson drum plotter and a SIGMA colour-graphics display with a Tektronix colour ink-jet printer.

A wealth of applications software allows computing staff to tackle directly the substantive problems, triggering much activity in computing. Heavy demand for interactive computing is already straining the VAX resources. Careful management will meet the user's demands temporarily but further hardware must be funded next year if the future computing needs of Rothamsted are to be satisfied.

Graphics. The major effort on graphics software has been sustained with the implementation of R$GRAPH (Bicknell and Hipgrave) a menu-driven simple graphics package, SURFACE II (Bicknell and Godfrey) a contouring and surface display package, Genstat graphics enhancements and colour mapping using the SIGMA display terminal (Bicknell). These developments have arisen from the needs of Rothamsted departments for good modern methods of investigating and displaying data and models.

Laboratory automation. Microcomputers allow computers and laboratory equipment to be interfaced cheaply, and data-gathering tasks automated. These applications centre

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around (a) Apple II and MIDAS systems for medium sized problems requiring complex interfacing, (b) Epson HX20 systems for field and laboratory data-logging with simple interfacing and (c) 68 000 microprocessor systems, for the more complex or substantial tasks.

Systems have been designed (Verrier and Moore) and software written (Moore, Shah, Summerfield and Hipgrave) for: the Soil Survey of England and Wales (SSEW) laboratory automation, glasshouse data-logging and environmental control interface, ^{15}N plant uptake and dry matter weight analysis, insect survey, counting wheatshoots in glasshouse experiments, field data collection and wheat grain trials. This activity is growing and is an important one which could compensate for some of the recent loss of staff at Rothamsted.

Databases. Rothamsted now has access to Database software; some databases are small, others are quite large (50 Mbyte for Entomology moths data, 200 Mbyte estimated for SSEW database); most have complex structure. Advice and assistance on designing databases is given to users (Thomas and Summerfield) and alternative more powerful database software suitable for the larger problems is under investigation (Summerfield and AFRCCC).

Data preparation. A key-to-disc data input service is provided. Approximately eight million characters were entered and verified; while this is more than last year, much, but not all, data preparation may soon be replaced by direct data-recording with hand-held loggers, or direct interfacing of laboratory apparatus to a microcomputer.

Staff

K. E. Bicknell is Chairman of the GHOST Technical Committee and UK GHOST representative for the Eurographics Chapter Committee; he presented a paper at the Eurographics Conference in Amsterdam. P. J. Verrier presented a keynote paper at the Sixth Hand-Held Data Symposium at Silsoe College.

Denise Pallett and Christine Lessells left, and Marjorie Bellingham, J. Hipgrave, N. Shah and S. Godfrey (six-month Sandwich Student) joined the Unit.

STATISTICS DEPARTMENT

Practical applications

As usual work has come from all Rothamsted Departments. Space does not permit a full listing but the following indicates the scope of work done.

Based on data from 1951 to 1971 a model for predicting the incidence of sugar beet virus yellows at the end of August from winter weather was brought up-to-date by using data from 1959 to 1983. The model predicts from December to May for each of 13 factory areas and nationally. (White, with Harrington, Entomology, and Dewar, Broom's Barn)

A diffusion model developed for the movement of soil in long-term experiments has been fitted to observations of metal concentration in the Woburn market-garden experiment. Large amounts of zinc, copper, nickel, cadmium, chromium and lead present in sewage sludge applied to plots between 1947 and 1961 have since spread outside the treated plots. The model fits well to observations of metal concentration on line transects made in 1984. (Lane, with McGrath, Soils and Plant Nutrition)

Multivariate methods such as biplots and principal coordinates analysis were used to analyse counts of blackfly trapped in the Volta River Basin Area of Western Africa, over 146 consecutive days in 1978. (Clark and Digby)

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Further work has been done on the possible use of trace element composition of insects to help identify their sites of origin and/or host plants. (Digby, with Bowden and Sherlock, Entomology)

Much advice on suitable non-linear models and how to fit them, has been given to various departments: Soils and Plant Nutrition, Plant Pathology, Insecticides, Soil Survey, Entomology, Biochemistry, Physiology and Environmental Physics, Soil Microbiology. (Ross)

