

# The Veterinary Record



Founded by WILLIAM HUNTING, FRCVS in 1888

**The Official Journal of the British Veterinary Association**

Editor: Edward Boden MPS

**VOLUME 105**  
**JULY TO DECEMBER 1979**

**THE BRITISH VETERINARY ASSOCIATION**  
7 Mansfield Street, London, W1M 0AT

# INDEX TO VOLUME 105, 1979

Names and authors are printed in capitals. Entries for Correspondence, Parliamentary Questions, Reviews and Short Communications are indicated by the use of symbols (C), (P), (R) and (SC) respectively.

## A

- ABBAS, B. *and others* The aetiology of a keratoconjunctivitis occurring in goats in the Sudan, 348
- Aberdeen, 48, 205
- Abortion, enzootic, 397
- mycotic, 331 (SC)
- Abstracts, 36, 82, 103, 105, 117, 121, 126, 164, 199, 233, 247, 272, 284, 296, 329, 343, 347, 353, 391, 394, 400, 423, 436, 443, 469, 491, 535, 578
- Aciproazine, 21 (C), 405 (C)
- Acetylpromazine, 397 (SC)
- Acholeplasma axanthum*, 100
- *laidlawii*, 100
- Acupuncture, 273, 541 (C)
- ADAMS, C. E. Anaesthesia of the ranch mink (*Mustela vison*) and ferret (*Mustela putorius furo*), 492 (SC)
- ADAMS, C. M. *see* WEAVER, A. D., 147
- ADENE, D. F. *see* FATUNMBI, O. O., 330
- Adenovirus antibody, 216
- ADETOSOYE, A. I. and AWAD-MASALMEL, M. Drug resistance in *Escherichia coli* isolated from diarrhoeic piglets, 306 (SC)
- Advertisement, vulgar, 475 (C), 516 (C), 582 (C)
- Advertisements, irritating, 404 (C)
- Aflatoxin, 492 (SC)
- African swine fever, 61 (SC)
- AFSHAR, A. and TADAYON, R. A. Rotavirus in diarrhoeic calves in Iran, 400 (SC)
- Agricultural Research Council, 544
- Training Board, 303
- Agriculture, Ministry of, staff changes, 135, 177, 259, 384, 545
- Airport animal deaths, 290, 311, 427 (C)
- AKPOKODJE, J. U. *see* OSUAGWUH, A. I. A., 125
- Albendazole, 98
- ALEXANDER, D. J. *and others* Isolation of Newcastle disease virus from a wild mallard duck (*Anas platyrhynchos*), 328 (SC)
- ALLAN, E. *see* WISEMAN, A., 469
- ALLAN, W. H. *see* ALEXANDER, D. J., 328
- ALLEN, J. G. *and others* The effect of lupinosis on liver copper, selenium and zinc concentrations in merino sheep, 434
- ALLEN, W. D. *see* PORTER, P., 516
- ALLEN, W. E. *and others* Evaluation of uterine tube function in pony mares, 364
- ALLEN, W. R. *see* JACKSON, P. S., 122
- ALTMAN, S. *see* JANSSENS, L., 273
- Anaesthesia of mink and ferret, 492 (SC)
- Anaesthetic risks, 427 (C)
- side effects, 109 (C), 152 (C), 288 (C)
- Analgesia of goats, 278
- ANGUS, K. W. and GARDINER, A. C. Mesangiocapillary glomerulonephritis in Dorset-Finnish landrace cross lambs, 471 (SC)
- Animal disease information service, 68
- Health Trust, 44
- housing, 266
- Nursing Auxiliaries, 21 (C), 171
- production, 5
- trade, 478
- welfare, 20 (C), 24 (P), 87, 363 *see also* Farm Animals Welfare Council
- Anthrax experiments, 68
- Antibiotics and fish, 496 (C)
- illegal sales, 113, 290, 362
- Antler velvet, harvesting, 263, 427 (C), 475 (C), 498, 581 (C)
- Anuria in bulls, 60 (SC)
- APPEL, M. J. G. *and others* Isolation and immunisation studies of a canine parvo-like virus from dogs with haemorrhagic enteritis, 156
- APPLEBY, R. C. Antibodies to bovine syncytial virus in dairy cattle, 80 (SC)
- Appointments, overseas, 427 (C)
- ARCHER, R. K. Congenital vitamin K dependent blood clotting factors in day-old turkey poults, 65 (C)
- ARMOUR, J. *and others* Observations on ostertagiasis in young cattle over two grazing seasons with special reference to plasma pepsinogen levels, 500
- ARMOUR, J. *see* BAIRDEN, K., 33; DUNCAN, J. L., 444; GETTINBY, G., 57
- ARONOVICI, A. *see* LIPKIND, M. A., 534, 577
- ARTHUR, G. H. Identifying etymological problems, 405 (C)
- Ascariasis, 16 (SC)
- ASHDOWN, R. R. *see* DONE, S. H., 520
- ASHLEY, A. S. *see* ROWE, B., 468
- ASHTON, D. G. Mebendazole toxicity in birds, 109 (C)
- Association of the British Pharmaceutical Industry. Compendium of Data Sheets for Veterinary Products, 204 (C)
- Ataxia, 91
- ATHERTON, J. C. *see* CHAPMAN, D. I., 573
- Aujesky's control using vaccine, 68
- disease, 1 (P), 88, 89, 260 (C)
- eradication, 293
- Aural surgery, canine, 85 (C)
- Avermectins, anti-parasitic, 168
- AWAD-MASALMEL, M. *see* ADETOSOYE, A. I., 306

## B

- Badger problem, 313
- Badgers, ill health and natural death, 546
- BAGNALL, B. G. IBR vaccine, 238 (C)
- BAINES, D. M. *and others* Field studies with thiophanate given as a 14-day low level in-feed anthelmintic to pigs, 81 (SC)
- BAINES, D. M. *see* DUNCAN, J. L., 444
- BAIRDEN, K. *and others* Bovine ostertagiasis: a changing epidemiological pattern?, 33
- BAIRDEN, K. *see* ARMOUR, J., 500; DUNCAN, J. L., 444; GETTINBY, G., 57
- BAKER, G. J. Tracheal collapse, 334 (C)
- BAKER, J. R. *see* WYN-JONES, G., 251
- BALL, H. J. *see* BRYSON, D. G., 566; MCCAUGHEY, W. J., 576
- BALLS, D. Dealing with data, 428 (C)
- BANATVALA, J. E. *see* CHRYSTIE, I. L., 405
- BANTRING, A. de L. Foot rot in sheep, 359 (C)
- BARBER, D. M. L. Foot rot in sheep, 194
- BARLOW, R. M. Further observations on bovine familial convulsions and ataxia, 91
- BARNARD, B. *see* SIMPSON, V. R., 329
- BAZELEY, K. J. *see* DAGLISH, R. A., 427
- BECKINGHAM, D. J. Hind-limb weakness in dogs, 41 (C)
- BEDFORD, P. G. C. Congenital vestibular disease in the English cocker spaniel, 530
- Belgian shepherd dogs, 427 (C), 496 (C)
- BELL, W. J. *see* CURTIS, R., 354
- BENDIXEN, G. *see* KRISTENSEN, S., 422
- BENITEZ-USHER, C. *see* GETTINBY, G., 57
- BENJAMIN, M. M. Outline of veterinary clinical pathology, 3rd ed, 202 (R)
- BENSON, G. J. *see* NELSON, D. R., 278
- Benzimidazole, 470
- anthelmintics, 261 (C)
- BERRETT, S. and HEBERT, C. N. A semi-quantitative spot test for glutathione peroxidase in blood of cattle and sheep for the assessment of biological selenium status, 145
- BICK, J. Toxic preservative, 152 (C)
- BLACKMORE, D. K. Non-penetrative percussion stunning of sheep and calves, 372
- BLADES, J. A. *see* CHIDLOW, J. W., 437; PORTER, P., 516
- BLANDFORD, T. B. *and others* Squamous cell carcinomas in broilers, 334 (C)
- BLAXTER, Sir K. Economic factors unfavourable to veterinary practice, 241
- BLAXTER, Sir K. The limits to animal production, 5
- Blood clotting factors, 65 (C)
- sports, 541 (C)
- BLOXHAM, P. A. *and others* Selenium status of cattle in Devon, 201 (SC)
- BOGAN, J. A. *see* MARRINER, S., 261; SNOW, D. H., 26
- BONGSO, T. A. Sedation of the Asian elephant (*Elephas maximus*) with xylazine, 442
- Books received, 170, 447
- BOOTH, P. G. An interesting case history, 85 (C)
- Bordetellosis, canine, 51

