Bovine Tuberculosis in Badgers

Report by the Ministry of Agriculture Fisheries and Food

November 1976

BOVINE TUBERCULOSIS IN BADGERS

REPORT BY THE MINISTRY OF AGRICULTURE, FISHERIES AND FOOD

CONTENTS

NOTE

This Report records events up to 31 August 1976.

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REPORT BY THE MINISTRY OF AGRICULTURE, FISHERIES AND FOOD

The Consultative Panel on Badgers and Tuberculosis

1. On 20 June 1975 the Government announced that it had decided to set up a panel of representatives of interested organisations which the Ministry would consult in connection with the measures needed to deal with the problem of bovine tuberculosis in badgers. The announcement was made by Lord Melchett in the course of a debate in the House of Lords on the Committee Stage of the Conservation of Wild Creatures and Wild Plants Bill.

2. The panel was established as the Consultative Panel on Badgers and Tuberculosis, and met for the first time on 24 September 1975. A list of the current members of the Panel is at Appendix 1. The Panel has subsequently met on four more occasions, and now, a year after it began its existence, is an appropriate time to review the problem with which it has been concerned, and to describe the action being taken.

Tuberculosis in badgers and other wild life

3. The incidence of bovine tuberculosis in cattle in Great Britain had been reduced to a very low level by 1960 following a major eradication campaign; but although it continued to decline generally thereafter, it persisted in some areas in the south west of England until the point was reached in the late 1960s where more herd breakdowns were occurring in those areas than in the whole of the remainder of the country. The history of these breakdowns indicated an undisclosed source of infection (although in south west Cornwall badgers had been suspected by some members of the farming community for some 20 years) but no clue came to light until June 1971 when Mycobacterium bovis was isolated at the Central Veterinary Laboratory, Weybridge (CVL), from a badger carcase found on a farm in Gloucestershire where bovine TB existed in cattle. Arrangements were accordingly made for a close study to be made of the wild life in the problem areas. The results up to 31 August 1976 of tests to determine the presence of M. bovis are summarised in Appendix 2.

4. The figures suggest that the disease is uncommon or non-existent in all species examined except the badger. In those cases where the organism was isolated from other species it was clear that the animals were relatively resistant to the disease and that it was n t progressive in them; moreover, the specimens examined had been obtained from farms with infection in both cattle and badgers. On the other hand, the examination of badger carcases revealed that the disease was progressive in this animal, with the kidneys and lungs often being severely affected which indicated that large numbers of bacilli could be produced and excreted.

5. Early in 1976 the Ministry undertook to collect and examine post mortem all badger carcases found by members of the public. This arrangement was brought to the notice of the interested sections of the general public through the organisations represented on the Consultative Panel. The results of the examination of the carcases received up to 31 August 1976 are set out in the table at Appendix 3. They show no evidence of tuberculosis in badgers outside the south west region except in a part of Surrey where further investigations are being made into the badger population and the history of the disease in cattle herds. Evidence of the disease in badgers in a part of East Sussex has also been revealed by laboratory examination of faeces samples and is being investigated. One isolated diseased badger was found in South Wales in 1974.

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The figures in the table in Appendix 3 exclude badgers examined in connection with herd breakdowns in the problem areas - these are included in the table at Appendix 2.

The extent of the problem

6. Following the discovery of infection in badgers it has become Ministry policy to investigate the health status of badgers on and near any farm where tuberculosis has been revealed in a herd and no other source of infection can be identified. Throughout these investigations and in all subsequent consideration of the problem the Ministry has maintained contact with the Nature Conservancy Council and other conservation and animal welfare organisations.

7. Up to 31 August 1976 these investigations had resulted in infected badgers being discovered in many parts of Gloucestershire, in parts of Avon, Cornwall, Devon and Wiltshire and in a relatively small area of Dorset. These areas are indicated in the map at Appendix 4. Examination of the histories of herd breakdowns in these areas has shown that although the frequent testing of cattle has ensured the removal of reactors before they could pass on the disease, cattle have continued to become infected, particularly in the case of stock at pasture. An analysis of 160 breakdowns in Avon and Gloucestershire for which no origin had been found revealed that 113 were within about $\frac{3}{4}$ km of places where infected badgers had been found, and a further 15 within about $1\frac{1}{2}$ km. It is known that badgers will roam more than a mile in search of food and although they use communal dung pits faeces have been found on the surface of pasture and in hedgerows. They also urinate randomly. Pasture can therefore be contaminated by infected badgers and can thus be a hazard to healthy cattle when grazing despite vigorous control procedures within herds at risk.

Experimental work

8. In the light of this evidence a programme of laboratory experimental work was set up at the CVL to investigate the transmission of infection between badgers and between badgers and cattle. The experiments are described in Appendix 5; their results show that healthy calves will develop tuberculin sensitivity and tuberculous lesions when in contact with either naturally- or experimentally-infected badgers.

9. A programme of experimental work was also followed at the Veterinary Investigation Centre at Gloucester. In particular the viability of the organism was investigated. The experiments are described in Appendix 6; their results show that urine and bronchial pus/sputum from badgers may present a much greater risk of infection to cattle than does faeces.

10. A project to study badger ecology and behaviour has been set up in a district of Gloucestershire. A progress report on this project is at Appendix 7. The knowledge gained from this project will be of assistance in the field operations that are carried out when herd breakdowns attributed to badgers occur.

11. The first area in which operations were undertaken to eliminate infected badgers was in South Dorset where for some years a high reactor rate had persisted in a dairy herd and a high level of infection existed in badgers. In the 6 years since 1970, 626 cattle were slaughtered because they reacted to the tuberculin test or had been exposed to infection. Various techniques of dealing with the problem were tried out in this area including cage trapping and gassing. A progress report is at paras 27 and 28.