An ingenious experiment to demonstrate anemotaxis in pea moth, involved video recordings. Formulae have been devised to eliminate perspective effects. (Perry, with Wall, Entomology)

Twelve years ago the Statistics Department took responsibility for data-management of the Rothamsted Insect Survey. This year the new VAX system has been set up to store, update and correct the survey records. Programs are similar to those used on the 4-70, but are now accessible from a user-friendly Tape Management System which reduces both mistakes and the time spent to put up new records. Investigations are continuing into more efficient methods of storage and retrieval. (Clark, with Summerfield, RESCU)

Sodium dodecylsulphate polyacrylamide gel electrophoresis (SDS-PAGE) is a standard technique for the separation of proteins from cereals, where the migration distance in the gel of each protein increases with its molecular weight. Proteins with known molecular weights are used for calibration. The logistic curve was found to give the best approximation to the relationship between migration distance and molecular weight. The unknown molecular weights of a set of proteins were estimated from their migration distances on three gel systems. Inconsistencies between these estimates showed that this method should be used with care. (White, with Bunce and Shewry, Biochemistry)

A Colour Difference Meter gave a three-dimensional assessment of tomato colour. Linear functions to discriminate between five subjectively chosen ripening classes of fruit and objective limits of the functions were calculated for several varieties. (Dixon, with G. E. Hobson, Glasshouse Crops Research Institute)

Routine analysis. The level of demand for processing experimental data for Rothamsted has remained at last year's level but ADAS data has increased slightly. Problems of archiving, print quality and the batch queue software of the VAX system, together with a considerable loss of data-processing staff in the last three months, extended the turn-round time to 6·3 days, slightly beyond our previous standard of 5–6 days.

The Jacquard J300 continues to cope adequately with data entry and word processing despite frequent break-down, mainly of the double daisy wheel printer and disc drive. Transfer to the VAX 750 involved major rewriting of the communications software; because of a fault in Jacquard software, communications require a high priority to work on the VAX.

EHF's have started to use Comart microcomputers to record data on floppy discs. A few discs, received in parallel with the usual hand-written sheets, have been read successfully but have not yet been transmitted directly to the VAX system. (Dyer, Smith and Todd)

Work for ADAS

Two training courses have been run for ADAS staff, both at the Hertfordshire College of Agriculture and Horticulture; one for Regional Soil Science staff and one for Experimental Husbandry Farm staff. Liaison with ADAS staff has been promoted also by visits to eight EHFs, the Feed Evaluation Unit, the Arable Unit at Stoneleigh and ADAS offices at Bristol, Shardlow, Cambridge and Reading. Contact has been

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maintained also by membership of ADAS committees, by seminars, and by visits of ADAS staff to Rothamsted. (Dyer, George, Kirby, Murray and Spechter)

Crop experiments. Designs and randomized plans, sometimes incorporating restricted randomization, have been provided for various ADAS crop experiments. (Bailey and George)

Much time has been spent on analysis of the 'Marathon' series of nitrogen on winter wheat trials carried out by ADAS, Eastern region, from 1981–83. There were 36 experiments in all, with data on soil nitrogen measurements, ^{15}N measurements of fertilizer N uptake, various components of yield and assessments of the nitrogen content of plant parts. Computer output of fitted yield curves giving summary information, including economic optima, was seen by ADAS staff, who suggested that similar output might be provided for all ADAS cereal nitrogen response trials. The programs have been developed into a set of general-purpose GENSTAT macros providing customized output suitable for non-statisticians. (Murray)

Previous work has estimated optimum potato seed rates taking into account the cost of seed and value of the ware product in the 40–80 mm size grade. Since the 40–60 mm and 60–80 mm size grades are now separately saleable, the data have been reanalysed to determine individual seed rates. The 40–60 mm size grade gives very erratic results and it is doubtful if it will be possible to produce reliable estimates. (Dyer)

Nutrition chemistry. Regression equations for the prediction of *in vivo* feed values from *in vitro* measurements which take account of between laboratory variation have been produced. Rival *in vitro* predictors, MADF and NCD, have been assessed. (George and Kirby)

