# THE ECOLOGY AND MANAGEMENT OF FERAL CAT COLONIES

A survey of feral cat colonies in Great Britain and an experimental field study of the effect of neutering on the ecology, behaviour and social organisation of a single colony

by

Paul Anthony REES

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# ABSTRACT

## THE ECOLOGY AND MANAGEMENT OF FERAL CAT COLONIES

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A postal questionnaire survey located over 700 feral cat colonies. Most were small, well - established and lived in association with man. The feral cat population of Britain was estimated to be one million and is concentrated in urban areas.

A domestic cat survey indicated a total population of 5.9 million cats in Britain. There appeared to be more females than males, and a higher proportion of females than males were neutered.

The effect of neutering on a colony of 30 adult cats living in the grounds of Winwick Hospital, Cheshire, was examined. Individual cats were recognised by differences in coat colour and pattern, and data were collected by direct observation. The colony was studied for one year before and one year after neutering.

Before neutering there appeared to be a seasonal fluctuation in numbers as a result of natality, mortality and migration. Male immigrants were recorded. After neutering the colony remained stable in size and only one (female) immigrant was observed.

The ecology and behaviour of 19 cats were studied in terms of home range, the distribution of sightings in time, and sociability. Before neutering cluster analysis was used to identify groups of similar cats: males, females, nomads and residents. After neutering no such groups could be distinguished and it is suggested that this was a result of changes in hormone balance.

A mathematical model was developed for the study of associations within populations. It was shown that the cats tended to form more discrete social groups after neutering with fewer movements between groups.

The adult cats were generally in good condition but there was evidence of exposure to feline calicivirus and feline herpesvirus.

Trapping of cats appeared to be efficient and humane, and neutering was considered to be an acceptable form of population management.

## ACKNOWLEDGEMENTS.

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Mr. F. Coates and Mr. P. Richardson assisted me on my visits to Menwith Hill U.S. Station and gave me considerable insight into the problems faced by cat-lovers who attempt to manage a feral cat colony.

My wife, Katy, assisted with much of the administrative work associated with the surveys and often accompanied me on visits to Winwick Hospital. My parents made it possible for me to purchase a car, without which my fieldwork would have been extremely difficult to organise. I am grateful for this and for the encouragement they and my wife have given to me over the years.

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# PART I

# GENERAL INTRODUCTION

# 1. STATUS, HISTORY AND DISTRIBUTION.

The existence of colonies of feral cats (*Felis catus* L.) in urban and industrial locations in the British Isles has been recognised for many years. Many of these cats live in close association with man, around his dwellings and places of work. In some circumstances they are considered to be pests and a variety of organisations ( commercial, governmental and voluntary ) are involved in their control. However, since feral cats have never entirely lost their domesticated status these organisations have experienced difficulty in formulating control policies which are both effective and acceptable to cat - lovers.

The term 'feral cat colony' requires explanation since it has been used to describe domestic cats living in groups in a variety of different situations. A number of definitions of the term 'feral' are available in the literature. The most useful is probably that of Box (1973) who has defined feral animals as 'those which have reverted from a domesticated to a wild state of living'. An interesting genetic definition of a feral population has been given by Brisbin (1971) as : 'one whose future gene - pool composition was at one time under the control of some regime of artificial selection, but is at present under the direct control of natural selection - mutation interaction'. This latter definition emphasises the fact that feral populations are affected by the same ecological and genetic factors as wild populations.

The term 'colony' has been used to describe a number of different types of associations between organisms of the same species. It is used to describe groups of bacteria and intraspecific associations in many invertebrate taxa. Examples of colonial forms may be found in the Porifera, Coelenterata, Polyzoa, Pterobranchia, Urochordata, and Insecta ( Barrington, 1972). Colonial life in invertebrates is characterised by polymorphism and a division of labour among the colony members, which are usually organically connected to each other, except in the colonies formed by certain insect species where individuals are 'bound together' by mechanisms which are chemical and physiological rather than structural.