12. An experimental badger clearance programme, agreed in outline with the Nature Conservancy Council was commenced near the town of Thornbury, Avon in December 1975. The area involved is bounded on the northwest by the River Severn, southwest by the M4, southeast by the M5 and northeast by the Little Avon river. Within this area lesions of tuberculosis have been disclosed from reactors in 39 cattle herds during the past 10 years and clear evidence of infection in badgers has also been obtained. The purpose of the experiment is to find out whether operations on this scale will eradicate bovine tuberculosis in the area. A progress report on this experiment is at paras 29 and 30.

Dealing with the problem

13. When the Ministry was confronted with the problem of tuberculous badgers a solution had to be found in order to obviate the risk to cattle and to assist farmers who were sustaining worrying losses. The Ministry was also concerned to reassure farmers that the problem was being contained and to discourage the indiscriminate taking of badgers for fear that they might present a disease risk. It proved to be impossible to live trap all the badgers associated with a breakdown herd (see para 14). Furthermore, no satisfactory method has been found of testing live badgers for the presence of the disease. The only practical means of dealing with the problem is to follow the same policy for badgers as is practised for cattle; that is to kill those affected and those exposed to infection.

14. One difficulty was to determine the best method for killing badgers. Snaring was impracticable if only because of the manpower involvement in checking snares at frequent intervals so live-trapping was investigated. In consultation with the Universities Federation for Animal Welfare (UFAW) traps were designed that were both efficient and humane. But the technique proved to be cumbrous and time consuming; over a period of 9½ months when 42 traps were used only 33 badgers were caught (see also Appendix 7, para 5). It was concluded that the only satisfactory method of eliminating tuberculous badger colonies was to gas them in their sets basing the method to be used on the technique already available for gassing rabbits in their warrens. This conclusion was accepted by the conservation and animal welfare organisations.

Gassing

15. Cyanogenetic powders have been used for rabbit destruction since 1900. The cyanide is used in the form of powdered compounds which, in contact with moist air, evolve hydrocyanic acid gas (HCN). The use of HCN for rabbit control owes much to UFAW who have encouraged and sponsored the technique since the early 1930s. The most effective and economical method of dealing with a large warren is to use either hand or petrol-driven pumps to blow sufficient powder into the warren to generate a lethal concentration of gas throughout the entire burrow system. The powder is pumped in at one of the holes until it is seen to emerge at others, which are then immediately blocked with turves and /or earth. (Holes should not be blocked before gassing powder is seen, since they may not be connected with the main warren and rabbits occupying these burrows will not be exposed to gas.) The principle of gassing rabbit warrens and badger sets is the same, although the volume of the sets may be much greater.

16. Although there were no legal restrictions on the use of gassing to control rabbits the use of this method to kill badgers in their sets was prohibited by the Protection of Animals Acts of 1911 and 1912. However, the Badgers Act 1973 (which is a badger-protection measure) authorises the Agriculture

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Ministers to issue licences for the killing of badgers to prevent the spread of disease, and this power was extended by including in the Conservation of Wild Creatures and Wild Plants Act 1975 a provision which, in effect, permitted the use of gas to be specified in such a licence. During the passage of this latter Act in Parliament an undertaking was given that licences for gassing would be issued only to Ministry staff or to persons under Ministry control.

17. Although this provision enabled gassing operations to get under way, since Ministry personnel have no powers of entry for this purpose they must seek the co-operation of the landowners and occupiers of land. For this reason, and because the tuberculous-badger problem highlighted the lack of powers to deal with all diseases of significance to farm livestock (except rabies) that can become established in wild life, two sections have been included in the Agriculture (Miscellaneous Provisions) Act 1976 enabling Agriculture Ministers to make Orders defining areas in which they could undertake destruction of wild life to prevent the spread of disease to farm livestock. These sections include powers of entry to land for investigational and surveillance purposes as well as for destruction operations.

Operations

18. When tuberculosis is found in a cattle herd, and no other source of the infection has been revealed, current practice is to consider the possibility that the outbreak is attributable to infected badgers. Badger specimens and badger faeces are collected and sent to a Veterinary Investigation Centre for laboratory examination. (From February to the end of May, the taking of badgers is confined (by cage trapping only) to males and obviously non-lactating females in order to avoid the cruelty to cubs which would result from killing lactating sows.) If the existence of the disease in badgers is confirmed a thorough survey of the infected farm and surrounding land is carried out to identify all badger sets. The survey extends normally to about 1 km from the farm boundary. The extent of gassing operations (ie "fire-brigade" action) that will be required is then determined by MAFF veterinary staff taking into account the nature of the evidence, and will include unoccupied as well as occupied sets.

19. As mentioned in para 16 an undertaking was given by the Government that only persons employed by or under the control of the Ministry would be licensed for badger-gassing work. Accordingly, as soon as the Conservation of Wild Creatures and Wild Plants Act 1975 received the Royal Assent steps were taken to recruit staff needed for the gassing work. The initial requirement was for 6 teams, each comprising a supervisor and 3 operators; 3 teams were for "fire-brigade" work (2 in Avon, Gloucestershire and Wiltshire and one in Cornwall plus an additional supervisor in each of these 2 areas for preliminary survey work), 2 teams for the experimental work near Thornbury (see paras 29-30) and one team for Dorset (see paras 27-28). The 3 "fire-brigade" teams were formed by November 1975, mainly by recruitment but with existing Ministry staff being diverted to the work where practicable. The 2 teams for the Thornbury experimental area were formed by December 1975 and the team for Dorset by August 1975.

20. The teams were trained in the techniques of gassing and trapping, the collection of faeces samples and surveying for sets, and informed of the biology and ecology of badgers. Safety precautions were also covered and after some initial experience had been gained a Code of Practice was written and issued to everyone engaged on badger-control work.

21. The first badger sets were gassed on 7 August 1975. Shortly after this, the first of several gassing demonstrations was given for the benefit of the TV and the Press. A gassing programme began on land in Dorset on 26 August 1975 and the

gassing programme for the Thornbury experimental area commenced during December of that year. "Fire-brigade" gassing programmes began as trained teams became available, ie in Avon, Gloucestershire and Wiltshire in December 1975 and in Cornwall in February 1976.