Livestock experiments. The main poultry projects during the year studied the effect of litter condition on the grading of broiler carcasses, the comparison of feeders for laying hens, aviary systems as an alternative to cage-housing for laying hens, the effect of dietary calcium and phosphorus on shell quality and production traits of laying hens, and the response of laying hens to lysine and methionine supplementation of low protein diets (Spechter). The effects of different bulls on calving difficulties of approximately 3000 two-year-old heifers have been analysed. Problems arising from repeated measurement of the same animal, and lack of true replication induced by group-management have been examined, but would benefit from closer liaison with clients. (Kirby)

Entomology. Diagnostic plots of data collected at the MAFF Hatching Green Laboratory on the lifetimes of Colorado beetles kept in controlled environment boxes show that a single parametric distribution will not fit the observations adequately; a combination of exponential and Wiebull distributions appears suitable. The model well reflects the biology because after a short period of sexual maturation with high mortality immediately following emergence from the pupal stage, the surviving beetles have a fairly long expectation of life. The model provides a parametric form for a type of survival curve frequent in ecological literature. (Murray)

Surveys

Sugar beet surveys. Specific field surveys organized by British Sugar in collaboration with Brooms Barn provide information about growers' practices and yield estimates from pre-harvest samples. Relationships between yields and practices are being examined using data for 1981–83. Preliminary results were reported to the British Sugar staff conference. Amongst other recorded factors, variety, sowing date, plant population and

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region are all associated with yield differences, but differences between growers' use of N per ha are unrelated to yield. (Church and Leech)

Fertilizer surveys. Surveys of fertilizer practice for England and Wales and for Scotland done in 1983 in collaboration with ADAS soil scientists and representatives of the Fertiliser Manufacturers' Association were reported. Analysis of these surveys was completed on the 4-70 computer but similar surveys for 1984 (1300 farms in England and Wales and 250 in Scotland) have been analysed on the VAX. Transfer of the current suite of programs to the VAX was efficiently achieved with minimal changes, and basic results for both surveys were available by the end of the year. Permanent transfer and reconversion of previous years' data stored in binary form for this and other surveys has been slow, due to constraints on disc space and archiving facilities. (Church, Elsmere and Leech)

Representative soil sampling. In this survey, soil samples are taken from a random sample of about 500 fields each year and re-sampled after five years to monitor trends in nutrient status. Data for a 10-year cycle (1974–83) is now almost complete. Meanwhile, an interim report has been written on trends in pH and lime requirement based on fields sampled in 1974–77 and 1979–82; this shows some increase in grassland acidity. Changes in analytical determinations on stored soil samples have also been examined. (Church, Gnanasakthy and Elsmere)

Calf-rearing survey. A study of 70 herds coordinated by the Department of Animal Husbandry, Bristol University, comparing calf behaviour under different rearing systems, and giving ancillary comparative information on calf health and injuries has been reported. (Church, Gnanasakthy and Webster *et al.*)

Theory

Quasi-likelihood. Wedderburn's idea of quasi-likelihood replaces the full distributional assumption of errors in a statistical model by assumptions about the first two moments only, in particular about how the variance changes with the mean. Originally applied to generalized linear models with a single error term, it is now being extended to allow, for example, an extra component of variance in the linear predictor of log-linear models, and the development of a 'split-plot' error structure with non-Normal errors. The quasi-likelihood formulation of the former reduces greatly the amount of computation. (Nelder)

Variance-mean relationships. The set of distributions described in (*Rothamsted Report for 1983,* 77) require only n+2 parameters (not the usual 2n) and two of these relate directly to Taylor's Law. The fit to eight sets of insect data, comprising a total of 89 observed histograms, compared well with that of other distributions, including the negative binomial. (Perry)

Non-linear inference. Several aspects of non-linear modelling have been studied. Improved algorithms have been written for fitting families of models having some common parameters. The success of a model in predicting a value may be associated with *effective replication* at a sampling point. Excessive attention tends to be paid to the aggregation parameter k of the negative binomial distribution; estimates of k have very poor properties, but the difficulties vanish if one estimates 1/k. Apparent paradoxes in assay work concerning differences between fiducial and confidence intervals and