- BORLAND, E. D. An incident of suspected furazolidone toxicity in pigs, 169 (SC)
- BORLAND, L. *see* ALEXANDER, D. J., 328
- BORO, B. R. *see* SARMA, G., 331
- Bovine diarrhoea virus, 336 (C)
- familial convulsions, 91
- BOWDEN, N. Canine aural surgery, 85 (C)
- BRADLEY, R. *see* CAWLEY, G. D., 398
- BRAEND, M. World veterinary manpower: comparative aspects, 77
- BRANCKER, W. M. Antibiotics and fish, 496 (C)
- BRAUND, K. G. *and others* Idiopathic facial paralysis in the dog, 297
- BREEZE, R. G. *see* MCCANDLISH, I. A. P., 9
- BREMNER, A. S. *see* BLANDFORD, T. B., 335
- BRIDGER, J. C. *see* MARTIN, H. T., 256
- BRISCOE, M. G. *see* COLES, G. C., 470
- BRISTOL UNIVERSITY, 107, 540
- British Equine Veterinary Association, 454
- British Small Animal Veterinary Association, 564
- Clinical Studies Trust Fund, awards, 204 (C)
- Congress, 403
- BRITISH VETERINARY ASSOCIATION, 84, 260, 580
- Animal Welfare Committee, 559
- Annual General Meeting, 310, 376
- Articles of Association, 203
- Committee Chairmen, 128
- Congress, 239, 315, 338
- Congress, 179 (summaries of scientific papers)
- Congress, Exhibition of products and services, 208
- Council, 18, 332
- Education and Technical Development Committee, 129, 538
- Bovine ketosis and its prevention, (Hibbitt), 13
- Tendon injuries and their treatment, (McCullagh *and others*), 54
- Foot rot in sheep (Barber) 194
- Euthanasia of horses (Oliver), 224
- Pyloric stenosis in the dog (Pearson), 393
- Equine Subcommittee, 401
- Executive Committee, 127
- European and Overseas Committee, 39, 129, 514
- General Purposes Committee, 62, 127, 149, 425, 579
- Honorary Membership, 312 (C)
- Large Animals Committee, 129, 449
- Poultry Subcommittee, 401
- President, 265
- Publications Committee, 106, 130, 402
- Public Health Committee, 130, 513
- /RSPCA Liaison Committee, 356
- Salaries and Appointments Committee, 18, 128, 472
- Small Animals Committee, 130, 494
- UKASTA/BVA/ADAS Headquarters Liaison Committee, 236
- British Veterinary Dermatology Study Group, 455
- British Veterinary Hospital Association, 430
- BROWN, R. H. *see* SWIFT, G. A., 65
- BROWNLIE, J. *see* GOURLAY, R. N., 100
- BROWNLIE, S. E. *see* MCTAGGART, H. S., 36
- Brucella abortus*, 305 (SC)
- Brucellosis compensation, 479
- eradication, 362
- in Scotland, 564
- Brushes with the law, 497
- BRYSON, D. G. *and others* The experimental production of pneumonia in calves by intranasal inoculation of parainfluenza type 111 virus, 566
- Bugs, veterinary, 288 (C)
- BULMAN, D. C. A possible influence of the bull on the incidence of embryonic mortality in cattle, 420
- BUTLER, E. J. *see* PEARSON, A. W., 200
- C
- C. pectinata*, 375 (SC)
- Calving difficulty, predictions, 533 (SC)
- Cambridge University, Duke's visit, 544
- Campylobacter, 451 (C)
- Campylobacter coli/jejuni*, 333 (C)
- Campylobacter infections, 80 (SC), 333 (C)
- Campylobacter mastitis, 333 (C)
- Campylobacteriosis, venereal, 295
- Canine emergency—unusual case, 173 (C)
- Topics, 386
- Carbon fibre implants, 223, 312 (C), 359 (C)
- Cardiac anomaly, 527
- arrest, 273
- Caribou (*Rangifer tarandus*), 336 (C)
- CARMICHAEL, L. E. *see* APPEL, M. J. G., 156
- Carpal check ligament, 66 (C)
- CARTER, D. Practice management—Defending a claim for unfair dismissal—some observations on self-representation, 234
- CARTER, H. E. Overseas appointments, 427 (C)
- Castration, immunological, 556 (SC)
- Cat owner's encyclopedia of veterinary medicine, 447 (R)
- Cattle imports, 519
- CAWLEY, G. D. *and* BRADLEY, R. Presumed congenital myodegeneration in a calf, 398 (SC)
- Centaur Services, 314
- Central nervous system, isolation of mycoplasma from, 102 (SC)
- Veterinary Society, 134
- Cerebrocortical necrosis, 480
- Certificates for emergency slaughter, 171, 172 (C), 562 (C)
- CHADWICK, M. Acupuncture treatment of cats, 541 (C)
- CHAKRABARTI, A. *and others* Dirofilarial haematuria in a dog, 238 (C)
- CHANDLER, N. Phenylbutazone toxicity in ponies, 108 (C)
- CHANDLER, N. Swabbing mares and stallions for CEM, 561 (C)
- CHAPMAN, D. I. *and others* Yersiniosis in a free-living fallow deer, 573
- CHAPMAN, N. G. *see* CHAPMAN, D. I., 573
- CHASEY, D. *see* DAWSON, M., 220
- CHIDLOW, J. W. *and others* Sow vaccination by combined oral and intramuscular antigen: a field study of maternal protection against neonatal *Escherichia coli* enteritis, 437
- China visit, 174 (C)
- CHINEME, C. N. *and others* Enteritis associated with *Eimeria leuckarti* infection in donkeys, 126 (SC)
- CHINEME, C. N. *see* GYANG, E. O., 255
- Chlamydia, ovine, 574
- Chlorhexidine gluconate, 122, 305 (SC)
- CHRISTIANSEN, K. H. *see* ELLIOTT, R. E. W., 170
- Chromosome 1 of cattle, 102 (SC)
- CHRYSSTIE, I. L. *and others* Rotavirus infection in a domestic cat, 404 (C)
- CIFELLI, S. *see* OSTLIND, D. A., 168
- CLARKE, P. B., RSPCA and Farm Animal Welfare Council, 561 (C)
- CLARKE-WILLIAMS, J. F. *and others* Some observations on the prediction of calving difficulty, 533 (SC)
- CLAYTON, H. M. *and others* Equine parasite control using pyrantel embonate, 389
- Cleft palate, 255 (SC)
- Clinical competence, 110 (C)
- Cloprostenol, 168 (SC)
- Clostridial vaccines, 551
- Clostridium sporogenes*, 480
- Clumber spaniel collapse syndrome, 334 (C), 405 (C)
- COCKRILL, T. *see* COULSON, A., 440
- Code of practice for injecting poultry, 519
- Codes of Recommendation for the Welfare of Livestock, 564
- Coenurosis, 21 (C)
- COLES, G. C. *and others* The activity of levamisole resistant *Haemonchus contortus* and *Trichostrongylus colubriformis*, 470 (SC)
- Colibacillosis, enteric, 159
- Colostrum deprivation, 11
- Comfrey, 42 (C)
- Comment
- The profession's attitude to animal welfare, 1
- Getting the name right, 23
- The UK and the World Veterinary Association, 43
- Helping Aunt Sally, 43
- Animal Welfare, Conservative style, 87
- Health mark for fowl, 111
- Giving value for money, 111
- From factotum to scientific clinician, 133
- Getting the form right, 153
- Looking forward, 175
- . . . and now Aberdeen '79, 205
- The stealthy salmonella, 206
- Medical myths and animal welfare, 263
- BVA Congress, 239
- Safeguarding the rural environment, 289
- Congenital and inherited diseases, 313
- Hazards on the road to the future, 337
- Legislating for experimental animals, 361
- Change in farm building standards, 383
- Promoting health and welfare of pets, 407
- RSPCA and farm animal welfare: a surprising decision, 429
- Making the right decisions on meat hygiene, 453
- Figures and fiction, 477
- Brushes with the law, 497
- The price of poor relations, 517
- Predicting the future, 543
- The end of a decade, 563
- Companion animal bond, 476 (C)
- "Computeritis", 85 (C)
- Congenital diseases, 313, 318
- CONNOR, T. J. *see* BRYSON, D. G., 566
- Cooperia punctata*, 375 (SC)
- Cooperiasis, 399 (SC)

COOPER, J. E. and ELEY, J. T. First aid and care of wild birds, 170 (R)  
 COOPER, J. H. Anaesthetic side effects, 288 (C)  
 CORMIE, J. L. Anaesthetic side effects, 152 (C)  
 CORNWELL, C. see MCCANDLISH, I., 540  
 CORNWELL, H. J. C. see MCCANDLISH, I. A. P., 167  
*Corynebacterium renale*, 301  
 COULSON, A. Dinoprost in pyometritis in the bitch, 151 (C)  
 CRAIG, G. R. see KERRY, J. B., 551  
 CRIGHTON, G. W. see WOOLCOCK, P. R., 30  
 CRITTALL, J. L. W. see PROLE, J. H. B., 581  
 CROUCH, J. R. F. Klebsiella infections in mares, 335 (C)  
 Cruelty to Animals Act, 1876, 2  
 — advisory committee, 24 (P)  
 CURTIS, R. and others Polyarteritis in a cat, 354 (SC)  
 CUSH, P. F. see BRYSON, D. G., 566  
 CUSHNIE, G. H. and others Cerebrocortical necrosis in ruminants: effect of thiaminase type 1-producing *Clostridium sporogenes* in lambs, 480  
 Cystic jaw lesion, 467 (SC)

## D

DALGLISH, R. A. and BAZELEY, K. J. Anaesthetic risk to tervuerens, 427 (C)  
 Dairy farming film, 455  
 DARCEL, C. le Q. Use of modified live bovine herpesvirus 1 (LBR) vaccines, 404 (C)  
 DARDIRI, A. H. see HAMDY, F. M., 445  
 DARROCH, R. A. see HINTON, M., 303  
 DAS, S. N. see CHAKRABARTI, A., 238  
 Data, dealing with, 118, 141, 196, 323, 366, 428 (C), 476 (C)  
 DAVID, J. S. E. see FRANK, C. J., 395  
 DAVIDSON, A. P. RCVS elections, 66 (C)  
 DAVIES, A. B. see TAYLOR, K. C., 35  
 DAVIES, G. L. Dinoprost in pyometritis in the bitch, 109 (C)  
 DAVIES, J. see HOLDSWORTH, R. J., 535  
 DAVIES, K. A. Potential speakers, 110 (C)  
 DAVIS, G. W. see BLOXHAM, P. A., 201  
 DAWSON, M. and others The demonstration of maedi/visna virus in sheep in Great Britain, 220  
 DAY, R. H. see DAWSON, M., 220  
 DEAN, S. P. see MCBEATH, D. G., 507  
 Deer Bill, 519  
 — farming, 263  
 Deformed goat birth, 359 (C)  
 DEMPSTER, D. G. see GALBRAITH, H., 283  
 DENNIS, P. see GASKELL, R. M., 243  
 DENNIS, S. M. Hypospadias in merino lambs, 94  
 DENNIS, S. M. Urogenital defects in sheep, 344  
 Deworming of cows, 315  
 Diaphragmatic defect, congenital, 251  
*Dictyocaulus viviparus* infection, 15 (SC)  
 Dimetridazole, 85 (C)  
 Dinoprost, 64 (C), 109 (C), 131 (C), 151 (C), 261 (C), 440, 452 (C)  
 Disease control programmes, 504  
 — outbreaks, 4, 44, 68, 259, 314, 385, 409, 431, 479, 499, 519, 545  
 Diseases, congenital and inherited, 313, 318  
 — of Animals (Declaratory Amendment) Bill, 431  
 — of Animals (Miscellaneous Fees) (Revocation) Order, 1979, 431  
 Dog disease, mystery, 517  
 — warden handbook, 447 (R)  
 Dismissal, unfair, 234  
 Dogs Bill delay, 112  
 DONALDSON, R. S. Firing of horses, 173 (C)  
 DONE, S. H. and others Detachment of the ischial tuberosity in sows, 520  
 "Doping" of horses, 25  
 DOUGLAS, T. A. see SNOW, D. H., 26  
 DOW, J. K. see WILKINS, D. B., 451  
 DRAGER, N. see SIMPSON, V. R., 61  
 Drug development cost warning, 67  
 — sales, illicit, 133  
 DUBLIN UNIVERSITY, 107, 386  
 DUCKHAM, T. N. Salmonellosis, 110 (C)  
 Duck virus hepatitis, 30  
 DUFF, H. M. M. Firing of horses, 381 (C)  
 DUNCAN, I. D. see GRIFFITHS, I. R., 405  
 DUNCAN, J. L. and others The efficacy of thiophanate against gastrointestinal nematodes of cattle including inhibited larvae of *Ostertagia ostertagi*, 444 (SC)  
 DUNCAN, J. L. see ARMOUR, J., 500; CLAYTON, H. M., 389  
 Durham ox, 25  
 DYSON, D. A. and SPENCE, J. A. A cystic jaw lesion in sheep, 467 (SC)  
 DYSON, D. A. see LINKLATER, K. A., 387

## E

EARLY, J. L. see MARTIN, H. T., 256  
 EASTON, N. J. VAT, 65 (C)  
 Economics in farm practice, 523  
 Ecthyma, contagious, 60 (SC)  
 EDINBURGH UNIVERSITY, 50, 108  
 EDNEY, A. T. B. Human-companion animal bond, 476 (C)  
 Education, 50, 107, 363, 565  
 — extramural, 351  
 EGLIN, R. M. see LANG, S. M., 397  
*Eimeria leuckarti* infection, 126 (SC)  
 ELAZHARY, Y. and others Serological evidence of IBR and BVD infection in caribou (*Rangifer tarandus*), 336 (C)  
 Elephant, sedation, 442  
 ELEY, J. T. see COOPER, J. E., 170  
 ELIASSON, E. C. see MUHAMMED, S. I., 11  
 ELISA, 360 (C)  
 ELLIOTT, C. K. Agricultural medicine, 358 (C)  
 ELLIOTT, R. E. W. and CHRISTIANSEN, K. H. editors Brucellosis: a veterinarian's guide to the literature, 170 (R)  
 ELLIS, P. R. and JAMES, A. D. The economics of animal health — (1) Major disease control programmes, 504 (2) Economics in farm practice, 523  
 ELLIS, R. N. W. Insurance problems, 86 (C)  
 EL REFAH, A. H. and MICHAEL, S. A. The effect of imidocarb dipropionate in anuria of unknown aetiology in Egyptian bulls, 60 (SC)  
 Embryo mortality in cattle, 420  
 — transfer, 432  
 — meeting, 149  
 Enteritis, 451 (C)  
 — haemorrhagic, 156  
 Enteropathogens, recycling, 515 (C)  
 Enzootic bovine leucosis, 68  
 Eosinophilia, 232 (SC)  
 Equine treatments, progress, 285  
 ERDTMANN, B. see MORAES, J. C. F., 102  
 ERNIC, 431, 542 (C)  
*Escherichia coli*, 306 (SC)  
 — diarrhoea, 228  
 — enteritis, 437  
 Etymological problems, 405 (C), 452 (C), 476 (C), 542 (C)  
 European Association for Animal Production, Conference, 175  
 — Economic Community, 178  
 — meat hygiene proposals, 544 (P)  
 — to report on egg batteries, 314  
 Euthanasia of horses, 224  
 EVANS, P. see BAINES, D. M., 81  
 EWART, J. M. see JONES, M. G. S., 492  
 Experiments on living animals, 113, 518  
 Experimental animals, legislating for, 361, 478, 495 (C)