22. As explained in para 17, surveying, sampling and gassing cannot be done in the absence of powers of entry without the full co-operation of the owner of a breakdown herd and the occupiers of the adjoining land. Most farmers and land-owners have readily co-operated, but a few have been unwilling. In cases where gassing is carried out care is taken to see that all owners and occupiers are kept fully informed of what is happening and advised to keep children and pets away from the blocked sets for at least a fortnight after gassing has been completed.

23. No gassing is carried out until clearance has first been obtained from the Water Authorities and Environmental Health Officers who are concerned to ensure that there is no risk to public health through the contamination of mains and private water supplies. There was a considerable hold-up in the early stages until these Authorities gained experience of the clearance arrangements, and confidence that water supplies were not being endangered, but they are now able to clear most cases fairly quickly. There are, of course, a few cases in which the quantity of gassing powder used has to be restricted and alternative arrangements have to be made, eg by use of repellents to clear the sets concerned.

General progress

24. Progress has been retarded not only by the factors mentioned in para 23 but by others such as the opening and possible re-colonisation of gassed sets. This could have been by badgers of the same social group, which had been living in sets not included in the original gassing operation or by other badgers moving into the control area. In these cases sets have been regassed and repellents used to discourage reoccupation. The problem has been most acute in Gloucestershire and North Avon where up to 75% of the sets have had to be regassed, many of them a considerable number of times. A sizeable effort therefore has had to be devoted to regassing, which, of course, has increased as more cases have been completed.

"Fire-brigade" operations

25. Progress to 31 August 1976 in dealing with "fire-brigade" cases (excluding those in the Dorset area and the Thornbury experimental area) is set out in the following table:

"FIRE-BRIGADE" CASES	AVON GLOS WILTS	CORNWALL	DEVON	TOTAL
No. of cases authorised	39	18	2	59
Surveyed	33	18	2	53
Initial Gassing Completed	23	10	0	33

26. In order to maintain a satisfactory impetus in dealing with "fire-brigade" cases and the volume of sampling work on hand two further teams were formed and trained in July and August 1976 - one for work in Avon, Gloucestershire and Wiltshire and the other for Devon and Cornwall. The Avon, Gloucestershire and Wiltshire team is now fully operational. The Devon/Cornwall team is awaiting medical clearance but, meanwhile, is being employed on the heavy volume of survey work that remains to be done. It is difficult to assess how long "fire-brigade" operations will have to continue. However, even if only a few new cases arise, the volume of survey work on hand, the regassing of sets (if this has to continue on the scale found necessary so far) during a period sufficient to ensure that sets are not reoccupied and thus residual TB infection in them disappears, should occupy the existing teams fully for at least a further 12 months.

Dorset area

27. The purpose of this work is explained in para 11. Gassing operations began on 26 August 1975 but were suspended between 8 November and 2 December 1975 because of concern by the Wessex Water Authority about possible contamination of the water supply. The Authority (who found no water pollution as a result of cyanide gassing) and the Environmental Health Officers were eventually reassured, but meanwhile 20 sets were reopened by badgers and some needed to be gassed several times. By 18 April 1976, the total number of sets (groups of holes) gassed was 247, and no new ones have been found since then, although many have been repeatedly gassed.

28. The central area of 1,200 hectares now seems to be clear of badgers and this position will be maintained for at least a year. A rat infestation in the same area has been cleared. To date, about 6 cwt of gassing powder has been used in 1898 holes. Some 4,500 hectares have been under surveillance. There are relatively few badgers in the 2,800 hectares beyond the area where the gassing has been carried out and any attempts to recolonize it will be discouraged. The total of badgers gassed is unknown. Recent tuberculin tests on the cattle have shown encouraging results - over 500 have been tested and all passed the test.

Thornbury experimental area

29. A survey of the area in the summer of 1975 revealed some 440 sets of which about 200 appeared to be occupied. Gassing began in the southern half of the area. With the fine weather in the early spring of 1976 progress was at first rapid; but arid conditions, resulting in cracked and porous soil, delayed gassing later in the year. (During the summer there were signs of badgers living in roadside drains and 4 were caught in them.) By 31 August 1976, 177 sets had been gassed, in some 2/3 of the 100 sq km area, and it had been necessary to re-gas on 235 occasions. One set was gassed 19 times, in spite of all efforts with repellents, before re-opening ceased. In the northern part of the area, which has not been gassed, badgers are fairly numerous and it is proposed to carry out some bait marking experiments here.

30. Repellents have been used with very modest success from early February to late May but at no site has it been possible completely to prevent re-opening of holes by badgers from the outside. Renardine, creosote and a mixture of creosote/diesel oil have been put into the entrances of gassed sets on newspaper and sacking and, in addition, Renardine and creosote have been sprayed liberally in the area of the set. In some instances repellent soaked material

has been raked from the entrances by badgers within 24 hours of it being placed there. One set was treated 10 times; after which badgers dug new entrances, leaving the blocked and tainted ones untouched.

The work of the Consultative Panel

31. The Panel has been fully consulted on all aspects of policy and operations. It has considered reports by the Ministry on the progress being made in dealing with the tuberculous-badger problem in the field and on the experimental programme. It has discussed aspects of this work with the senior officers concerned and has given advice on a number of the problems encountered. One of its more important functions has been to maintain liaison between the Ministry and the organisations represented by Panel members. As a result there is now a clearer understanding of the problem among the conservationist and animal welfare interests and a better appreciation by farmers that outside the problem areas in the South West badgers do not present a risk to cattle herds and should not be destroyed. Work carried out at the Panel's request has put the winter population of badgers in Great Britain at 75-90,000. The Panel visited the Thornbury Experimental Area and the Gloucester Veterinary Investigation Centre to see the work being carried out there and individual members have been to the site in Gloucestershire where the ecological study is taking place.