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differences in estimates of the variance of the LD50 based on probit and logit models have been resolved. (Ross)

Diagnostic keys. Criteria used for test selection in diagnostic keys were studied using real and artificial data. Although some criteria were better than others, all produced the best key for at least some sets of data. Genkey, therefore, offers users a choice of criteria. (Dixon and Payne)

Multivariate analysis. Graphical displays for cluster analysis continue to be investigated. Robust principal components analysis is now routinely used for the ordination of groups with outliers. The method is a two-stage procedure: an outlier-resistant method is used to estimate the group means, and then the centering and rotation given by a principal components analysis of the group means is also applied to the units to show within-group scatter. (Digby)

Restricted randomization. A new valid restricted randomization scheme has been discovered for complete-block designs when no treatment occurs more than twice in any column; this has already been used for the ADAS SB36 experiments. A powerful theorem has been found which generalizes many isolated results on valid restricted randomization. A paper has been prepared on the restricted randomization necessary to preserve 'neighbour balance' in fungicide trials, and the consequences for analyses. (Bailey)

Statistical computing

Genstat 4. Genstat 4.04 was handed over to the AFRCCC in March for installation at AFRC sites. The Prime and IBM versions were largely produced at Rothamsted while our external converters completed versions for VAX (Unix), Honeywell (GCOS), Honeywell (Multics), ICL2980(EMAS), ICL2980(VME), Telefunken and Univac. The versions for CDC6000, CDC7600, DEC10 and Harris are near completion. (Simpson)

Support. Genstat courses and demonstrations were given at the Welsh Plant Breeding Station, the Building Research Establishment, the Civil Service College, the John Innes Institute, Rothamsted, the National Institute for Research in Dairying, FBC Ltd, and overseas in Harare, Zimbabwe.

It is our policy to encourage non-Rothamsted people to give courses and help has been given for courses at the National Vegetable Research Station, the University of Bristol and at the Catholic University of Chile. (Digby, Dixon, Lane, Payne, Ryder and Simpson)

Genstat was demonstrated at the 5th International Biometric Conference in Tokyo and at Compstat in Prague.

Documentation. The Installation Guide was revised for 4.04B (Simpson). A handy reference summary giving details of the Genstat language has been printed by the Numerical Algorithms Group who will distribute it (Lane). A booklet containing the scripts of the video-tapes, 'Genstat: a preview', has been printed at Rothamsted. It will be distributed free with the tapes, and may be bought separately by those needing preliminary information about Genstat.

A new version of the macro-library with uniform standards and documentation is being prepared under the editorship of Jane Bryan-Jones (College of Arts and Technology, Cambridge). Those macros produced at Rothamsted have been revised, extended and redescribed to comply with the new standards. (Harding, Digby and Dixon)

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Genstat 5. This is the first stage in a major revision that should meet our needs for the next 10 years. The Genstat language has developed in an *ad hoc* fashion and it is now being rationalized and enhanced, while leaving the basic statistical functions and algorithms relatively unchanged. Subsequent stages of development are planned to include much better graphics and menu control. Documentation will be improved.

Specification of the new syntax has been agreed. The semantics have been much simplified to give a single unified set of rules which should make the language much easier to learn and remember. Changes in compilation and in the presentation of output will make interactive working more convenient. Extensions include a general text vector, facilities for the manipulation of pointers, the ability to write procedures whose invocation will look identical to that of directives and new control structures like IF-THEN-ELSE and CASE; these should improve the programming facilities of Genstat, in particular making it easier to customize for particular applications. The detailed specification of directives has been completed. (Digby, Dixon, Gower, Harding, Lane, Leech, Nelder, Payne, Ross, Simpson and Todd) The main routine for compiling lists of items is being written. (Harding and Simpson)

MLP. Agreement was reached in February that the Numerical Algorithms Group (NAG) should take over the licensing and distribution of MLP, on terms similar to those governing Genstat. Over 50 licences have now been issued (November 1984).