## F

FABIYI, J. P. and others Late dry season outbreak of clinical haemonchosis and cooperiasis in cattle of Northern Nigeria, 399 (SC)  
 FABIYI, J. P. and others Thiophanate in the treatment of *Cooperia punctata*, *C. pectinata* and *Haemonchus placei* in cattle, 375 (SC)  
 Factory farming film, 44 (P)  
 Fallopian tube test, 414  
 Farm Animals Welfare Council, 429, 430, 515 (C), 541 (C), 543, 561 (C),  
 — building standards, 383  
 FATUNMBI, O. O. and ADENE, D. F. Occurrence and pathogenicity of tetramerisias in guinea fowl and chickens in Nigeria, 330 (SC)  
 Fees, 310, 431  
 — LVI, 84  
 Fenbendazole, 204 (C), 261 (C), 507  
 FENWICK, G. R. see PEARSON, A. W., 200  
 FERREIRA, M. C. S. and others *Campylobacter*, dogs and human enteritis, 451 (C)  
 Ferret, anaesthesia, 492 (SC)  
 — and Ferreting Society, 86 (C)  
 FEY, H. see NICOLET, J., 301  
 Films, 44 (P), 545  
 FINDLAY, M. A. Veterinary Visual Journal, 288 (C)  
 Firing of horses, 108 (C), 173 (C), 312 (C), 381 (C), 451 (C), 476 (C)  
 Fish conference, 545  
 FISHER, E. see MCCANDLISH, I., 540  
 FISHER, E. W. "Streak's" ventricular septal defect, 382 (C)  
 FISHER, E. W. see NASH, A. S., 71  
 Fisheries conference, 132 (C)

- FLAGSTAD, A. *see* KRISTENSEN, S., 422  
 FLANNIGAN, I. Liverpool orthopaedic refresher courses, 406 (C)  
 FLANNIGAN, I. Tortoiseshell tom, 382 (C)  
 FLEMING, M. P. *see* TRIBE, G. W., 333  
 FLOWERS, M. J. *see* DAWSON, M., 220  
 Fly infestation, 341  
 Food animal welfare, 562 (C)  
 Footrot in sheep, 194, 359 (C)  
 Form procedure, 153  
 FORMSTON, C. *and* PENNY, R. H. C. Retirement of Professor G. H. Arthur, 582 (C)  
 Fox grants, 89 (P)  
 Fractures, femoral neck, 248  
 Frank Drury memorial prize for anatomy, 174 (C)  
 FRANK, C. J. *and* others Code of practice for the control of contagious equine metritis and other equine venereal diseases for the 1980 covering season, 395  
 FRAPE, D. L. *see* BAINES, D. M., 81  
 FRASER, A. C. Firing horses, 312 (C)  
 FRASER, H. M. *see* ROBERTSON, I. S., 556  
 FRECHETTE, J. L. *see* ELAZHARY, Y., 336  
 From the Schools, 50, 107, 172, 203, 386, 540  
 Furazolidone toxicity, 169 (SC)  
 FURMINGER, I. G. S. *see* ROBERTSON, W. W., 258  
*Fusarium tricinctum*, 252  
 FUSELIER, R. H. *see* WILLIAMS, J. C., 98

## G

- GALBRAITH, H. *and* DEMPSTER, D. G. Effect of hexoestrol on the response of finishing steers to treatment with trenbolone acetate, 283  
 GALLAGHER, J. *and* NELSON, J. Cause of ill health and natural death in badgers in Gloucestershire, 546  
 GARDINER, A. C. *see* ANGUS, K. W., 471  
 GASKELL, C. J. *see* GASKELL, R. M., 243  
 GASKELL, R. M. *and* others Studies on a possible viral aetiology for the feline urological syndrome, 243  
 GEE, R. W. ELISA detection of antibody against mycoplasma, 360 (C)  
 GEE, R. W. Legislating for experimental animals, 495 (C)  
 German veterinary specialisation, 147, 291  
 GETTINBY, G. *and* others A prediction model for bovine ostertagiasis, 57  
 GILBERT, G. A. *see* CLAYTON, H. M., 389  
 GILL, K. P. W. *see* LANDER, K. P., 333  
 GLASGOW UNIVERSITY, 107, 540  
 Glomerulonephritis, 471 (SC)  
 GLOSSOP, C. *and* HODSON, N. Frank Drury memorial prize for anatomy, 174 (C)  
 Glutathione peroxidase, 145  
 Goat conference, 66 (C)  
 — Veterinary Society, 453  
 GODFREY, C. Poor style and abuse of words, 476 (C)  
 GOLDWATER, P. N. *see* CHRYSTIE, I. L., 405 (C)  
 GOODSHIP, A. E. *see* MCCULLAGH, K. G., 54  
 GOURLEY, J. Blood sports, 541 (C)  
 COURLEY, R. N. *and* others Inoculation of *Acholeplasma laidlawii* strains and *Acholeplasma axanthum* into the bovine mammary gland, 100  
 GRACE, M. Importance of labelling and records, 203 (C)  
 GRACEY, J. F. Welfare in slaughterhouses, 381 (C)  
 GRAHAM-JONES, O. Agricultural medicine, 452 (C)  
 GRAHAM-JONES, O. Animals stranded at airport, 311 (C)  
 GREENHAM, L. W. *and* WARE, G. C. Mustelid anaesthesia and halothane hepatitis, 104 (SC)  
 GREER, F. G. Veterinarian's China visit, 174 (C)  
 GREEVES, P. R. *and* WITHERINGTON, D. H. Horse markings: their importance to the integrity of racing and breeding, 213  
 GRIFFIN, R. M. Sensitivity of treponemes to dimetridazole, 85 (C)  
 GRIFFITHS, I. R. *and* DUNCAN, I. D. Collapsing Clumber spaniels, 405 (C)  
 GRIMSHAW, W. T. R. *and* others Bovine leucosis (lymphosarcoma): a clinical study of 60 pathologically confirmed cases, 267  
 GRIPPER, J. N. Pet health insurance, 132 (C)  
 Groundnut meal, contaminated, 492 (SC)  
 GRUNSELL, C. S. G. *see* KING, J. O. L., 476  
 GYANG, E. O. *and* others Microcephaly associated with kyphoscoliosis and cleft palate in a Yankassa lamb, 255 (SC)
- HADLEY, J. Who carries the can?, 424  
 HADLEY, J. You and your premises, 512  
 HADLEY, J. Your business premises, 136  
 Haematuria, dirofilarial, 238 (C)  
 Haemonchosis, 399 (SC)  
*Haemonchus contortus*, 470 (SC)  
 — *placei*, 375 (SC)  
 Haemorrhagic syndromes, 252  
 HALL, M. L. M. *see* THRELFALL, E. J., 21  
 HALL, R. The activity of chlorhexidine gluconate against *Brucella abortus*, 305 (SC)  
 HALL, R. *see* JACKSON, P. S., 122  
 HALL, S. A. Poor style and abuse of words, 452 (C)  
 HALL, S. A. Veterinary research and the EEC, 178  
 Halothane hepatitis, 104 (SC)  
 HAMDY, F. M. *and* DARDIRI, A. H. Enzyme-linked immunosorbent assay for the diagnosis of African swine fever, 445 (SC)  
 HAMER, J. *see* COULSON, A., 440  
 HANNAM, R. W. Cause of sloughing, 151 (C)  
 HARBORD, R. S. VAT, 132 (C)  
 HARGREAVES, B. Unabsorbable sutures warning, 516 (C)  
 HARKNESS, J. W. *see* MORZARIA, S. P., 410  
 HARRIS, D. L. *see* JOENS, L. A., 463  
 HARRIS, J. W. *see* MCMARTIN, D. A., 574  
 HARRISON, V. A. Pet health insurance schemes, 41 (C)  
 HARVEY, D. G. Honorary membership, BVA, 312  
 HARVEY, M. J. *see* WEAVER, A. D., 230  
 HATCH, P. *see* SMYTH, G. B., 248  
 HAXBY, D. L. Useful service, 204 (C)  
 HAXBY, D. L. Vulgar advertisement, 582 (C)  
 HAYES, A. W. *see* PATTERSON, D. S. P., 252  
 Hazards on the road to the future, 337, 339  
 HEAD, K. W. *see* MCTAGGART, H. S., 36  
 Health and Safety at Work Act: a guide for veterinary practices, 16 (R)  
 HEATH, E. *and* KUKRETI, J. P. Persistent truncus arteriosus communis in a two-year-old steer, 527  
 HEBERT, C. N. *see* BERRETT, S., 145  
 HEEVER, L. W. VAN DEN, Antibacterial properties of udder creams and ointments, 238 (C)  
 HENDERSON, D. B. *see* HOSIE, B. D., 80  
 HENRY, A. C. *see* LANG, S. M., 397  
 Hepatitis, duck virus, 30  
 — sequel to halothane, 104 (SC)  
 Herpesvirus, isolation, 256 (SC)  
 — vaccines, 404 (C)  
 — 1 vaccine, bovine, 451 (C)  
 HERRTAGE, E. *and* HOULTON, J. E. F. Collapsing Clumber spaniels, 334 (C)  
 Hexoestrol, 283  
 HIBBITT, K. G. Bovine ketosis and its prevention, 13  
 HILL, A. C. Mycoplasma isolation from the central nervous system, 102 (SC)  
 HILL, A. W. *and* SHEARS, A. L. Recurrent coliform mastitis in the dairy cow, 299  
 HILLIDGE, C. J. Section of carpal check ligament, 66 (C)  
 HILLS, L. D. Comfrey: information sought, 42 (C)  
 Hind-limb weakness in dogs, 41 (C)  
 HINTON, M. *and* DARROCH, R. A. Organisation and function of the Agricultural Training Board, 303  
 HITCHCOCK, L. M. *and* SCARNELL, J. Canine parvovirus isolated in UK, 172 (C)  
 HODSON, N. *see* GLOSSOP, C., 174  
 HOLDSWORTH, R. J. *and* DAVIES, J. Measurement of progesterone in goat's milk: an early pregnancy test, 535 (SC)  
 Holiday exchanges and au pair, 45, 357, 386  
 HOOGSTRAAL, H. *see* MEEGAN, J. M., 124  
 HOPKINS, G. F. *see* JOHNSTON, W. S., 526  
 HOPKINS, R. J. Animals at Rome airport, 427 (C)  
 Horse markings, 213  
 — sale code, 89  
 HOSIE, B. D. *and* others *Campylobacter* infections in normal and diarrhoeic dogs, 80 (SC)  
 Houghton Poultry Research Station, 111, 113  
 HOULTON, J. E. F. *see* HERRTAGE, E., 334  
 HOWARD, C. J. *see* GOURLAY, R. N., 100  
 HUMPHREY, M. VAT on veterinary services, 237 (C)  
 HUNT, P. S. Snaring survey, 132 (C)  
 HUNTER, A. R. *see* MCMARTIN, D. A., 574  
 Hydatidosis, equine, 335 (C)  
 Hypospadias in lambs, 94

## I

- IBR vaccine, 238 (C), 474 (C)  
 Illegal antibiotic sales, 113, 290, 362  
 Imidocarb dipropionate, 60 (SC)  
 IMLAH, P. *see* MCTAGGART, H. S., 36  
 Immobilisation of sea lions, 465