Conclusion

32. It is too early to evaluate the results of the measures that have been taken so far. This cannot be done until gassing has been completed in the areas concerned, the results of successive tests of cattle there are available and the health status of badgers which have been allowed to recolonise those areas is known. However, there are some indications that the level of infection in breakdown herds in the first areas to be gassed has been reduced. Until the problem is solved, the general health of cattle and badgers in the areas concerned is at risk. It has been noted that there has been a reduction in the movement of badgers by naturalists. This should assist in the control of the disease by removing the risk of spreading it from one location to another.

33. The work has provided an opportunity to add to knowledge of badger behaviour, biology and population density. It has become known that the badger population in the south west region is high and that there will be no shortage of badgers to recolonise gassed areas. Equally, it has shown that there is no justification for the indiscriminate killing of badgers outside the problem areas and that the task of dealing with the badgers within those areas should be left to the specialist services of the Ministry.

34. The laboratory experimental work has confirmed the inference drawn from field evidence that badgers are susceptible to the disease and can play a significant role in transmitting infection to cattle.

Appendix 1.

CONSULTATIVE PANEL ON BADGERS AND TUBERCULOSIS

Members

The Panel comprises the following members:

*Mr M Clark	Representing The Mammal Society
The Earl of Cranbrook	Conservationist
Mr R S R Fitter	Representing The Council for Nature
Dr D A Haig	Representing The Agricultural Research Council
Mr J A Jackson	Representing The National Farmers' Union
Mr W J Jordan	Representing The Royal Society for the Prevention of Cruelty to Animals
Mr C Le Grice	Representing The Country Landowners' Association
Dr Ernest Neal	Leading expert on badgers
Dr F B O'Connor	Representing The Nature Conservancy Council
Dr R J Paget	General medical practitioner and co-author of Badgers of Yorkshire and Humberside
Mr J H Parsons	Representing The British Veterinary Association
Mr M J Penistan	Representing the Society for Promotion of Nature Conservation
Mr E Pill	Representing The National Union of Agricultural and Allied Workers
Major W N Scott	Representing The Universities Federation for Animal Welfare

The Chairman is Mr C H Shillito, an Under-Secretary of the Ministry of Agriculture, Fisheries and Food. The Chief Veterinary Officer (Mr A C L Brown) and other senior officials of the Ministry also attend Panel meetings. The Secretary is Mr J H Seymour, Ministry of Agriculture, Fisheries and Food, Animal Health Division 3A, Room 7C, Government Buildings, Garrison Lane, Chessington, Surrey KT9 2LN.

*Mr Clark replaced the late Mr C L Russell in November 1975.

Terms of Reference

To keep under review:-

1. the evidence relating to bovine tuberculosis in badgers, including its incidence and its relationship to bovine tuberculosis in cattle; and

2. the operations to be undertaken by the Ministry in order to eradicate bovine tuberculosis from badgers and to monitor its existence in the badger population.

Appendix 2.

WILDLIFE STUDIED IN THE PROBLEM AREAS

(Covering the period 1 July 1971 to 31 August 1976)

Species examined (viscera except where otherwise shown)	Number	Number from which *M. bovis* isolated
Mammals		
Badger	1934	336
- faeces	2534	117
Fox	126	3
- faeces	42	0
Deer	4	0
- faeces	40	0
Brown rat	163	5
Rabbit	92	0
Grey squirrel	54	0
Hedgehog	10	0
Mole	59	2
Mink	3	0
Stoat	4	0
Field vole	350	0
Common shrew	60	0
Pigmy shrew	1	0
Water shrew	1	0
Weasel	2	0
Bank vole	78	0
Woodmouse	115	0
"Mice"	88	0
Birds		
Starling	27	0
Rook	7	0
Jackdaw	10	0
Magpie	2	0
Gulls	4	0
Woodpigeon	1	0
Carrion crow	1	0

Appendix 3.

BADGER CARCASES SUBMITTED BY THE PUBLIC

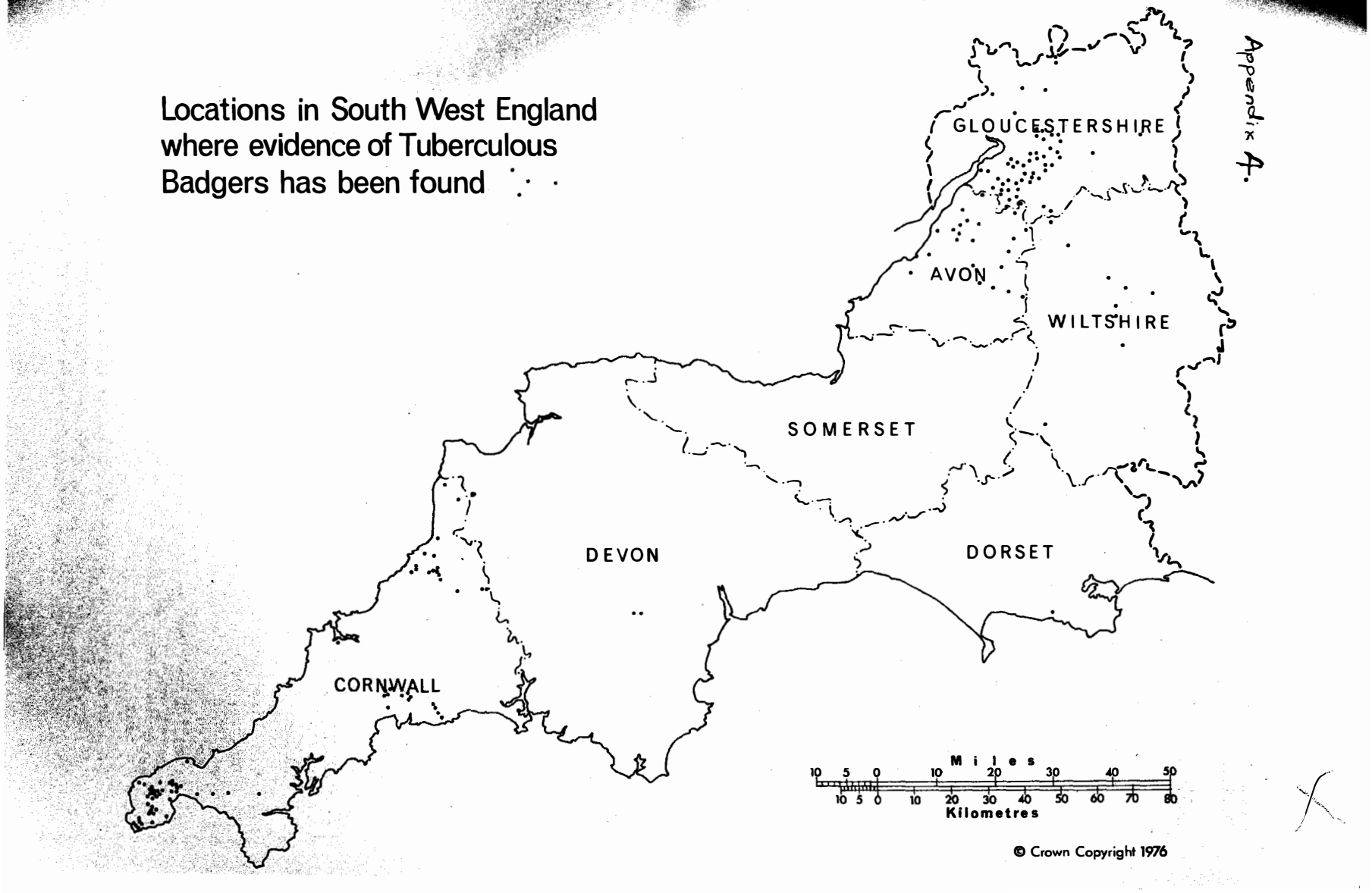
(Covering period 1 January to 31 August 1976)