Intraspecific associations of vertebrates have also been called 'colonies'. The term has been widely used to describe populations of sea - birds (Thomson ., 1967) and to a lesser extent mammals such as seals (Pinnipedia) and badgers (*Meles meles* L.). According to Wilson (1980), 'In vernacular usage the term colony is applied to almost any group of organisms, especially a group of nesting birds or a cluster of rodents living in dens'. When a group of vertebrates is described as a colony this usually implies a close genetic relationship between the group members, a more or less permanent association with a particular place, and some degree of isolation from similar groups of the same species. It is in this sense that feral cats may be considered to live in colonies.

Macdonald and Apps (1978) refer to a colony of one male and three female cats, while other workers have used the same term for much larger populations. This leads to problems of definition since these larger colonies tend to consist of a number of small social units similar in size to the colony described by Macdonald and Apps. In her study of the feral cats in Portsmouth dockyard Dards (1979) did not use the term colony but referred only to the population as a whole and its constituent social groups. In this study a colony is considered to be a group of interbreeding feral cats of any size, which lives in a particular place. The concept of a colony is most useful where the place is a building complex situated in its own grounds, and isolated from the surrounding area, such as a hospital, a factory or a dockyard. Where feral cats are distributed more or less continuously over a wide heterogeneous area, for example an inner city area, the concept of a colony is of little use. Tabor (1981) has, however, used the term colony to describe cats which come together at feeding places in London, but some of these 'colonies' appear to be collections of unrelated strays.

By definition all feral cats must originally be descended from domestic cats. There is no evidence that feral cats are a new phenomenon and it seems likely that they have existed for as long as the domestic cat. Animals are undoubtedly continually recruited into the feral population from the domestic population as cats stray or are abandoned. Some colonies exist for only a few weeks or months before they are removed (many of these contain stray rather than feral cats), while others, like that in Portsmouth dockyard (Dards, 1979) are of considerable age. In considering the origin of the feral cat the history of the domestic cat must be examined since they are the same species and their historical origins are inextricably linked.

It is generally accepted that the domestic cat (*Felis catus*) is descended from the African Wild Cat (*Felis lybica* Forster) which is also called the Desert Cat, Caffer Cat or Bush Cat. This cat is considered by some authors to be one of the ten subspecies of *Felis sylvestris* Schreber listed from Africa and the Near East (Guggisberg, 1975). *F. lybica* is widely distributed over Africa (except the Sahara and the equatorial rain forest) and also Sardinia, Corsica, Majorca and in south - west Asia from Arabia to Pakistan.

Interbreeding occurs between *F. lybica* and domestic cats which run wild in great numbers in Africa ( Dorst & Dandelot, 1970) and also between domestic cats and the European Wild Cat ( *Felis sylvestris* ) in Scotland ( Lawrence & Brown, 1967).

The relationships between *F. catus*, *F. lybica* and *F. sylvestris* are not clear, but most authors agree that *F. catus* is descended from *F. lybica* and not *F. sylvestris*, and that all three are closely related ( Burton, 1970; Dorst & Dandelot, 1970; Guggisberg, 1975; Lever, 1977). The distribution of *F. sylvestris* has been considerably reduced by man. Two centuries ago it was still found in parts of England and Wales and over much of Europe ( Burton, 1970). Now it is confined to Scotland, within Great Britain, but its continental distribution still extends to southern Europe and the Mediterranean coast ( van den Brink, 1967).

*F. sylvestris* is secretive, notoriously ferocious and reported to be impossible to tame even if taken as a kitten ( Burton, 1970; Guggisberg, 1975). In contrast, although *F. lybica* is also secretive in its habits, it often lives close to villages and farms, kittens being easily reared in captivity ( Guggisberg, 1975). During his travels in Africa, Schweinfurth (1878) reported that wild cats were common in the country south of the Bahr el Ghazal and described the natives' practise of capturing young kittens which, when older, were kept to control the rats around their huts and enclosures. When compared with *F. sylvestris*, *F. lybica* may be regarded as practically predestined to domestication.