## H

- HADLEY, J. Collecting money due, 355  
 HADLEY, J. Don't rush to judgment, 45

Import of cattle from Eire, 564  
 IMRAY, W. S. Use of dinoprost, 452 (C)  
 Inactivated respiratory viral vaccine, 410  
 Infectious bovine rhinotracheitis, 317, 469 (SC)  
 — bovine tracheitis, 3  
 Infertile cows, investigations, 489  
 Influenza, equine, 43, 544  
 — vaccination, equine, 404 (C)  
 — virus, avian, isolation, 534 (SC), 558 (SC)  
 — virus isolation, 510 (SC)  
 Influenza viruses, avian, identification, 558 (SC)  
 Inherited diseases, 313, 318  
 Insemination, timing, 542 (C)  
 Institute of Animal Physiology, Babraham, 24, 44 (P)  
 Insurance companies, 86 (C)  
 — schemes, 41 (C)  
 International Symposium on Veterinary Epidemiology and Economics, 2nd, 2  
 Intestinal perforation, 16 (SC)  
 IRWIN, D. *see* MCCAUGHEY, W. J., 576  
 Ischial tuberosity, 520

## J

JACKSON, P. G. G. Treatment of canine pyometra with dinoprost, 131 (C)  
 JACKSON, P. S. Timing of insemination after LH treatment, 542 (C)  
 JACKSON, P. S. *and others* The irritancy of chlorhexidine gluconate in the genital tract of the mare, 122  
 JAMDAR, M. N. *see* CHINEME, C. N., 126  
 JAMES, A. D. *see* ELLIS, P. R., 504, 523  
 JANSEN, H. *see* KRISTENSEN, S., 422  
 JANSSENS, L. *and others* Respiratory and cardiac arrest under general anaesthesia: treatment by acupuncture of the nasal philtrum, 273  
 JENKINS, D. H. R. Carbon fibre in ligament and tendon repair, 312 (C)  
 JENNINGS, F. W. *see* ARMOUR, J., 500  
 JOENS, L. A. *and others* Comparison of selective culture and serologic agglutination of *Treponema hyodysenteriae* for diagnosis of swine dysentery, 463  
 JOHNSON, J. B. Firing of horses, 108 (C)  
 JOHNSTON, R. W. Intra rumen medication, 204 (C)  
 JOHNSTON, W. S. *and others* The possible involvement of seagulls (*Larus sp*) in the transmission of salmonella in dairy cattle, 526  
 JONES, C. R. V. Welfare in slaughterhouses, 237 (C)  
 JONES, D. E. Tracheal collapse, 333 (C)  
 JONES, D. M. *and* MANTON, V. J. A. Harvesting antler velvet, 475 (C)  
 JONES, M. G. S. *and* EWART, J. M. Effects on milk production associated with consumption of decorticated extracted groundnut meal contaminated with aflatoxin, 492 (SC)  
 JONES, R. S. Acepromazine in male horses, 405 (C)  
 JORDAN, W. J. Oil pollution and birds, 358 (C)  
 JUBB, S. C. Don't waste women graduates, 238 (C)

## K

K88 receptor, 228  
 Kennel Club chief, 409  
 Keratoconjunctivitis, 125 (SC), 348  
 KERRY, J. B. *and* CRAIG, G. R. Field studies in sheep with multi-component clostridial vaccines, 551  
 KESSY, B. M. *and* NOAKES, D. E. Determination of patency of fallopian tubes in the cow by means of phenosulphonphthalein and starch grain tests, 414  
 KESSY, B. M. *and* NOAKES, D. E. The use of the starch grain and phenosulphonphthalein tests to investigate infertile cows, 489  
 KESSY, B. M. *see* ALLEN, W. E., 364  
 Ketosis, bovine, 13  
 Kidney disease, proliferative, 330 (SC)  
 KING, A. A. *see* DAWSON, M., 220  
 KING, J. O. L. The effects of changes in the body-weight of cows on the composition of their milk, 116  
 KING, J. O. L. *and others* Retirement of Professor Arthur, 476 (C)  
 KINYON, J. M. *see* JOENS, L. A., 463  
*Klebsiella aerogenes*, 335 (C)  
 — infection, 335 (C), 475 (C)  
 KNOX, J. W. *see* WILLIAMS, J. C., 98  
 KOLTE, G. N. *see* VEGAD, J. L., 16, 446  
 KRISTENSEN, S. *and others* The absence of evidence suggesting that systemic lupus erythematosus is a zoonosis of dogs, 422 (SC)  
 KROGSRUD, J. *see* KUMMENEJE, K., 60

KUEBART, G. *see* SIMPSON, V. R., 329  
 KUKRETI, J. P. *see* HEATH, E., 527  
 KUMAR, N. *see* VEGAD, J. L., 16  
 KUMMENEJE, K. *and* KROGSRUD, J. Contagious ecthyma (orf) in reindeer (*Rangifer tarandus*), 60 (SC)  
 Kyphoscoliosis, 255 (SC)

## L

Labelling, importance of, 203 (C)  
 Laboratory animals, 113  
 — bill, 407  
 — council, 259  
 — shortage, 2 (P)  
 Lactation yield, 507  
 LAING, A. H. *see* MCTAGGART, H. S., 36  
 LAING, P. W. *see* CURTIS, R., 354  
 LAIRD, H. *see* MCCANDLISH, I. A. P., 167  
 LAKE, P. *see* BAINES, D. M., 81  
 LAMONT, P. H. Vaccination against IBR, 474 (C)  
 LANDER, K. P. *and* GILL, K. P. W. *Campylobacter mastitis*, 333 (C)  
 LANG, R. *see* OSTLIND, D. A., 168  
 LANG, S. M. *and others* Acetylpromazine administration: its effect on canine haematology, 397 (SC)  
 Large animal practice, 519, 543  
 LAWSON, W. J. *see* CUSHNIE, G. H., 480  
 LEACH, T. M. Meat products directive, 21 (C)  
 LEACH, T. M. RCVS elections, 22 (C)  
 LEACH, T. M. Welfare in slaughterhouses, 152 (C)  
 LEECH, F. B. *and* SELLARS, K. C. Statistical epidemiology in veterinary science, 474 (R)  
 LEES, P. *and* MICHELL, A. R. Phenylbutazone toxicity in ponies, 150 (C)  
 LEITCH, B. L. *see* YOUNG, A. S., 531  
 Leucosis, bovine, 267  
 — enzootic, 68  
 Levamisole, 470 (SC)  
 LEWIS, N. D. Feline lungworm infection, 65 (C)  
 Ligament repair, 223, 312 (C), 359 (C)  
 Lignocaine, 278  
 LINKLATER, K. A. *and* DYSON, D. A. Field studies on enzootic abortion of ewes in south-east Scotland, 387  
 LIPKIND, M. A. *and others* The first isolation of animal influenza virus in Israel, 510 (SC)  
 LIPKIND, M. A. *and others* Identification of avian influenza virus isolated from a turkey farm in Israel, 534 (SC)  
 LIPKIND, M. A. *and others* Identification of avian influenza viruses isolated from wild mallard ducks in Israel, 558 (SC)  
 LIPKIND, M. A. *and others* The isolation of yucaipa-like paramyxoviruses from epizootics of a respiratory disease in turkey poult farms in Israel, 577 (SC)  
 LITTLEWOOD, H. F. Carbon fibre in ligament repair, 359 (C)  
 LITTLEWOOD, H. F. Tendon injuries, 108 (C)  
 LITTLEWOOD, H. F. Treatment of sprained tendons in horses with carbon fibre implants, 223  
 Liver damage, 200 (SC)  
 LIVERPOOL UNIVERSITY, 50, 172, 203, 386, 565  
 LLOYD-EVANS, L. P. Clinical competence, 110 (C)  
 LLOYD-EVANS, L. P. Use of modified live bovine herpesvirus 1 vaccine, 451 (C)  
 LOGAN, E. F. *see* PEARSON, G. R., 159  
 LOGUE, D. N. Tortoiseshell tom, 381 (C)  
 LONDON UNIVERSITY, 107  
 LONG, S. E. Tortoiseshell tom, 382 (C)  
 LUCAS, M. H. *see* DAWSON, M., 220  
 LUCKE, J. N. *and* SANSOM, J. Penile erection in the horse after acepromazine, 21 (C)  
 LUGTEN, P. C. Disturbing trends, 359 (C)  
 Lungworm infection, feline, 65 (C), 85 (C)  
 Lupinosis, 434  
 Luteinising hormone levels, 440  
 LUTTGEN, P. J. *see* BRAUND, K. G., 297  
 Lymphosarcoma, 36 (SC), 267

## M

MCBEATH, D. G. *and others* The effect of a preparturient fenbendazole treatment on lactation yield in dairy cows, 507  
 MCCANDLISH, I. Canine parvovirus—a new disease, 292  
 MCCANDLISH, I. *and others* Parvovirus infection in dogs, 540 (C)  
 MCCANDLISH, I. A. P. *and* THOMPSON, H. Canine bordetellosis: chemotherapy using sulphadiazine-trimethoprim combination, 51

- MCCANDLISH, I. A. P. *and others* Hormone producing ovarian tumours in the dog, 9
- MCCANDLISH, I. A. P. *and others* Isolation of a parvovirus from dogs in Britain, 167 (SC)
- MCCAUGHEY, W. J. *and others* Ureaplasmas in sheep, 576 (SC)
- MCCULLAGH, K. G. *and others* Tendon injuries and their treatment in the horse, 54
- MCDONALD, M. Tracheal collapse in a Yorkshire terrier, 262 (C)
- MCDONALD, M. *see* WEAVER, A. D., 230
- MCDONALD, S. M. *see* PATTERSON, D. S. P., 252
- MCEWAN, A. D. *and others* Effects of anthelmintics on the pathology of *Dictyocaulus viviparus* infection in cattle, 15 (SC)
- MACKENZIE, G. M. *see* MAXWELL, M. H., 232
- MACKENZIE, J. N., Vulgar advertisement, 516 (C)
- MACKENZIE, P. S. *see* TRIBE, G. W., 333
- MACKIE, D. P. *see* PEARSON, J. K. L., 456
- MACKINNON, J. D. Klebsiella infections in mares, 475 (C)
- MACLACHLAN, G. K. *see* JOHNSTON, W. S., 526
- MCLACHLAN, I. *see* RANDALL, C. J., 41
- MCMARTIN, D. A. *and others* Experimental pneumonia in red deer (*Cervus elaphus* L) produced by an ovine chlamydia, 574
- MCNEILL, R. Weights and measures, 109 (C)
- MCNULTY, M. S. *see* BRYSON, D. G., 566
- MCTAGGART, H. S. *and others* The genetics of hereditary lymphosarcoma, 36 (SC)
- Maedi/visna virus, 220, 335 (C)
- MAGHUR, F. H. TSI slants and salmonella identification, 475 (C)
- MALES, R. *and* MALES, V. Foaling: brood mare and foal management, 202 (R)
- MALES, V. *see* MALES, R., 202
- Mallard ducks, influenza viruses, 558 (SC)
- MANLEY, F. H. A veterinary odyssey, 447 (R)
- MANTHORPE, R. *see* KRISTENSEN, S., 422
- MANTLE, P. G. *see* PENNY, R. H. C., 392
- MANTON, V. J. A. *see* JONES, D. M., 475
- MARRINER, S. *and* BOGAN, J. A. Ruminant bypass with benzimidazole anthelmintics, 261 (C)
- MARTIN, H. T. *and others* The isolation of herpesvirus from psittacine birds, 257 (SC)
- MARTINDALE, L. *see* WIGHT, P. A. L., 470
- MASON, T. A. Suppurative pericarditis treated by pericardiectomy in a cow, 350
- MASON, T. A. *see* SMYTH, G. B., 248
- MASTERS, H. G. *see* ALLEN, J. G., 434
- Mastitis, 294, 307, 456  
— coliform, 299
- MATTEVI, M. S. *see* MORAES, J. C. F., 102
- MATTHEWS, J. G. *see* PATTERSON, D. S. P., 252
- MAUND, P. A. *see* MORZARIA, S. P., 410
- MAXWELL, M. H. *and others* Eosinophilia associated with facial oedema in fowls, 232 (SC)
- MEADEN, F. A manual of European bird keeping, 202 (R)
- Meat and Livestock Commission, 363  
— hygiene, 24, 453  
— products directive, 21 (C)
- Mebendazole toxicity, 109 (C)
- Medication, intra rumen, 204 (C)
- Medicine, agricultural, 358 (C), 452 (C)  
— preventive, 23  
— sales exemptions, 314
- MEEGAN, J. M. *and others* An epizootic of Rift Valley fever in Egypt in 1977, 124
- Megaloblastosis, 359 (C)
- MERCER, R. *see* WINDSOR, R. S., 276
- MEREDITH, M. J. *see* DONE, S. H., 520
- Mesangiocapillary glomerulonephritis, 471 (SC)
- Metritis, contagious equine, 131 (C), 172 (C), 337, 395, 561 (C)  
— laboratories, 89
- MICHAEL, S. A. *see* EL REFAII, A. H., 60
- MICHELL, A. R. *see* LEES, P., 151
- Microcephaly, 255 (SC)
- Milk, composition, 116
- MILLER, E. L. Prediction of the protein requirements of farm ruminants and implications of these predictions for diet formulation, 485
- MILLER, W. M. Irritating advertisements, 404 (C)
- MILLIGAN, W. A. Dealing with data, 476 (C)
- MILNE, J., Firing horses, 451 (C)
- Mink, anaesthesia, 492 (SC)
- MOORE, F. B. Unusual case, 173 (C)
- MORAES, J. C. F. *and others* Densitometric analysis of the C-band variability in chromosome 1 of cattle, 102 (SC)
- MORZARIA, S. P. *and others* A field trial with a multicomponent inactivated respiratory viral vaccine, 410
- Moscow hosts WVA's 21st Congress, 46
- MOUSSA, M. I. *see* MEEGAN, J. M., 124
- MSOLLA, P. *see* WISEMAN, A., 469
- MUHAMMAD, S. I. *and* ELIASSON, E. C. The prevalence of antibodies to *Mycobacterium johnei* in colostrum deprived lambs, 11
- MUNRO, C. D. *see* MCCANDLISH, I. A. P., 9; WEAVER, A. D., 230
- MUNYABUNTU, C. M. *see* ONAWUNMI, O. A., 359
- MURPHY, S. Practitioners' needs, 541 (C)
- Mustelid anaesthesia, 104 (SC)
- Mycobacterium johnei*, 11
- Mycoplasma, isolation, 102 (SC)
- Mycoplasma mycoides* subsp *mycoides*, 165
- Myodegeneration, presumed congenital, 398 (SC)
- Myopathy, acute, 276