The MLP manual was transferred to the VAX system as a text file, and new sections added in a form from which NAG can produce a complete new edition. A new prospectus is being prepared. (Ross and Harding, with Mr Michael Richardson of NAG)

Version 3.08 was released in June for testing at Rothamsted. Facilities since incorporated include: differential equation models with several variables, new functions, facilities for truncated continuous distributions, calculation of Effective Replication, the hat matrix for general models, the determinant of the dispersion matrix (for optimal design studies), abbreviated three- and four-way likelihood plots, confidence bands for fitted curves, full plots of fitted functions in general models and linear regression, and (for interactive use) a new branched HELP system with complete instructions and graphs of typical models. (Ross)

GLIM. GLIM 3.12 is available at over 900 sites in nearly 50 countries. Release 3.77 is now ready and the Reference Guide drafted. NAG expects to distribute it at the start of 1985—initial requests look very promising. New facilities include extensive tabulation and table printing directives, flexibly formatted output, histogram drawing, simpler calculation directives, a macro library, better control over I/O, etc. By rewriting the code in a subset of Fortran 77, the program has been fitted on to micros (including the IBM-PC and the new BBC micro). (Baker, Nelder and White)

Overseas

The Overseas Development Administration continued to fund the Biometric Unit (Preece, Ryder and Riley). Ryder visited Zambia and Zimbabwe, the latter to give a Genstat course; Riley made her second visit to the Falkland Islands, to examine and advise on trials and to conduct a series of workshops.

The amount of work has remained steady, coming this year from countries which include Belize, Botswana, Costa Rica, the Falkland Islands, The Gambia, Indonesia, Kenya, Malawi, Nepal, Paraguay, Tanzania, Tuvalu, the Yemen Arab Republic, Zambia and Zimbabwe. However there were fewer personal visits to the Unit; efforts are being made to remedy this, for a better service can be given when personal communication is

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established, and it is particularly valuable for scientists to visit before taking up a period of duty abroad.

Work from the Falkland Islands has increased yet again partly because of increased collaboration with the research team and partly because of scientists returning at the end of their contracts, several of whom spent time at Rothamsted; this proved valuable and others are encouraged to do the same. (Riley)

Work has continued on the analysis of the effects of storage methods on the germination of tropical tree seeds for Dr P. Tompsett of the Royal Botanic Gardens. (Ryder)

There is an increasing demand for advice on statistical software for microcomputers that are now commonly in use in the remoter parts of the world. Clearly some systematic work is needed here. (Riley and Ryder)

Riley continued her work on intercropping. With Professor R. Mead (Reading University) she prepared a paper on stability of intercropping systems and further work is in progress. She has prepared a paper comparing the Effective Land Equivalent Ratio and Staple Land Equivalent Ratio and has begun to explore the use of multivariate models.

Twenty further statistical topics have been discussed at informal Departmental seminars, mainly organized by Preece, who wrote most of the supporting texts. These perform a useful educational role; discussion reveals where misunderstandings arise or where amplification is needed, so that the texts can be edited accordingly. Many of these topics deal with basic matters such as data-recording, much used (but often little understood) statistics, what is and what is not reasonable etc. Some of the texts have been issued as Statistical Notes, suitable for distribution to, amongst others, ODA Advisers and Technical Cooperation Officers.

Staff and visiting workers

J. A. Nelder retired in October. He was Head of the Department for 16 years and became the first Head of the Division on its foundation in 1983. His time at Rothamsted was characterized by the continued development of statistical computing and especially his work on Genstat and GLIM. Genstat is the main computing tool of the Department and of many other AFRC statisticians; it has an international following and earns substantial revenues for the AFRC. It was with great pleasure that we heard of J. A. Nelder's Inventor's Award for the development of Genstat (see p. 11). Unlike Genstat, GLIM owes much to outside collaborators, through the Royal Statistical Society's Working Party on Statistical Computing, of which Nelder was chairman; like Genstat, GLIM also has international usage. Nelder has been responsible not only for GLIM itself but also for the unification, development and popularization of generalized linear models as a powerful methodology that subsumes many standard statistical models, as well as some new ones, that have applications in most fields of study. His retirement is to be an active one. He is President Elect of the Royal Statistical Society, taking office in July 1985, and, based at Imperial College, he is working on the use of artificial intelligence techniques in statistics; he also has an appointment at the London Business School.