The ancestors of our domestic cats came mainly from the ancient wild cat populations of Palestine and Egypt. There is evidence that cats roamed the streets of Jericho in the late sixth and early fifth millennium B.C., and small statues of women playing with cats have been found at the archaeological site of Haçilar in Asia Minor. The domestic cat probably first appeared in Egypt about 2000 B.C.

The first Egyptian cats may have reached Greece and Rome around the beginning of the Christian Era ( Guggisberg, 1975), but there are signs that cats were domesticated among the people of the Bronze Age Period in Europe. According to Guggisberg (1975) the earliest record of the domestic cat's presence in central Europe appears to be footprints in bricks which were unearthed at a second - and - third - century Roman settlement at Stillfried on the March in Austria. The writings of Palladius on agricultural topics in 350 A.D. refer to the cat as a widely distributed animal. Although first kept only by the wealthy, the early domestic cats undoubtedly wandered into the rural districts where they replaced the semi-tame martens and weasels which had been tolerated around farms and homesteads to control rodents. Interbreeding between these cats and the indigenous wild cats was probably commom.

Further progress across Europe appears to have been slow and cats seem to have been rare in England up to the tenth century. Lever (1977) has suggested that the domestic cat was introduced into Britain at some time prior to the Middle Ages. The earliest remains of a domestic cat in Britain were discovered in a midden in the Roman City of Silchester,Hampshire (Hope & Fox, 1898; Hope , 1906 ). The first written evidence of the cat in Britain is to be found in a code of laws attributed to the tenth century Welsh prince, Hywel the Good, which describes the penalty for killing a cat ( Wade - Evans, 1909).

There is evidence for the existence in the past of a continuous distribution of wild cats from Britain and Europe to southern Africa and the Near East. It may be that although the domestic cats introduced into Britain were descendants of cats from southern Europe they were the same species as the wild cats living in Britain, Europe and Africa at that time.

Cats have been introduced into some parts of the British Isles in more recent times. In the Shetland Islands, in the 1890's, cats were released on Noss to control the rat population. They have also been introduced on to South Havra and Holm of Melby at various times. Cats have been released in the Hebrides to control previously introduced rabbits, and in 1930 a dozen cats were released on St. Kilda. In Ireland, three dozen cats were released on Great Saltee Island off Ballyteige Bay in Co. Wexford in 1950, also to control rabbits. These recent introductions have been described by Lever (1977).

The process of colonisation practised by the British and the European powers from around 1500 A.D. undoubtedly led to the introduction of the domestic cat to the Americas, Australasia, and many other parts of the world. It is not surprising that many of these areas now support large feral cat populations. The more recent establishment of meteorological stations and the settling of whalers and sealers on remote islands have led to the introduction of cats into areas where there were no other terrestrial predators, often with disastrous consequences for the indigenous wildlife ( Holdgate & Wace, 1971; van Aarde, 1978).

Feral cats have been reported from a variety of different habitats, and they exhibit variation in their social organisation and their dependence upon man for food and shelter. At one extreme they may be dispersed in small groups over a wide area on a remote island living independently of man ( van Aarde, 1978). At the other extreme they occur in high densities in urban areas dependent upon man for food and shelter, and often subjected to attempts at population control ( see Fig. 1.1). It is these urban colonies which have attracted considerable attention from the animal welfare organisations in Britain and it is interesting to postulate how they have arisen.

Managed Urban — High

Localised Urban

Dispersed Urban — Degree of dependence upon man

Localised Rural

Dispersed Rural

Island — Low

Fig.1.1. A classification of feral cat colonies.