## N

- NASH, A. S. *and others* Membranous nephropathy in the cat: a clinical and pathological study, 71
- NASH, A. S. *see* MCCANDLISH, I. A. P., 9
- Natamycin, 554
- NEGEDU, J. O. *see* FABIYI, J. P., 375, 399
- NEILL, S. D. *see* BRYSON, D. G., 566
- NELSON, D. R. *and others* Spinal analgesia and sedation of goats with lignocaine and xylazine, 278
- NELSON, J. *see* GALLAGHER, J., 546
- NELSON, M. Applications for CSTF awards, 204 (C)
- NELSON, M. Dinoprost in small animals, 261 (C)
- Nematodes, gastrointestinal, 444 (SC)
- Nephropathy, membranous, 71
- Newcastle disease, 258 (SC)  
— virus, 323 (SC), 104 (SC)
- NEWCOMB, R. Surgical and non-surgical transfer of bovine embryos, 432
- New products field evaluations, 315
- News & Reports, 1, 24, 43, 67, 87, 112, 133, 153, 175, 207, 259, 285, 289, 313, 337, 361, 383, 407, 429, 454, 477, 497, 517, 543, 564
- News in Brief, 4, 44, 68, 90, 115, 155, 259, 314, 363, 385, 409, 431, 479, 499, 519, 545, 565
- NICOL, P. G. Feline lungworm infection, 85 (C)
- NICOLET, J. *and* FEY, H. Antibody coated bacteria in urine sediment from cattle infected with *Corynebacterium renale*, 301
- NICOLSON, T. B. *see* HOSIE, B. D., 80
- NOAKES, D. E. *see* ALLEN, W. E., 364; COULSON, A., 440; KESSY, B. M., 414, 489
- Norgestomet, 256 (SC)
- Nutrition award, 431
- NUTTALL, J. E. *see* SWIFT, G. A., 65

## O

- OAKLEY, G. A. *see* MCEWAN, A. D., 15
- Obese dogs, 237 (C)
- Oedema, facial, 232 (SC)
- Oestrus, control, 41 (C)  
— synchronisation, 256 (SC), 440
- O'GORMAN, M. G. *see* CLARKE-WILLIAMS, J. F., 533
- Oil pollution and birds, 358 (C)
- OJO, S. A. *see* GYANG, E. O., 255
- OLDENKAMP, E. P. Natamycin treatment of ringworm in cattle in the United Kingdom, 554
- OLIVER, D. F. Euthanasia of horses, 224
- OLIVER, D. F. RCVS elections, 22 (C)
- OLUYEDE, D. A. *see* FABIYI, J. P., 375, 399
- OMWOYO, P. L. *see* YOUNG, A. S., 531
- ONAWUNMI, O. A. *and others* Deformed goat birth, 359 (C)
- ONOVIRAN, O. *and* TAYLOR-ROBINSON, D. Detection of antibody against *Mycoplasma mycoides* subsp *mycoides* in cattle by an enzyme-linked immunosorbent assay, 165
- ORDISH, L. S. Figures and fiction, 540 (C)
- Oregon disease, 470 (SC)
- Orf in reindeer, 60 (SC)  
— measures effective, 89 (P)
- Orthopaedic refresher course, 406 (C)
- Ostertagia ostertagi*, 98, 444 (SC)
- Ostertagiasis, bovine, 33, 57, 500
- OSTLIND, D. A. *and others* Insecticidal activity of the anti-parasitic avermectins, 168 (SC)
- OSUAGWUH, A. I. A. *and* AKPOKODJE, J. U. Infections keratoconjunctivitis in goats and sheep in Nigeria, 125 (SC)
- O'SULLIVAN, B. Firing horses, 476 (C)
- O'SULLIVAN, B. M. *see* PENNY, R. H. C., 392
- OTT, R. S. *see* NELSON, D. R., 278
- Ovarian condition, 446 (SC)
- OXHOLM, P. *see* KRISTENSEN, S., 422

## P

- PAGE, W. *see* GASKELL, R. M., 243  
 Parainfluenza type III virus, 566  
 Paralysis, facial, 297  
 Paramyxoviruses, 577 (SC)  
 Parasite control, 389  
 PARKINS, J. J. *see* ARMOUR, J., 500; BAIRDEN, K., 33  
 Parliament, 1, 2, 24, 25, 44, 68, 89, 430, 431, 455, 477, 478, 479, 498, 519, 544  
 Parvovirus, canine, 44, 167 (SC), 172 (C), 292, 517, 518, 540 (C), 560, 581 (C)  
 PATTERSON, D. S. P. *and others* The failure of trichothecene mycotoxins and whole cultures of *Fusarium tricinctum* to cause experimental haemorrhagic syndromes in calves and pigs, 252  
 PEARSON, A. W. *and others* Rapeseed meal and liver damage: effect on plasma enzyme activities in chicks, 200 (SC)  
 PEARSON, G. R. *and* LOGAN, E. F. The pathogenesis of enteric colibacillosis in neonatal unsuckled calves, 159  
 PEARSON, H. Changing attitudes to congenital and inherited diseases, 318  
 PEARSON, H. Pyloric stenosis in the dog, 393  
 PEARSON, J. K. L. *and* MACKIE, D. P. Factors associated with the occurrence, cause and outcome of clinical mastitis in dairy cattle, 456  
 Penile erection, 21 (C)  
 PENNY, R. H. C. *and others* Clinical studies on tremorgenic mycotoxicoses in sheep, 392  
 PENNY, R. H. C. *and others* Food animal welfare, 562 (C)  
 PENNY, R. H. C. *see* FORMSTON, C., 582  
 PEPPER, R. T. Casualty slaughter certificates, 562 (C)  
 Pericardiotomy, 350  
 Pericarditis, 350  
**PERSONAL**  
 Appointments, Bedford, J. M., 171; Chamings, R., 260; Cook, R., 203; Jones, R. A., 495; Mackinnon, J., 473; Meddows, C. J., 171; Porter, D. G., 171; Schofield, D., 450; Wishart, D. E., 426  
 Births, 19, 64, 106, 131, 171, 203, 236, 260, 332, 357, 380, 426, 450, 473, 539, 560, 580  
 Honours:  
 Harries, J. A. J. (CBE), 386  
 Marriages, 380, 495, 540, 561  
 General:  
 Arthur, G. H. (retirement), 476 (C), 582 (C)  
 Baldry, A., (ARAS), 539  
 Biggs, P. (award), 332  
 Boundy, T. (award), 260  
 Davies, G. P. (sheriff), 539  
 Delinks, D. A. (exchange), 539  
 Foulds, A. B. (move), 171  
 Goodwin, L. G. (lecture), 561  
 Gunn, S. D. (President), 265  
 Harvey, D. G. (emeritus professor), 203  
 Muirhead, M. R. (North American visit), 473  
 Parkinson, J. (China visit), 2  
 Roberts, A., (award), 431  
 Deaths:  
 Baird, W. H., 332; Barnard, A. J., 171; Barr, J., 357, 402; Bee, B. R., 171, 203, 260; Burrows, W. H., 203; Cameron, A. K., 426; Crocker, R. W., 495; Dawson, A. H., 580; Drury, F. S., 106; Gahan, M. A., 64; Hall-Patch, P. K. J., 540, 561; Haywood, J. D., 426; Hughes, W. D., 84; Hyslop, N. St. G., 473; Kay, J. S., 580; Lawther, J. M., 540; Lemon, D. A., 19, 107; McCrone, R. R., 171; McDonnough, L. T., 84; Mackinnon, M. M., 426, 515, 580; Marshall, C., 426; Mathieson, C., 450; Ogilvie, W. A. R., 131, 171; O'Neil, J. A., 64; Orr, D. E., 260; Parry, R. T., 380; Pretty, E. C., 357; Roberts, A. W., 84; Singh, B. S., 381; Smythe, R. H., 40; Walker, R. B., 203; Walton, R. M., 40, 107; Williams, B. H., 287; Williams, D. G., 332, 381  
 Pet food, amount spent on, 384  
 — Health Council, 90  
 — and welfare, 407, 408  
 — insurance schemes, 41 (C), 132 (C)  
 — Plan Insurances, 136  
 PETRIE, L. *see* GRIMSHAW, W. T. R., 267  
 Pharmaceutical industry, 67  
 Phenosulphonphthalein test, 414, 489  
 Phenotypic intersex, 230  
 Phenylbutazone, 26  
 — toxicity, 85 (C), 108 (C), 150 (C)  
 PICKLES, R. W. Consequences of Aujeszky's disease, 260 (C)  
 Pins, plastic caps for bone, 405 (C)  
 PIRIE, H. M. *see* WISEMAN, A., 469  
 Plasma enzyme activities, 200 (SC)  
 — progesterone levels, 440, 500  
 Plastic caps for bone pins, 405 (C)  
 PLATT, H. *see* CHAPMAN, D. I., 573  
 Pleuropneumonitis, 16 (SC)  
 PLUNKETT, R. K. Return of *Brunus edwardii*?, 582 (C)  
 Pneumonia in calves, experimental, 566  
 — in red deer, experimental, 574  
 POLAND, J. Veterinary Visual Journal, 382 (C)  
 Pollution, environmental, 289  
 — oil, 358 (C)  
 Polyarteritis, 354 (SC)  
 PORTER, P. *and others* Hazards of recycling enteropathogens, 515 (C)  
 PORTER, P. *see* CHIDLOW, J. W., 437  
 Postscript, 22, 42, 66, 86, 110, 132, 152, 174, 204, 238, 262, 288, 312, 336, 359 (C), 360, 382, 406, 428, 452, 476, 496, 516, 542, 562, 582  
 Poultry Meat Inspectors, 385  
 — (Hygiene) Regulations, 111  
 — (Hygiene) (Amendment) Regulations, 25 (P)  
 Poultry Science, spare copy, 360 (C)  
 Practice management:  
 Collecting money due, 355  
 Defending a claim for unfair dismissal— some observations on self-representation, 234  
 Don't rush to judgment, 45  
 Who carries the can? 424  
 You and your premises, 512  
 Your business premises, 136  
 Pregnancy test, 535 (SC)  
 PRESTON, N. K. *see* MCBEATH, D. G., 507  
 Product Notes, 4, 50, 68, 90, 177, 207, 259, 314, 340, 363, 385, 479, 565  
 Progesterone as pregnancy test, 535 (SC)  
 PROLE, J. H. B. *and* CRITTALL, J. L. W. Parvovirus infection and greyhounds, 581 (C)  
 Protection of Animals (Scientific Purposes) Bill, 430  
 Protein requirements, 482, 485  
 Pseudohermaphroditism, female, 230  
 Pyloric stenosis, 393  
 Pyometra, canine, 131 (C)  
 Pyometritis, 64 (C), 151 (C)  
 Pyrantel embonate, 389