NOTE These figures exclude badgers examined in connection with herd breakdowns and included in the table at Appendix 2.

County	Road accidents	Others	Total	Positive M. bovis	Neg.	Pending
All regions except SW						
Hants	4	2	6	0	6	0
Bucks	1	0	1	0	1	0
Kent	5	1	6	0	6	0
Derby	1	0	1	0	1	0
Herts	0	1	1	0	1	0
Lincolnshire	1	1	2	0	2	0
Leicestershire	5	1	6	0	6	0
Oxford	1	1	2	0	2	0
Northumberland	2	0	2	0	2	0
North Yorkshire	1	1	2	0	2	0
Cambridge	1	1	2	0	2	0
Essex	1	0	1	0	1	0
Hereford	4	1	5	0	5	0
Northants	1	0	1	0	1	0
Worcester	5	0	5	0	5	0
Warwick	4	1	5	0	5	0
Salop	1	0	1	0	1	0
W. Midland	1	0	1	0	1	0
Dyfed	1	0	1	0	1	0
Surrey	3	3	6	2	1	3
Peebleshire	0	1	1	0	1	0
Total	43	15	58	2	53	3
South West Region						
Cornwall	31	26	57	1	41	15
Devon	18	6	24	0	18	6
Dorset	17	4	21	0	21	0
Avon	12	4	16	0	16	0
Total	78	40	118	1	96	21
Great Britain	121	55	176	3	149	24

Appendix 4.

Locations in South West England where evidence of Tuberculous Badgers has been found



Appendix 5.

EXPERIMENTAL WORK CARRIED OUT AT THE CENTRAL VETERINARY LABORATORY WEYBRIDGE

Experimental Transmission of Tuberculosis in Badgers and Cattle

A. The virulence to badgers of M. bovis isolated from cattle and contact transmission of the infection within a badger community.

1. Healthy badgers were selected for this experiment. Three badgers, one from each of 3 separate groups, were inoculated intravenously with different doses of a strain of M. bovis isolated from cattle. The badgers were examined regularly, weighed, tuberculin tested using a number of different methods and blood samples were collected for examination using a complement fixation test. Faeces samples were taken for cultural and biological examination for tubercle bacilli.

2. The badger challenged with the largest dose of M. bovis died 2 months after inoculation and a contact badger from another group died after 8 months. In both cases widespread tuberculosis particularly of the lungs was found at post-mortem examination. The remaining badgers appeared healthy and gained weight but all had lesions of tuberculosis when examined post mortem a few months later.

3. The tuberculin tests were negative throughout the experiment but the complement fixation test became positive in all the challenged and most of the contact badgers. However, the level of reaction was variable and the test is not specific for tuberculosis. Tubercle bacilli were found in faeces samples collected during life in the 2 badgers which died and in 2 others before they were killed. Tubercle bacilli were recovered from lesions found in the challenged and contact badgers and all isolates were subsequently identified as M. bovis.

B. Contact transmission of tuberculosis from experimentally-infected badgers to cattle.

4. A calf was placed in contact with each of the 3 groups of badgers described above. The calves were tuberculin tested every 2 months and were killed after the second positive tuberculin test or when they became clinically ill. Two calves reacted to the tuberculin test after 6 months contact and one after 8 months. One of the calves became ill after 6 months contact and was killed. Lesions of tuberculosis were found in the lungs and some lymph nodes of this calf. The other 2 calves were killed after 8 months exposure and both had lesions of tuberculosis. M. bovis was isolated from the tissues of all the calves.

C. Contact transmission of tuberculosis from naturally infected badgers to cattle.

5. Nine badgers live trapped near a set which had been shown to contain tuberculous badgers were kept in a covered cattle yard (12 x 8.5 m) together with 3 calves. The badgers were examined, weighed and tuberculin tested regularly. Blood and faeces samples were collected for complement fixation and bacteriological tests. The calves were also tuberculin tested every 2 months and were killed after the second positive tuberculin test.