Cats have probably always played the dual rôle of domestic pet and pest controller in and around man's dwellings. With the arrival of the industrial revolution in Britain the cat found a new 'niche' killing rodents inside man's newly constructed factories and mills. At one time the wool mills of West Yorkshire appear to have supported colonies of cats to protect their valuable produce from soiling and damage by rats. Indeed, in 1977 the author visited a wool mill in Bradford where eleven cats were allowed to roam at will inside the buildings for this purpose. This encouragement of cats in industrial areas along with the associated poor quality housing where cats would have been kept for rodent control must have resulted in large numbers of cats straying and becoming the basis for a feral population.

By the middle of the nineteenth century the majority of the people of England and Wales lived in towns, and by 1951, 81% of the people were urban ( Jones, 1966). Britain was the first country to achieve this high degree of urbanisation. In 1800 the only city in Europe which had a population approaching a million was London, with 950,000 people. It is therefore probable that Britain in general and London in particular has had a large population of feral cats for a considerable time. Writing in 1898 the naturalist W. H. Hudson estimated that the entire cat population of London may have been as high as three - quarters of a million and that there may have been as many as 100,000 'ownerless' cats in the city ( Hudson, 1898). Hudson commented that he was not aware of any literature on the subject of the number of cats in London. This is interesting and perhaps indicates that cats were so much a part of the urban environment at the turn of the century that they attracted little attention. Hudson reports the deliberate 'straying' of unwanted pet cats by poor families and that people at the time were anxious to get rid of the strays but were at a loss to know how to do it. His main concern, however, was the effect of their depredations on London's bird - life and not the welfare of the cats themselves.

## 2. ECOLOGY AND BEHAVIOUR.

Cats have always been a favourite experimental animal among animal behaviourists, psychologists and neurophysiologists, working in laboratory conditions. Much of this work has been reviewed by Fox (1975).

Field studies of the ecology and behaviour of feral cats are rare. Early ecological studies of cats were concerned with their feeding habits and impact on wildlife ( Errington, 1936; Nilsson, 1940; McMurry & Sperry, 1941; Latham, 1950; Hubbs, 1951; Eberhard, 1954). They found that small mammals were the main prey, but some birds and insects (mainly Orthoptera) were taken. However, in an urban area McMurry & Sperry (1941) found that up to two - thirds of the diet consisted of garbage. Studies of the feeding ecology of cats have recently been reviewed by Fitzgerald & Karl (1979).

A number of recent studies of feral cats have examined populations on sub - Antartic islands, where cats have been only recently introduced and their numbers are still increasing (for example Derenne, 1976 on Kerguelen Island; Jones, 1977 on Macquarie Island; van Aarde, 1978 on Marion Island). These populations have attracted interest because of their destructive influence on the endemic bird species. Van Aarde (1978) estimated that over 600,000 burrowing petrels (Family Procellariidae) were killed by cats on Marion Island from September 1974 to to October 1975. At the beginning of the 1975 birth season he estimated the feral cat population on the island at 2,137 individuals.

There have been few studies of the behaviour of feral cats. Leyhausen (1979) studied caged domestic cats and free - ranging cats. He described social hierarchies which indicated that cats are not as asocial as had previously been thought. Leyhausen also studied territoriality, fighting and other aspects of cat behaviour.

Macdonald & Apps (1978) have studied the social behaviour of a group of semi - dependent farm cats and report stable relationships between the group members and an 'amicable community' which excludes strangers.

The only available large scale study of a well established feral cat population in an urban area is that of Dards (1979). Dards studied a population of approximately 200 adult cats living in Portsmouth Naval dockyard (an area of about 85 ha.). She found that the females lived in small groups of related animals with almost totally overlapping home ranges. These groups also contained kittens, juveniles and young males which apparently were not sexually mature. Male ranges overlapped with each other and with the ranges of females.

Interactions between the cats were generally amicable but interactions between males were characterised by aggression, tolerance or avoidance. Aggression was largely ritualised and few fights were observed. The adult population appeared to be very stable but with a high turnover of individuals and high kitten mortality. Dards suggested that the population may be regulated by social behaviour and considered management to be unnecessary.