## R

- Rabies, 2 (P)  
 RANAS *see* Animal Nursing Auxiliaries, 21 (C), 171  
 RANDALL, C. J. *and* MCLACHLAN, I. Retinopathy in commercial layers, 41 (C)  
 RANDALL, C. J. *see* BLANDFORD, T. B., 335  
 RAO, A. R. *and* RAO, S. V. Synchronisation of oestrus in buffaloes with norgestomet, 256 (SC)  
 RAO, A. R. *and* RAO, S. V. Treatment of suboestrus in buffaloes with cloprostenol, 168 (SC)  
 RAO, S. V. *see* RAO, A. R., 168, 256  
 Rapeseed meal, 200 (SC)  
 RAZIG, S. A. *see* ABBAS, B., 348  
 RECHCIGL, M. *editor* Nitrogen, electrolytes, water and energy metabolism, 170 (R)  
 Records, importance of, 203 (C)  
 REDDING, R. W. *see* BRAUND, K. G., 297  
 Reindeer, orf in, 60 (SC)  
 RENAULT, F. *and* ZYGRAICH, N. Comparison of the safety and efficacy of two Newcastle disease vaccine virus strains with LaSota strain, 104 (SC)  
**REPORT**  
 Wellcome Trust biennial report, 25  
 Research exchange scheme, 409  
 Respiratory arrest, 273  
 — disease course, 385  
 — in turkeys, 577 (SC)  
 Retinopathy, 41 (C)  
**REVIEWS**  
 BENJAMIN, M. M. Outline of veterinary clinical pathology, 3rd ed., 202  
 Cat owner's encyclopedia of veterinary medicine, 447  
 COOPER, J. E. *and* ELEY, J. T. First aid care of wild birds, 170  
 Dog warden handbook, 447  
 ELLIOTT, R. E. W. *and* CHRISTIANSEN, K. H. *editors* Brucellosis: a veterinarian's guide to the literature, 170  
 Health and Safety at Work Act: a guide for veterinary practices, 16  
 LEECH, F. B. *and* SELLARS, K. C. Statistical epidemiology in veterinary science, 474  
 MALES, R. *and* MALES, V. Foaling: brood mare and foal management, 202  
 MANLEY, F. H. A veterinary odyssey, 447  
 MEADEN, F. A manual of European bird keeping, 202  
 RECHCIGL, M. *editor*, Nitrogen, electrolytes, water and energy metabolism, 170



- TAYLOR, D. J. Pig diseases, 236  
 WATSON, P. F. *editor* Artificial breeding of non-domestic animals, 236  
 WEST, G. *editor* Black's veterinary dictionary, 13th ed, 447  
 Rhinotracheitis, infectious bovine, 3, 317, 469 (SC)  
 RIBEIRO, V. L. S. *see* FERREIRA, M. C. S., 451  
 RICCIARDI, I. D. *see* FERREIRA, M. C. S., 451  
 RICHARDS, M. S. *see* MORZARIA, S. P., 410  
 RICHARDSON, A. J. *see* CUSHNIE, G. H., 480  
 RICKETTS, S. W. *see* JACKSON, P. S., 122  
 Rift Valley fever, 124  
 Ringworm, 554  
 ROBERTS, B. A. *see* PATTERSON, D. S. P., 252  
 ROBERTS, D. H. Maedi/visna testing service for imported sheep, 335 (C)  
 ROBERTS, D. H. *see* DAWSON, M., 220  
 ROBERTS, L. Bovine venereal campylobacteriosis (vibriosis) in north east Scotland, 295  
 ROBERTS, P. RSPCA and Farm Animal Welfare Council, 515 (C)  
 ROBERTSON, I. S. *and others* Immunological castration in male cattle, 556 (SC)  
 ROBERTSON, W. W. *and others* Improved vaccination of day-old chickens against Newcastle disease, 258 (SC)  
 ROBINSON, M. *see* MCEWAN, A. D., 15  
 ROCKLEY, P. A. Vulgar advertisement, 516 (C)  
 ROGER, P. A. *see* CLARKE-WILLIAMS, J. F., 533  
 ROGERS, P. A. M. *see* JANSSENS, L., 273  
 ROGERSON, P. *see* WEAVER, A. D., 230  
 Rotavirus in calves, 400 (SC)  
 — infection in a cat, 404 (C)  
 ROWE, B. *and others* International spread of multiresistant strains of *Salmonella typhimurium* phage types 204 and 193 from Britain to Europe, 468 (SC)  
 ROWE, B. *see* THRELFALL, E. J., 21  
 ROY, R. S. *see* ELAZHARY, Y., 336  
 ROYAL COLLEGE OF VETERINARY SURGEONS: 106, 171, 386, 560, 580  
 — Council election, 22 (C), 66 (C), 537  
 — Council meeting, 37, 536  
 — Disciplinary Committee, 88, 112  
 — Register, 386, 431  
 — Retention fees, 287  
 Royal Society for the Protection of Animals, 2, 408, 515 (C), 518, 541 (C), 543, 561 (C)  
 Royal Veterinary College Alumnus Association, 496 (C)  
 RUBEN, J. M. Anaesthetic side effects, 109 (C)  
 RUTTER, J. Welfare in slaughterhouses, 287, 451 (C)

## S

- Safety, animal house and laboratory, 430  
 SAHA, A. C. *see* CHAKRABARTI, A., 238  
 Salmonella, 206, 526  
 — *dublin*, 20 (C)  
 — identification, 475 (C)  
 — *saint paul*, 35 (SC)  
 — *typhimurium* phage types, 204 and 193, 468 (SC)  
 Salmonellosis, 110 (C)  
 — reports, animal, 1978, 207  
 SALZANO, F. M. *see* MORAES, J. C. F., 102  
 SAMUEL, R. M. Vulgar advertisement, 582 (C)  
 SANDER, C. J. Anaesthetic risk to teruuerens, 496 (C)  
 SANSOM, J. Vulgar advertisement, 516 (C)  
 SANSOM, J. *see* LUCKE, J. N., 21  
 SARD, D. M. Dealing with data: the practical use of numerical information—(11) Association implied, 118  
 SARD, D. M. Dealing with data: the practical use of numerical information—(12) Rates, ratios and proportions, 141  
 SARD, D. M. Dealing with data: the practical use of numerical information—(13) Predictable differences, 196  
 SARD, D. M. Dealing with data: the practical use of numerical information—(14) Monitoring changes, 323  
 SARD, D. M. Dealing with data: the practical use of numerical information—(15) Planning for an end, 366  
 SARMA, G. *and others* Mycotic abortion in a cow, 331 (SC)  
 SARMAH, A. K. *see* SARMA, G., 331  
 SAROR, D. I. Classification of the anaemia of bovine trypanosomiasis 96  
 SCARNELL, J. *see* HITCHCOCK, L. M., 172  
 Scheduled (notifiable) disease outbreaks, 2, 155, 363, 431  
 SCOTT, F. W. *see* APPEL, M. J. G., 156  
 SCOTT, P. W. The occurrence of proliferative kidney disease on a chalk stream, 330 (SC)  
 Screening tests, 226  
 Seagulls and salmonella, 526  
 Sea lions, immobilisation, 465  
 Sedation of goats, 278  
 “Seeing practice”, 351  
 SEILER, R. J. The non-diseased reactor: considerations on the interpretation of screening test results, 226  
 Selenium status, 145, 201 (SC)  
 SELLARS, K. C. *see* LEECH, F. B., 474  
 SELLWOOD, R. *Escherichia coli* diarrhoea in pigs with or without the K88 receptor, 228  
 SELMAN, I. E. *see* GRIMSHAW, W. T. R., 267; WISEMAN, A., 469  
 SHARMAN, G. A. M. *see* CUSHNIE, G. H., 480  
 SHAW, B. I. *see* PENNY, R. H. C., 392  
 SHEARS, A. L. *see* HILL, A. W., 299  
 SHEEHAN, D. *see* WILLIAMS, J. C., 98  
 Sheep Veterinary Society, 89  
 SHELLEY, M. C. Plastic caps for bone pins, 405 (C)  
 Shepherd of the year, 545  
 SHIGIDI, M. T. A. *see* ABBAS, B., 348  
 SHIHMANter, E. *see* LIPKIND, M. A., 510, 534, 558, 577  
 SHOHAM, D. *see* LIPKIND, M. A., 510, 534, 558, 577  
 SHOLLIck, G. W. Vulgar advertisement, 475 (C)  
 SHREEVE, B. J. *see* PATTERSON, D. S. P., 252  
 SHUKLA, R. R. *see* VEGAD, J. L., 446  
 SILLER, W. G. *see* MAXWELL, M. H., 232; WIGHT, P. A. L., 470  
 SILVER, I. A. *see* MCCULLAGH, K. G., 54  
 SIMPKIN, K. G. *see* COLES, G. C., 470  
 SIMPSON, V. R. *and* DRAGER, N. African swine fever antibody detection in warthogs, 61 (SC)  
 SIMPSON, V. R. *and others* A fatal case of Wesselsbron disease in a dog, 329 (SC)  
 SIMS, M. A. Megaloblastosis in the dog, 359 (C)  
 SINGH, K. B. Pelvic urethrotomies in bulls, 137  
 Slaughterhouses, veterinary supervision, 289  
 — welfare in, 237 (C), 287 (C), 381 (C), 451 (C)  
 Sloughing, 151 (C)  
 Slurry risk, 455 (P)  
 SMITH, A. H. Phenylbutazone toxicity in ponies, 85 (C)  
 SMITH, H. *see* FRANK, C. J., 395  
 SMITH, O. B. *see* ONAWUNMI, O. A., 359  
 SMITH, R. B. Vulgar advertisement, 516 (C)  
 SMYTH, G. B. *and others* Surgical repair of femoral neck fractures in two dogs and a calf, 248  
 Snares and traps, 44 (P)  
 Snaring survey, 132 (C)  
 SNODGRASS, N. Problems facing the veterinary profession, 339  
 SNOW, D. H. *and others* Phenylbutazone toxicity in ponies, 26  
 Society for Veterinary Ethnology, 409  
 Sodium pentachlorophenate, 152 (C)  
 SONGER, J. G. *see* JOENS, L. A., 463  
 SORJONEN, D. C. *see* BRAUND, K. G., 297  
 SPACKMAN, D. *see* ALEXANDER, D. J., 328  
 Speakers for regional meetings, 110 (C)  
 SPENCE, J. A. *see* DYSON, D. A., 467  
 SPENCER, A. J. *see* NASH, A. S., 71  
 SPRATLING, F. R. Poor style and abuse of words, 542 (C)  
 SPRATLING, F. R. Veterinary responsibility for welfare, 20 (C)  
 Squamous cell carcinomas, 334 (C)  
 STALBOW, M. Tail docking, 20 (C)  
 Starch grain test, 414, 489  
 State Veterinary Service, fees, 431  
 STEPHENSON, R. L. *see* BLOXHAM, P. A., 201  
 STOCK, J. E. Tortoiseshell tom, 336 (C)  
 STOCKMAN, V. Parvovirus infection treatment, 581 (C)  
 STORK, M. G. The epidemiological and economic importance of fly infestation of meat and milk producing animals in Europe, 341  
 “Streak’s” ventricular septal defect, 382 (C)  
 STUART, N. C. Fisheries conference, 132 (C)  
 Stunning of sheep and calves, 372  
 Suboestrus, treatment, 168 (SC)  
 Sulphadiazine-trimethoprim combination, 51  
 Sutures, unabsorbable, 516 (C)  
 SWARBRICK, O. Spare copy of *Poultry Science*, 360 (C)  
 SWERCZEK, T. W. Elimination of CEM organism from mares by excision of clitoral sinuses, 131 (C)  
 SWIFT, G. A. *and others* Dinoprost in pyometritis in the bitch, 64 (C)  
 Swine dysentery, diagnosis, 463  
 — fever, African, 61 (SC), 445 (SC)  
 Syncytial virus, 80 (SC)  
 Systemic lupus erythematosus, 422 (SC)