6. On arrival one badger was found to be excreting tubercle bacilli in its faeces and subsequently 4 other badgers excreted the bacilli intermittently. The number of bacilli excreted was probably small. All the

tuberculin tests were negative but on arrival 7 of the 9 badgers gave a positive reaction to the complement fixation test. After one year in captivity 2 badgers died and a third was killed in poor condition.

7. All 3 had excreted tubercle bacilli in their faeces during life and all had small lung lesions and in addition one had tuberculous lesions in the kidney. M. bovis was recovered from all these lesions.

8. One calf reacted to the tuberculin test after 6 months, a further calf after 8 months and a third after 10 months. Two calves had obvious lesions of tuberculosis at post-mortem examination and the third had less conspicuous lesions in the retropharyngeal lymph nodes. M. bovis was isolated from the lesions in all 3 calves.

D. Comment

9. The experiments described at A, B and C above demonstrate that contact with either naturally or experimentally-infected badgers causes tuberculin reactivity and the development of tuberculous lesions in cattle. Wide variations in the degree of infectivity amongst tuberculous badgers and in the susceptibility of cattle probably account for a longer duration of contact required before tuberculin sensitivity developed in these experiments than is sometimes reported from the field. Preparations for an experiment are in hand to determine whether badgers acquire tuberculosis by contact with infected cattle.

E. Survival of tubercle bacilli in a badger set

10. Naturally infected badger tissues and artificially infected badger faeces were placed in an old disused set and samples of the material were removed for examination regularly.

11. Tissues sampled after 1, 3 and 8 months contained viable tubercle bacilli but samples taken at 6 months were negative. Further tests are in progress. Artificially-infected badger faeces were positive after one month but subsequent tests up to 8 months have been negative. A second batch of similar badger tissues and faeces is also being examined.

REPORT ON WORK CARRIED OUT AT GLOUCESTER VETERINARY INVESTIGATION CENTRE TO 31 JULY 1976

A. Study of the pathology of tuberculosis in wild badgers

1. An account of this work was published in the Veterinary Record (1976) Vol. 98, No. 1, pages 9-14.

B. Development of improved cultural methods for the isolation of M. bovis

2. An agar medium containing a range of antibiotics to which contaminant bacteria and fungi are generally susceptible but having no effect on M. bovis has been successfully developed. It is more sensitive than the existing culture media tried and in a comparative trial of this medium and the guinea-pig test on approximately 500 badger tissue samples, 91% of all recoveries were made on culture and 99% by the animal test. This work has been detailed in a paper for submission to Research in Veterinary Science.

3. The cultural method has also been applied to faeces samples and comparative trials with artificially-infected faeces indicated a good correlation between culture and the animal test. However, contaminating bacteria and fungi can cause problems and further work is being carried out on refinements of technique.

C. Trials on the viability of M. bovis in badger products

4. Using the selective method developed, numbers of organisms in badger products can be determined. Deterioration in their numbers can then be measured after exposure to the elements. The following trials have been carried out:-

Urine - samples of urine from badgers found naturally infected were tipped onto permanent pasture and after one week of exposure to the elements, during winter, fairly large numbers of organisms were recovered from grass pulled out by the roots. Scant numbers persisted for 4 weeks and were still found to be pathogenic to guinea-pigs. This trial was repeated in the summer and no organisms were recovered even after only 3 days of exposure.

Bronchial pus/sputum - again samples from naturally-infected badgers were used. After 4 weeks of exposure during winter appreciable numbers of organisms were still detected and scant numbers were recovered after 10 weeks of exposure. During the summer no organisms could be recovered after only one week of exposure.

Faeces - during the winter naturally-infected faeces remained infected for one month but in the summer samples taken after 2 weeks of exposure were negative.

5. The initial counts of organisms from the different samples varied greatly. Very large numbers were recovered from urine - up to 300,000 per ml. Bronchial pus contained similarly large numbers up to 200,000 organisms per ml recorded but counts on faeces samples were generally much lower. The high counts largely explain the remarkable persistence of infection in urine and to a lesser extent bronchial pus. Even though 90% of organisms were killed by sunlight within a day or two sufficient numbers probably found shelter from the winter sunlight and rain in the humus layer in pasture. The bronchial pus was semi-viscous and some

probably reached the humus mat but organisms in this type of specimen would also benefit from protection afforded by mucous. The efficiency of solar disinfection was seen in the summer trials where the prevailing strong sunshine resulted in the rapid killing of infection in all samples. Faeces samples remained intact for a few weeks and thus remained in an exposed state. The pungent musk smell was detectable for 2 weeks and sometimes longer.

6. From the results of these trials it is concluded that urine and bronchial pus/sputum present both a real and potential source of infection whereas faeces are the most unlikely source. The badger can void about 30 ml of urine - thus a heavily infected animal could expel several million organisms by this route at one urination. Sputum contamination of pasture might present a serious hazard where an infected badger has been muzzling and digging for 'titbits'. Sites where there has been such activity are commonly found in parts of Gloucestershire.

D. Trials on the viability of M. bovis within infected sets

7. Two sets which were known to have contained infected badgers were enclosed within an electric fence for 6 months after they had been gassed. The sets remained unoccupied by badgers although a family of shrews and a family of voles took up residence in one. Both sets were opened after this period and samples of decomposed carcase, bedding and dust and faeces, as well as the nests of shrews and voles, were taken for analysis. Results are not yet available.

E. Trials on the persistence of infection in carcases

8. Severely-infected badgers showing an even distribution of lesions in the lungs have been carefully sutured up after post-mortem examination and allowed to rot. Anaerobic putrefaction starts with generation of heat and has the effect of eventually killing many bacterial species. Rotting carcases were sampled at fortnightly intervals with the following results:-

On pasture - a carcase left on pasture showed a very sharp fall in the level of infection after 2 weeks of decomposition and by 4 weeks no M. bovis could be recovered at all.

Underground - 3 carcases have been buried in pits of about 3 feet in depth. The carcases were bedded on hay then covered with more hay before filling in with soil. Two carcases yielded no growths of M. bovis after 2 and 3 weeks and the third after 6 weeks.