In recent years interest in feral cats has increased due to the general increase in interest in animal welfare, the possible importance of cats in the transmission of rabies and the detrimental effect that feral cats have had on many rare species of wildlife (especially birds) on islands around the world.

In 1974 the National Conference on the Ecology of the Surplus Dog and Cat Problem was held in the United States of America sponsored in part by the Humane Society of the United States and the American Veterinary Medical Association. A major objective of this conference was to reach an agreement on the future rôle of sterilisation in animal control. The conference concluded that, 'Co - operative spaying and neutering programs which involve humane organisations, governmental agencies and veterinary medical associations appear to be the most feasible and economical means of increasing surgical sterilizations'. The conference participants recognised, however, that surgical sterilisation is not the ultimate answer to the problems of dog and cat population control ( Hodge, 1976). This conference was followed by the National Conference on Dog and Cat Control in 1976 (Anon.a,1976).

The First International Conference on Domestic Cat Population Genetics and Ecology was held in 1978 and included papers on social behaviour (Macdonald & Apps, 1978), home range ( Dards, 1978a ), social organisation and feeding ecology (Corbett, 1978), reproduction and population ecology (van Aarde, 1978). In the same year feral cats were included in the Mammal Society's symposium on Carnivore Biology and Management (Dards, 1978b; Rees, 1978).

In 1980 the Universities Federation for Animal Welfare held a symposium on the Ecology and Control of Feral Cats which included scientific papers ( Dards, 1981; Macdonald, 1981; Rees, 1981; Tabor, 1981), reports from central and local government agencies ( Ablett, 1981; Nicholson, 1981; Southam, 1981) and contributions from veterinary and animal welfare workers ( Cronin, 1981; Hammond, 1981; Jackson, M., 1981; Jackson, O.F., 1981; Kristensen, 1981; Remfry, 1981; Young, 1981). This symposium brought together people who have to deal with the problems caused by feral cats and should have provided a forum for the discussion of different approaches to control. However, neutering was the only control method discussed in detail in spite of the fact that some cat colonies are controlled by the administration of chemical contraceptives and others by the removal of kittens. The various control methods available are discussed in Chapter 14

In January 1977 the Feral Cat Working Party ( F.C.W.P.) was set up by the Royal Society for the Prevention of Cruelty to Animals (R.S.P.C.A.) under the chairmanship of Dr. Oliphant Jackson ( Curator, Cat Breeding Unit, Royal Free Hospital, London ). The brief of the F.C.W.P. was to investigate the feral cat 'problem' in Great Britain and to report its findings to the Council of the R.S.P.C.A. The F.C.W.P. gathered information from a wide variety of sources including veterinary surgeons, research biologists, voluntary and professional animal welfare workers, commercial cat trappers and education officers. Many aspects of the 'problem' were considered including the trapping, marking, euthanasia, distribution and abundance of feral cats; the education of the public in responsible pet ownership; and the possibility of initiating a national neutering campaign in Britain (Jackson, O.F., 1981).

Interest in the use of neutering to control feral cat colonies appears to be increasing. In 1976 the Humane Society of the United States maintained a list of 185 neutering programmes which were at that time being administered by humane societies, municipal agencies and veterinary associations in the United States ( Hodge, 1976). In Britain the R.S.P.C.A., Cats Protection League and the Universites Federation for Animal Welfare are among the large organisations involved in neutering feral cats. New organisations have been formed specifically to deal with the welfare of feral cat colonies including the Cat Action Trust and the National Cat Rescue Co-ordinating Committee. Cat-lovers recently formed a group called 'Cats in Industry' to rescue, re-home and give veterinary treatment to the cats which live in derelict parts of the River Don steelworks. In addition to these organisations there are many other small groups of people and individuals involved in small scale neutering programmes around the country (see for example Hammond, 1981). There are also a number of cat shelters which temporarily house and attempt to re-home strays, for example the Wood Green Animal Shelter at Heydon, Cambridgeshire, where between two and three hundred cats are kept in small compounds.