J. C. Gower was appointed head of the Statistics Department and the Biomathematics Division. Patricia K. Neill and Elsie Davies retired. Jill F. B. Altman, Gul Baust, Elaine P. Bangs and Frances C. Featherstone left.

D. A. Preece, J. C. Gower and J. Riley attended the 12th International Biometrics Conference in Tokyo. J. Riley organized the session on intercropping and, with Professor R. Mead of Reading University, gave an invited paper; J. C. Gower also gave an invited paper. From Tokyo, J. Riley and Professor R. Mead went to the International Rice Research Institute in the Philippines, where they gave a seminar on intercropping; they

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then went on to a conference at the Indian Agricultural Statistics Research Institute in New Delhi, where J. Riley gave a paper.

J. A. Nelder attended the Interface Conference in Atlanta, and gave a paper on 'Statistical computing; progress and prospects'. He also gave a paper at the American Statistical Association's meeting in Philadelphia. R. A. Bailey spent January to June as a visiting Professor at the University of North Carolina at Chapel Hill. J. C. Gower attended the Classification Society meeting in Santa Barbara, and gave seminars at AT & T Bell Laboratories.

Compstat 84 was held in Prague. J. Baker, T. J. Dixon, P. W. Lane, J. A. Nelder (Conference chairman) and G. J. S. Ross (session organizer) attended and gave papers. R. A. Bailey organized a session on design at the European Meeting of Statisticians in Marburg. Invited papers were given by J. C. Gower at the International Conference on Taxonomy of Leishmania, in Montpellier and by J. N. Perry at a Conference on Attractant Pheromones, held in Hungary.

The 150th anniversary celebration of the Royal Statistical Society was held in London. R. J. Baker, P. G. N. Digby, C. J. Dyer, B. J. George, J. C. Gower, S. A. Harding, S. P. J. Kirby, P. W. Lane, J. A. Nelder, R. W. Payne, D. A. Preece, J. Riley, G. J. S. Ross, K. Ryder and R. P. White attended; J. A. Nelder gave a paper on 'Statistical computing'. J. C. Gower devised display boards, now a permanent feature in the Department, showing statistical development at Rothamsted from the early days to the present. J. C. Gower, J. A. Nelder and J. Riley gave talks to various regional groups of the RSS.

Professor C. Prado-Campos of the Pontificia Universidad Catolica de Chile visited (mid-January–March); Dr N. Carter of the Game Conservancy Board continued with us until March; Dr A. Kutylowski visited (March–May). Dr K. McRae from Agriculture Canada arrived in mid-August, Dr P. R. Wild of CSIRO, Australia arrived in October and Dr L. Underhill of the University of Cape Town arrived in December to visit the Department for varying periods.

PUBLICATIONS

Computing Unit

General Paper

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046/84 RES Network Cabling
047/84 Barcode Program: C39BARS.BAS
048/84 Interface Cables
049/84 R$TRANPLOT—Overhead Transparency Production

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050/84 CODE39 Barcodes Standards Guide
051/84 R$SURF (SURFACE II)
052/84 R$LIBSEARCH
053/84 SSM Microcomputer Products I04 Board for S100 Systems
054/84 Getting more from the EDT Editor
055/84 Lear Siegler Model 310 Serial Printer
056/84 Barcode Reading on the Epson HX20
057/84 Optimising DATATRIEVE Indexed Files
058/84 Mettler Balance Data Capture Program
059/84 Program APHIDS.BAS for the Epson HX20
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061/84 Plant Pathology Infestation System User Guide
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063/84 IDRIS (IMP variant) Operating System Command Summary
064/84 Entomology Department Potato Aphid System User Guide
065/84 Entomology Department Potato Aphid System Program Guide
066/84 Plant Pathology Airborne Micro-organism Samples Database Users Guide
067/84 Plant Pathology Airborne Micro-organism Samples Database Program Guide
068/84 RIS Tape Management System User Guide
069/84 RIS Tape Management System Software Guide
070/84 RIS Tape System Input Forms
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