9. From the results of these trials it is concluded that carcases can be expected to 'self-sterilize' by natural decomposition within a matter of a month or two. Samples of the 'bedding' used have been taken for analysis but the results are not yet available.

BADGER ECOLOGY AND BEHAVIOUR AT A SITE IN GLOUCESTERSHIRE

PROGRESS REPORT

A. Purpose and location of project

1. This project is intended to give much needed ecological information on badger ranges and movements in connection with the role of badgers in the transmission of tuberculosis to cattle.

2. The site is inside the region of the Cotswold escarpment where the TB problem is at its worst. In addition there is no public access, and the project has the keen support of the tenant as well as the surrounding farmers and landowners.

3. Before commencing experimental work, the area was thoroughly surveyed in order to locate all badger sets and latrines.

B. Baiting experiments

4. An initial attempt at defining the home range boundaries of badger social groups using the method of bait marking was made during the winter of 1975-6; badger activity was low at this time and the returns were very poor. Another attempt was made in the spring of 1976, which also gave only a partial picture of social group ranges throughout the study area, owing to a shortage of different coloured plastic beads to incorporate in the food at the various sets. More coloured plastic beads are now available. During the summer months the use of latrines has been very sporadic. Undoubtedly the best time of year to conduct bait marking experiments is during the period February to May when range boundaries are vigorously marked and defended. The two baiting experiments have given some limited information on the extent of badger ranges and have also enabled the technique to be improved. The next experiment will be in the spring of 1977 when efforts will be concentrated towards giving a complete picture of social group boundaries within the study area.

C. Catching badgers

5. Both cage traps and snares have been used to catch live badgers in the study area. Analysis of the relative success of these methods revealed that up to 31 July 1976 one badger, 2 jays and one pheasant were caught in 64 trap-nights, and 12 badgers and 2 foxes were caught in 44 snare-nights. The obvious advantage of snares over traps in catching badgers, and the disproportionately large amount of time required pre-baiting and setting traps, has meant that snares only are now used when badgers are required for radio tagging.

6. Snares are carefully designed so as to avoid injury to the animal and, in practice, none of the animals caught in them has shown any sign of injury. A comparison is being made of different kinds of snares; that currently in use incorporates the swivel, and does not have a "stop" since it is thought that this might cause skin abrasion in captive animals. A large loop set low on a badger track is used with the intention of catching the animal round the body. The snare is anchored with a 60 cm stake made from $\frac{5}{8}$ in. steel rod and care is taken to set well away from saplings, fences or other snags that might cause captive animals to become entangled. If snares cannot be kept under constant observation (eg from a platform nearby using infra-red binoculars) checks are made at least every hour after they have been set. Where possible they are

placed where they can be seen from a distance, so as to minimise the amount of human scent left in their immediate vicinity.

7. Captive badgers are restrained with a sack and a heavy forked stick and anaesthetised using Ketamine hydrochloride. The dose is calculated to give approximately 40 minutes anaesthesia. During this time blood, faecal, sputum and urine samples are taken for TB analysis and the radio transmitter is fitted. Before full recovery from the anaesthetic, badgers are released on the set at a hole nearest the point of capture. This avoids any possible mishaps during the "groggy" stages of recovery.

8. Traps will remain in use for catching cubs and yearlings in straightforward marking studies, where the traps can be left overnight and visited each morning.

D. Telemetry

9. The transmitter unit used in radio tracking measures 80 x 50 x 10 mm and weighs 250 g (243 grams of which is protective encapsulation). It has a range of approximately half a mile depending on conditions, and the theoretical life is 14 months. A harness made of rawhide is used to attach the transmitter to a badger. Considerable attention has been given to the design of the harness which has been developed using a captive individual. The pattern now in use has been worn by our captive badger for 9 weeks to date without any sign of abrasion or discomfort, despite the animal increasing 1.5 kilograms in weight since the harness was fitted.

10. Ten individuals (3 males and 7 females) have been radio-harnessed. Transmitters have worked extremely well but there has been a problem with the loss of harnesses.

11. One male caught in February 1976 yielded some very useful information until the transmitter stopped working in May. This happened shortly after the animal was injured, probably in a road accident. The badger had lost the use of the left hind leg and had a 8 cm cut over the right eye. It was subsequently possible to make occasional observations on the same badger using the beta light. This is a source of fluorescent illumination incorporated in the transmitter encapsulation that can be seen with the naked eye at up to 200 metres. Early in August it was noticed that the animal had forced the left foreleg through the neck strap of the harness. This was probably made possible by stretching of the leather. The harness appeared to be causing some discomfort so it was decided to catch the badger. This was done using a noose held from a platform above the set and peanuts were used to attract the badger into the right position. It was found on examining the badger that the cause of the loss of use of the left hind leg was a badly lacerated foot pad. The thigh muscle was also atrophied with a large lump (possibly a haematoma). The transmitter encapsulation was smashed which must have been the cause of its failure. Some skin abrasion had resulted from the foreleg being forced through the neck strap of the harness, and the harness was duly removed. The badger is still seen occasionally and appears to be continuing to recover slowly from its injuries.

12. Other radio harnessed badgers have produced an interesting accumulation of data. A map showing the revealed ranges of all marked badgers is attached at Annex 1. The range area of male badgers varies between 2.0 hectares and 57.5 hectares with a mean of 33.5 hectares (n = 3), whereas female ranges vary between 2.0 hectares and 19.0 hectares with a mean of 12.6 hectares (n = 7). Obviously the period of observation will

directly affect the revealed range size, and in this context it should be noted that male No. 10 and female No. 5 mentioned in the above figures have only been marked for short periods. Female No. 7 forced the harness off immediately after release. If the data from these 3 individuals is excluded the mean range sizes for males and females are 49.3 hectares and 14.7 hectares respectively. The results are summarized at Annex 2 and the most important points to mention regarding these results are that males had much larger ranges than females during the period of observation, and that individuals within the social group had their own "preferred areas" within the overall group range, which may only be a small fraction of the total area covered by the group as a whole.