Although neutering of feral cat colonies is now a widespread practise among animal welfare organisations, the effect of neutering does not appear to have been carefully studied in the field. There are numerous anecdotal reports of the 'success' achieved in neutering programmes but these are almost always given by advocates of neutering and they are not based on a controlled comparison of neutered and entire colonies, (Hammond, 1981; Remfry, 1981; Young, 1981).

The effect of sterilisation on the physiology and behaviour of mammals has been studied in laboratory conditions. Changes in sexual behaviour and aggression have been described as a result of changes in the levels of sex hormones. Some of the studies which have examined the relationship between sex hormones and behaviour have been reviewed by Slater (1978). Other relevant studies are discussed in Section 5.1.

Humans are emotive about feral cats. Wherever they occur there is a conflict of interest between cat-lovers and those who would remove the cats completely, with various shades of opinion between. Advocates of neutering believe they have a solution which stabilises cat colonies and makes their presence more acceptable. However, the usefulness of neutering depends upon many factors: its effectiveness in controlling numbers, its cost, the number of colonies which are suitable for neutering, the effect of neutering on individual cats, and so on. If neutering is to be undertaken on a much larger scale than at present (as suggested by Jackson, O.F., 1981) the organisations involved will need information on the distribution and abundance of feral cat colonies if they are to examine potential problems and the cost of such a project.

This study had three objectives: to investigate the distribution, abundance and habitat preferences of feral cat colonies in Great Britain; to examine the potential of the domestic cat population in contributing to the feral population;

and to examine the effect of neutering on the ecology and behaviour of a feral cat colony and its effectiveness as a means of population management. The first two objectives were achieved by conducting questionnaire surveys and the third by undertaking a two-year field study of a colony of about 30 feral cats living in the grounds of a large hospital.

This study was financed by the Royal Society for the Prevention of Cruelty to Animals from October 1977 to December 1980, and its progress was monitored by the Feral Cat Working Party. Some additional fieldwork was undertaken in 1981.

# PART II

## SURVEYS OF FERAL AND DOMESTIC CAT POPULATIONS

# 3. SURVEY OF FERAL CAT COLONIES IN GREAT BRITAIN.

## 3.1. INTRODUCTION

This survey is the first systematic attempt to examine the distribution, abundance and nature of feral cat colonies in Great Britain. While the existence of certain specific colonies is known to animal welfare organisations, such as the R.S.P.C.A., Environmental Health Departments and pest control firms, they appear to have kept few records. Those records that do exist are scattered around the various offices of these organisations and refer only to local areas. The aim of this study was to gather information on the location of feral cat colonies and details of their size, stability, removal operations, habitats utilised and other aspects of their ecology.

The distributions of mammals in Britain have been widely studied. In 1965 the Mammal Society began collecting records of the presence of mammals in 10 kilometre squares of the National Grid. These records were first published by Corbet (1971) but have been recently revised by Arnold (1978) and include maps of some feral and escaped species. These maps are based on reports of mammals from individual local recorders, with some species having been the subject of special surveys e.g. badger, ( *Meles meles* (L)),harvest mouse ( *Micromys minutus* ( Pallas)).

Where smaller areas have been studied different approaches have been used. Fargher (1977) examined the distribution of the Brown hare ( Lepus capensis L.) and the Mountain hare ( Lepus timidus L. ) in the Isle of Man. One kilometre squares of the island were examined by one to three persons on foot and from a vehicle. Insley (1977) estimated the density of the Red fox ( Vulpes vulpes L.) in the New Forest using a team of six to eight persons walking in parallel lines to search 53 randomly selected one kilometre squares for dens.

This survey of feral cat colonies was initiated in October 1977 in Bradford and originally restricted to West Yorkshire. It was subsequently decided to extend the study to cover the North of England ( north of a straight line joining Liverpool and Hull) and finally the whole of Great Britain.