## T

- TADAYON, R. A. *see* AFSHAR, A., 400  
 Tail docking, 20 (C)  
 TAYLOR, D. J. Pig diseases, 236 (R)  
 TAYLOR, G. B. RSPCA and Farm Animals Welfare Council, 541 (C)  
 TAYLOR, K. C. *and* DAVIES, A. B. Persistent *Salmonella saint paul* excretion in a small dairy herd, 35 (SC)

- TAYLOR, P. Control of oestrus in ferrets, 41 (C)  
 TAYLOR-ROBINSON, D. *see* OBOVIRAN, O., 165  
 TEALE, A. J. Irritating advertisements, 404 (C)  
 Tendon injuries in the horse, 54, 108 (C), 109 (C)  
 — sprained, 223, 312 (C), 359 (C)  
 Tervuerens, 427 (C), 496 (C)  
 Tetrameriosis, 330 (SC)  
 Textbook help, 428 (C)  
*Theileria parva*, 531  
 Thiaminase, 480  
 Thiophanate, 81 (SC), 375 (SC), 444 (SC)  
 THOMPSON, D. J. RCVS elections, 66 (C)  
 THOMPSON, H. *see* MCCANDLISH, I. A. P., 51, 167, 540: NASH, A. S., 71:  
 SNOW, D. H., 26  
 THOMPSON, R. C. A. Equine hydatidosis, 335 (C)  
 Thoroughbred identification—raising the standard, 308  
 THRELFALL, E. J. *and others* Plasmid-mediated antimicrobial drug  
 resistance in *Salmonella dublin* in food animals, 20 (C)  
 THRELFALL, E. J. *see* ROWE, B., 468  
 THURMON, J. C. *see* NELSON, D. R., 278  
 TIMONEY, P. J. Contagious equine metritis in Ireland, 172 (C)  
 TOOVEY, J. A. VAT, 21 (C)  
 TORDOFF, D. B. ERNIC benefit, 542 (C)  
 Tortoiseshell tom, 336 (C), 381 (C), 382 (C), 406 (C)  
 Toxicology studies, 383  
 Toxocara in humans, 44 (P)  
 — not a major hazard, 307, 540 (C)  
 Toxicariasis, 477  
 Toxoplasmosis in sheep, 309  
 Tracheal collapse, 262 (C), 333 (C), 334 (C)  
 TREACHER, R. J. The application of new ideas on the protein re-  
 quirements of the dairy cow, 482  
 Tremorgenic mycotoxicoses, 392  
 Trenbolone acetate, 283  
*Treponema hyodysenteriae*, 463  
 Treponemes, 85 (C)  
 TRIBE, G. W. *and others* Incidence of thermophilic *Campylobacter*  
 species in newly imported simian primates with enteritis,  
 333 (C)  
*Trichostrongylus colubriformis*, 470 (SC)  
 Trichothecene mycotoxins, 252  
 TRILLMICH, F. *and* WIESNER, H. Immobilisation of free-ranging  
 Galapagos sea lions (*Zalophus californianus wollebaeki*), 465  
 Truncus arteriosus communis, 527  
 Trypanosomiasis, bovine, 91  
 TSI slants, 475 (C)  
 TULPULE, S. S. *see* CHINEME, C. N., 126  
 Tumour centre, 519  
 Tumours, ovarian, 9  
 TURNER, T. Luring RANAs, 21 (C)  
 TURNER, T. RVC Alumnus Association, 496 (C)

## U

- Udder creams and ointments, 238 (C)  
 Ureaplasmas in sheep, 576 (SC)  
 Urethrotomies, pelvic, 137  
 Urogenital defects in sheep, 344  
 Urological syndrome, feline, 243  
 Uterine tube function, 364

## V

- VAT, 21 (C), 65 (C), 132 (C), 237 (C)  
 — on horse sales "unfair", 455 (P)  
 VAUGHAN, L. C. *see* KING, J. O. L., 476  
 VEGAD, J. L. *and others* Intestinal perforation and pleuropéritonitis  
 in ascariasis in a white leghorn cockerel, 16 (SC)  
 VEGAD, J. L. *and others* An ovarian condition with multiple cystic  
 follicles in a hen, 446 (SC)  
 Venereal disease, equine, 395  
 Venison, 361  
 Vestibular disease, 530  
 Veterinary Audio-Visual Library, 512  
 — Benevolent Fund Ladies Guild, 384  
 — drugs, 177  
 — History Society, 479  
 — Investigation Service, 114, 154, 290, 448, 498  
 — Officers, shortage, 1 (P)  
 — practice, economic factors, 241  
 — Products Committee, 153  
 — profession, problems, 339

- role, 46  
 — status, 133, 134  
 — Public Health Association, 361  
 VETERINARY RECORD, content, 541 (C)  
 — Notes for contributors, 17  
 — research, 178  
 — Scene, 147, 178  
 — schools' problems, 239  
 — service in the USSR, 69  
 — students, demographic studies, 280  
 — supplies legal case, 497  
 — Surgeons Act, Amendments, 381 (C)  
 — Visual Journal, 288 (C), 382 (C)  
 VICARY, R. W. G. Coenurosis in sheep, 21 (C)  
 Viral diagnostic unit, equine, 564  
 Vitamin K, 65 (C)  
 VOGEL, C. J. Equine influenza vaccination, 404 (C)  
 VOYLE, C. A. *see* GASKELL, R. M., 243

## W

- WALL, R. Textbook help for Ghanaian student, 428 (C)  
 WALLACE, S. R. *see* ALLEN, J. G., 434  
 Warble fly infestation, 2  
 WARD, L. R. *see* ROWE, B., 468  
 WARDEN, D. *see* ROBERTSON, W. W., 258  
 WARE, G. C. *see* GREENHAM, L. W., 104 (SC)  
 WATSON, P. F. *editor* Artificial breeding of non domestic animals,  
 236 (R)  
 WEAVER, A. D. Demographic studies on final year veterinary students  
 of nine European schools, 280  
 WEAVER, A. D. Extramural study experience and practical ex-  
 perience of final year veterinary students of nine European  
 schools, 351  
 WEAVER, A. D. *and* ADAMS, C. M. A specialist German practice, 147,  
 291  
 WEAVER, A. D. *and others* Phenotypic intersex (female pseudo-  
 hermaphroditism) in a dachshund dog, 230  
 Weights and measures, 109 (C)  
 WEISMAN, Y. *see* LIPKIND, M. A., 510, 534, 558, 577  
 Welfare, animal, *see* Animal welfare  
 — in slaughterhouses, 152 (C), 237 (C), 287 (C), 381 (C), 451 (C)  
 Wellcome, new award, 565  
 WELLS, T. Vulgar advertisement, 582 (C)  
 WELLSTEAD, G. Ferret and Ferreting Society, 86 (C)  
 Wesselsbron disease, 329 (SC)  
 WEST, G. *editor* Black's veterinary dictionary, 13th ed, 447 (R)  
 Whale products ban, 545  
 WHARRIER, J. Tortoiseshell tom, 406 (C)  
 WHEELER, A. F. *see* PENNY, R. H. C., 562  
 WHITE, K. Tortoiseshell tom, 406 (C)  
 WIESNER, H. *see* TRILLMICH, F., 465  
 WIGHT, P. A. L. *and others* Oregon disease and husbandry, 470 (SC)  
 WIJK, A. *see* KRISTENSEN, S., 422  
 WILKINS, D. B. *and* DOW, J. K. Welfare in slaughterhouses, 451 (C)  
 WILLIAMS, B. M. Goat conference, 66 (C)  
 WILLIAMS, B. M. Obese dogs, 237 (C)  
 WILLIAMS, J. C. *and others* Further evaluation of the activity of  
 albendazole against inhibited larvae of *Ostertagia ostertagi*, 98  
 Willows Francis—Norbrook link, 177  
 WILSON, J. C. *see* ROBERTSON, I. S., 556  
 WILSON, N. R. P. Casualty slaughter veterinary certificates, 172 (C)  
 WILSON, N. R. P. *see* PENNY, R. H. C., 562  
 WINDSOR, R. S. *and* MERCER, R. Suspected acute myopathy of pigs, 276  
 WINTERS, W. D. Human adenovirus antibody in sera of normal and  
 tumour-bearing dogs, 216  
 WISEMAN, A. *and others* The financial burden of infectious bovine  
 rhinotracheitis, 469 (SC)  
 WISEMAN, A. *see* GRIMSHAW, W. T. R., 267  
 WITHERINGTON, D. H. *see* GREEVES, P. R., 213  
 Women graduates, 238 (C)  
 WOOD, C. Veterinary bugs, 288  
 WOOLCOCK, P. R. *and* CRIGHTON, G. W. Duck virus hepatitis: serial  
 passage of attenuated virus in ducklings, 30  
 World Veterinary Association, 43, 46  
 — Congress, 69, 83  
 — manpower, 77  
 WRIGHT, N. G. *see* MCCANDLISH, I. A. P., 167: NASH, A. S., 71  
 WYN-JONES, G. *and* BAKER, J. R. A probable congenital diaphrag-  
 matic defect in an adult pony, 251

## X

- Xylazine, 278, 442

Y

Yersiniosis in deer, 573  
 YOUNG, A. S. and others Induction of infective stages of *Theileria parva* by exposure of host ticks to high temperature, 531  
 YOUNG, C. D. Harvesting antler velvet, 427 (C), 581 (C)  
 YOUNG, M. Veterinary Surgeons Act amendments, 381 (C)  
 Yucaipa virus, 577 (SC)  
 YUVAL, C. see LIPKIND, M. A., 534

Z

ZYGRAICH, N. see RENAUT, F., 104

Corrections, 580, 581

IN PRACTICE

Aural surgery, canine, (4), 5  
 Back problems in the horse, (5), 4  
 BAKER, G. Dental disease in horses, (6), 19

CLARKSON, M. Helminth zoonoses in Britain, (5), 26  
 Dental disease in the horse, (6), 19  
 Diarrhoea in the dog, (6), 4  
 Ear, surgery of, (4), 5  
 Helminth zoonoses, (5), 26  
 Hypervitaminosis A, (6), 1, 27  
 JEFFCOTT, L. Back problems in the horse—a method of clinical examination, (5), 4  
 LANE, G. Canine aural surgery, (4), 5  
 MARTIN, B. Non-parasitic respiratory infections of sheep in Britain, (5), 20  
 MURDOCH, D. Diarrhoea in the dog, (6), 4  
 Nervous disorders of the pig, (4), 25  
 OLDHAM, J. Nervous disorders of the pig, (4), 25  
 PIRIE, H. see WISEMAN, A., (4), 19  
 Pyrexia in dairy cows, (6), 16  
 Respiratory diseases, bovine, (4), 19, (6), 12, 27  
 Respiratory infections in sheep, non-parasitic, (5), 20  
 Self-assessment. How do you score on adverse reactions? (4), 17, 31  
 Self assessment. How do you score on bovine respiratory diseases? (6), 12, 27  
 Self-assessment. How do you score on small animal vaccination? (5), 17, 32  
 Sheep scab (5), 1, 31  
*Thelazia gulosa*, (4), 1, 31  
 THOMAS, G. W. Pyrexia with dermatitis in dairy cows, (6), 16  
 Tskrjabini, (4), 1, 31  
 WISEMAN, A. and PIRIE H. Respiratory diseases of cattle, (4), 19

## Concordance of pages with issues

The following table gives a key to the dates of issue and page numbers of the 1979 volume of THE VETERINARY RECORD up to the end of December 1979.