13. It has become clear that radio tracking is very time consuming. Nevertheless there is no other way of obtaining the information required and radio tracking is bound to remain the most important field technique used in this study.

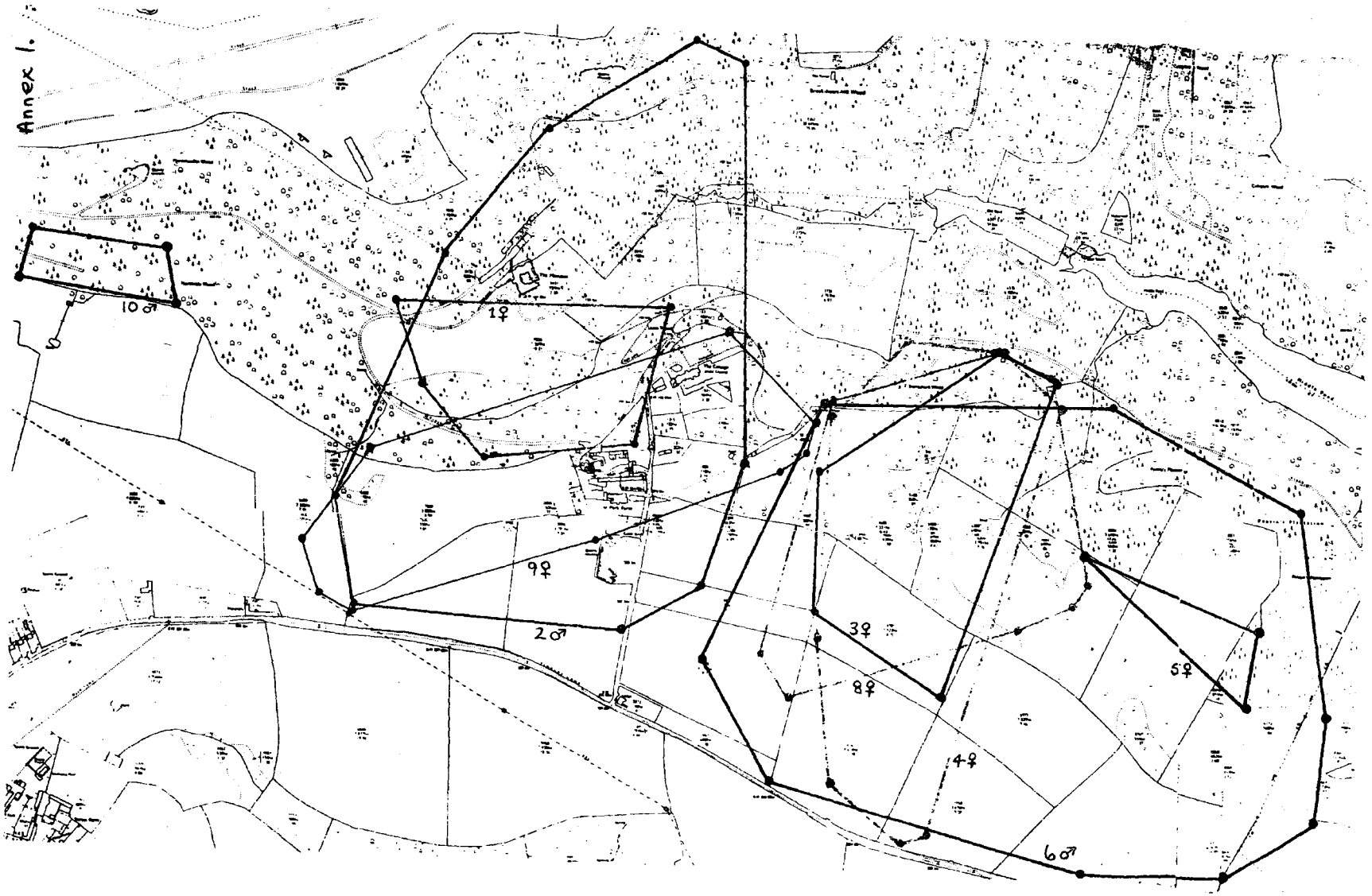
E. Feeding observations

14. It is noteworthy that during the hot dry summer of 1976, earthworms were almost unobtainable as a source of food for badgers. Other invertebrate food sources were also apparently scarce (although no quantitative data are available) and badgers may have experienced a food shortage during the period before cereals, blackberries and other fruits became available. Badgers often spent the whole night foraging, often from before dusk until after dawn. Typically they would leave the set immediately after emergence without indulging in play or grooming and head for the likely feeding areas and stay there all night, returning to the set well into daylight. Most night observations were made using infra-red binoculars after location of a badger by radio tracking.

F. Other work

15. Ear tags and tattooing apparatus have been obtained for the purpose of marking badgers. It is thought that this will be the best means of permanently marking individuals in order to study dispersal and long distance movements.

Annex 1.



Annex 2.

BADGER RANGES BY RADIO-TRACKING FEBRUARY-SEPTEMBER 1976

Badger No.	Sex	Revealed Range (hectares)	Dates Observed
1	♀	7.5	9.2.76 - 28.4.76
2	♂	41	16.2.76 - 21.6.76
3	♀	10.5	24.2.76 - 20.4.76
4	♀	19	30.3.76 - 7.6.76
(5	♀	2	18.5.76 - 26.5.76)
6	♂	57.5	7.6.76 - present
7	♀	*	22.6.76
8	♀	18.5	29.6.76 - present
9	♀	18	19.7.76 - present
(10	♂	2	20.9.76 - present)

*forced harness off soon after release ie no data.
Bracketted individuals only marked for short periods.

Dots on the map represent the outermost points of each badger range and areas are drawn by the "Exclusive Boundary Strip" method ie all re-entrant angles are ignored.

Map Scale: 12.5 cm = 1 km (approximately)