Pages	Date	No.	Pages	Date	No.
1-22	July 7	1	313-336	Oct 6	14
23-42	" 14	2	337-360	" 13	15
43-66	" 21	3	361-382	" 20	16
67-86	" 28	4	383-406	" 27	17
87-110	Aug 2	5	407-428	Nov 3	18
111-132	" 11	6	429-452	" 10	19
133-152	" 18	7	453-476	" 17	20
153-174	" 25	8	477-496	" 24	21
175-204	Sept 1	9	497-516	Dec 1	22
205-238	" 8	10	517-542	" 8	23
239-262	" 15	11	543-562	" 15	24
263-288	" 22	12	563-582	" 22 &	25 &
289-312	" 29	13		29	26

than a faecal sample in determining an animal's exposure to infection. In addition, the test could be performed on sera submitted to diagnostic facilities for other purposes, such as brucellosis or Aujeszky's disease serology.

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## Immobilisation of free-ranging Galapagos sea lions (*Zalophus californianus wollebaeki*)

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*Veterinary Record* (1979) 105. 465-466

Nine free-ranging Galapagos sea lions were immobilised for marking, using a combination of ketamine (3 to 5 mg per kg) and xylazine (0.5 to 1.0 mg per kg). The degree of effect depended largely on the animals' behavioural and physiological state before immobilisation (after parturition, high arousal, subject to aggression, etc.) All nine animals survived. Overheating in the immobilised state may quickly result in heart and circulatory failures.

IMMOBILISATION of pinnipeds by means of drugs administered intramuscularly presents difficulties (Geraci 1973, Geraci and Sweeney 1978, Eulenberger and Puschmann 1976, Gauckler 1976). On dry land, these animals are unable to regulate their body temperature by physiological means, even in a moderately warm environment, because of their thick blubber layer (Whittow and others 1971). Overheating may lead to heart and circulatory collapse. Experience with the immobilisation of nine Galapagos sea lions (*Zalophus californianus wollebaeki*) in the wild is reported, with comments on their thermoregulatory behaviour.

### Materials and methods

For tagging, five immature and four adult healthy Galapagos sea lions were drugged with a combination of ketamine and xylazine. In four cases hyaluronidase (150 iu) was added to the mixture to accelerate resorption.

The drugs were injected using the Telinject blowpipe system as described by Wiesner (1975). The projectile syringes were blown at the animals through a 1 m blowpipe from distances between 0.5 and 4 metres. A syringe holds a maximum of 2 ml, which is injected with a 1.2 × 38 mm special needle.

The drugs were injected intramuscularly into the thigh, where the blubber layer is comparatively thin, and penetration into the muscle easiest. Records were kept of the animals' behaviour from injection to recovery. Some were observed occasionally for several days subsequently. Only animals well inland were injected, to avoid the risk that they might re-enter the sea and drown. As the animals easily overheat, they were immobilised only during the cool early morning or late evening, and kept wet.

Weight estimates were not very accurate. Average-sized adult females were assumed to weigh about 80 kg; the measured weights of a few immatures were about 25 kg. According to their size and physical state, other animals were estimated between these extremes. The degrees of immobilisation obtained were categorised into six classes (Table 1), similar to those defined by Briggs and others (1975).

### Results and discussion

Every syringe penetrated the tough hide, but the extreme tips of some of the needles were bent slightly. Only one syringe, shot obliquely, did not penetrate deeply enough to inject the drugs.

Table 1 shows the results of nine immobilisations of Galapagos sea lions with a combination of ketamine and xylazine. Some animals hardly reacted to the syringe's impact, bit at it, stood up, walked a few steps, looked round, and sat or lay down again. Because of their general inactivity, it was difficult to determine when the drugs took effect, and this time is given in the table only to the nearest five minutes. Often the first sign of an effect was somewhat laboured breathing, while the animal still tried to keep its head up, scanning the surroundings. Immobilised animals sat still or lay down after five to 10 minutes.

TABLE 1: Results of immobilisation experiments with Galapagos sea lions

Number	Age	Sex	Estimated weight (kg)	Ketamine dosage (mg/kg)	Xylazine dosage (mg/kg)	Kinetin (150 iu)	Time (min) before first effects	Recovery after (min)	Degree of effect*	State before injection
1	1y	♂	30	4.3	0.5	—	<5	75	1	Sleeping
2	1y	♀	25	3.2	0.5	—	5	60	3	Sucking
3	3y	♀	30	4.0	0.5	—	5	30	3	Resting
4	2-3y	♂	30	5.0	1.0	+	5	40	3	Interacting with
5	3-4y	♂	40	4.25	0.75	+	<5	60	2	each other
6	adult	♀	80	2.0	0.3	—	10	25	1	After
7	adult	♀	80	2.5	0.85	—	10	ca 120	1-2	giving birth
				1.5†	0.25	—	—	—		Walking
8	adult	♂	70	1.8	0.3	+	—	—	0	Resting
9	adult	♂	70	2.8	0.35	+	5	70	2	

\* 0=no visible effect; 1=incapable of locomotion but able to resist handling; 2=capable of movements of head and hindquarters; 3=incapable of any movement; 4=flaccid; 5=sleeping totally relaxed

† Second dosage given 40 min after first injection

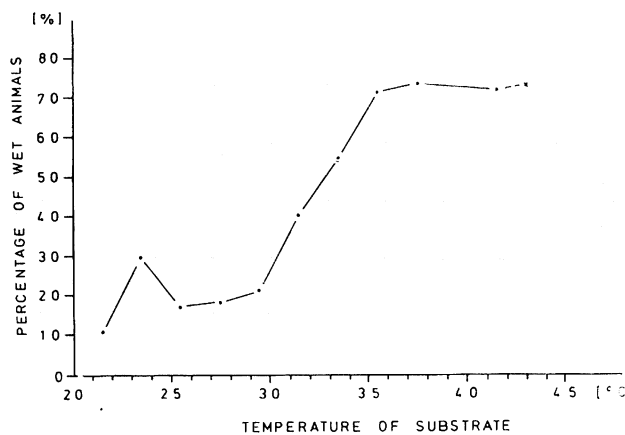


FIG 1: Thermoregulatory response of adult and immature Galápagos sea lions to substrate temperature. Points represent the percentage of wet animals averaged over a two-degree range. The cross gives the value for 43°C (N=30). The number of observed animals varies between 93 and 394 animals per point with a mean of 258

The maximum degree of immobilisation reached in each animal did not appear to be strictly dose-related. One reason may be that the weight estimates were only rough ones. In addition, the spots hit by the syringes were of course not exactly uniform, and in some cases some of the drugs may have been lost in the blubber.

Another factor strongly affecting the success of the immobilisation was the activity and/or excitation of the animals before the injection. The one-year-old male (1) was sound asleep when injected. He actually slept for about 20 minutes while immobilised and was unable to move for about an hour, with a dosage of 4.3 mg per kg ketamine and 0.5 mg per kg xylazine. Males 4 and 5 had been moving slowly and occasionally interacting with one another when injected, with about the same dosage as male 1, but these showed a lesser degree of immobilisation (Table 1). Male 8 was injected with only 1.8 mg per kg ketamine and 0.3 mg per kg xylazine, a dosage obviously too low to immobilise a sea lion; it showed no signs of immobilisation. Generally, a dosage of 3 to 4 mg per kg ketamine and 0.5 to 1.0 mg per kg xylazine permitted safe handling. However female 7 was injected twice, receiving a total dosage of 4.0 mg per kg ketamine and 1.1 mg per kg xylazine, and it could still resist handling, at least by a single person. It had given birth about eight to 10 hours before, and the physiological stress of birth may have made it more drug-resistant.

A similar finding was made in the Münchner Tierpark Hellabrunn when one of us (H.W.) tried to immobilise a very excited South American sea lion (*Otaria byronia*) directly after parturition. The animal was estimated to weigh 50 kg. It showed no effect after the injection of 3.6 mg per kg ketamine and 0.18 mg per kg xylazine. This dosage was repeated after 20 minutes, again with no results.

As mentioned by Geraci (1973) and Briggs and others (1975), animals immobilised with ketamine alone showed moderate to strong tremors. For that reason ketamine should not be used in pinnipeds suffering from any form of respiratory disease, or on animals with a history of hypersensitivity to cyclohexanones (Geraci 1973, Eulenberger and Puschmann 1976, Geraci and Sweeney 1978). In this series, even the animal receiving about 5 mg per kg ketamine and 1 mg per kg xylazine showed no tremors, only the typical muscle relaxation caused by the xylazine. But all animals experienced slight breathing problems, breathing far more deeply than usual and sometimes snorting forcibly, as surfacing animals do after a dive. This is also a well-known side effect of xylazine. Salivation was apparently somewhat increased. This should be prevented by the use of atropine in the next trials. But even animal 1, which was sleeping deeply, kept

breathing quite regularly, although occasionally gurgling a little.

Later on, animals 1, 2, 3, 6 and 7 were seen several times, and showed no after-effects of the immobilisation.

#### Thermoregulatory risks accompanying immobilisation

In the California sea lion it has been demonstrated that at an air temperature of 30°C physiological means of thermoregulation are insufficient to maintain body temperature at a normal level (Whittow and others 1971, 1972). Temperatures at which this applies may even be much lower, as the 19° to 29°C range was not tested. Observations on free-living California sea lions (Peterson and Bartholomew 1967, Odell 1974), Steller sea lions (Gentry 1973), and other pinnipeds (eg. White and Odell 1971, Gentry 1973, Bartholomew and Wilke 1956) and these observations on the Galápagos sea lion (Fig 1) show that even resting animals tend to sluice themselves increasingly as radiation and substrate temperatures rise. Dry pups of the Galápagos sea lion overheat considerably within only 15 minutes when active at substrate temperature 29°C and air temperature 23.8°C (Trillmich, unpublished data).

In the helpless, immobilised state there is grave danger of death from overheating, as the pinnipeds are incapable of the thermoregulatory behaviour normally resorted to. Also when recovering from immobilisation there was high sustained activity, especially when trying to escape from an observer. The animals would rear up and move with highly exaggerated movements, falling down frequently. All this could soon have caused overheating, if the animals had not been kept wet by sluicing with cold sea water until their movements became almost normal. Sluicing also wets the sand on which they rest, increasing heat loss by conduction (Ohata and Whittow 1974).

Although the few immobilisations of Galápagos sea lions with ketamine plus xylazine do not yet provide conclusive evidence that the method is safe, the described results show it to be superior to the use of ketamine alone (Eulenberger and Puschmann 1976, Geraci 1973). Perhaps the xylazine dosage should be slightly increased to obtain a higher degree of immobilisation. In further experiments the behavioural state of the animals (activity, general arousal, parturition, etc) should be taken into consideration, as well as the danger of heat prostration, which may be the main cause of heart and circulatory failure in pinnipeds after immobilisation.

**Acknowledgements.**—We thank J. Cilio, D. Nakashima, and K. Trillmich for their help in the field work. The support of the Galápagos National Park authorities, represented on Galápagos by Miguel Cifuentes, and of the Charles Darwin Research Station through its director Hendrik N. Hoek is gratefully acknowledged. We thank Mrs C. Kasche for drawing the graph, and Mrs P. Rechten for correcting the English. This is contribution 250 from the Charles Darwin Foundation for the Galápagos.

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