## 3.2. METHODS

In order to obtain information on the location of feral cat colonies a number of organisations concerned with the welfare or control of cats were contacted. All members of the R.S.P.C.A. Inspectorate were sent a request for information via R.S.P.C.A. Headquarters. Offices of the Ministry of Agriculture, Fisheries and Food were contacted with the help of Mr. J.G. Cormack, Deputy Regional Veterinary Officer, Agricultural Development and Advisory Service, Leeds. Requests for information were also sent to all branches of the pest control firm 'Rentokil'.

An individual circular letter was sent to every Environmental Health Department in Britain (452) and each of the District and Area Health Authorities in the National Health Service (344). Particular attention was paid to hospital properties as they were considered to be a favourite habitat for feral cats.

In addition, all Central Electricity Generating Board power stations were contacted in the North of England and all catteries, cat breeders and pest control firms in South Manchester.

Requests for information were published in a number of journals. Biologists were contacted via the Biologist ( Institute of Biology), Bulletin of the Institute for the Study of Animal Problems, Mammal Society Newsletter, and Proceedings of Mammal Society Symposium on Carnivore Biology and Management. Animal welfare workers and cat-lovers were contacted via Today (R.S.P.C.A.), The Ark (Catholic Study Circle for Animal Welfare), Humane Education Journal ( Humane Education Council) and The Cat ( Cats Protection League). Requests for information from veterinary surgeons and environmental health officers were published in Veterinary Record ( British Veterinary Association) and Environmental Health Journal ( Association of Public Health Inspectors), respectively and a letter to the editor was published in the magazine Wildlife ( Wildlife Publications Ltd.).

Some information on the location of feral cat colonies in and around Bradford was available from a study made by Miss Jane Godfrey ( an undergraduate from the University of Bath) during the summer of 1977.

When a report of the location of a colony was received a questionnaire was sent to the address provided with an explanatory letter, or to the person who provided the original report. This questionnaire was revised at an early stage in the survey, and the second version ( Fig. 3.1.) included a number of additional questions. These changes are indicated in Table 3.1.

Approximately 466 questionnaires were distributed. The precise number of questionnaires that could have been returned was not known since occasionally requests were made for several questionnaires, for example from Environmental Health Departments, but were not all returned. On other occasions one questionnaire was sent and copies were made so that more were returned than had originally been despatched.

Questionnaires were distributed from November 1977 to April 1979 but towards the end of this period the amount of time spent on the survey was considerably reduced due to the demands made by the fieldwork described below. Some of the colonies reported could not be investigated further for this reason, including a large number of reports received from R.S.P.C.A. Inspectors in March 1979.

UNIVERSITY OF BRADFORD

Bradford West Yorkshire BD7 1DP
Telephone Bradford 33466 (STD Code 0274)
Telex 51309 University Brad ext 8414.

Postgraduate School of Studies
in Environmental Science
Chairman : Dr B Stonehouse MA D Phil BSc

Argyll & Bute Hospital

Please quote ref. QN/77.

UNIVERSITY OF BRADFORD
FERAL CAT SURVEY

DATE. 7/3/79 QN. 306

1. Description of premises (eg. hospital, warehouse, factory etc.)
PSYCHIATRIC HOSPITAL OF 452 BEDS

2. Full address of premises. ARGYLL & BUTE HOSPITAL
LOCHGILPHEAD, ARGYLL PA31 8LB
Tel.No. LOCHGILPHEAD 2323

3. What occupies the land surrounding the premises ?
Please tick as many of the following as necessary. Do not include gardens, woodland, etc. within the boundaries of the premises.

| | | | |
|---|---|---|---|
| Housing. | | Industrial premises. | |
| Derelict land. | | Agricultural land. | ✓ |
| *Woodland. | ✓ | Other - Please state below. | |

*INCLUDES FORESTRY COMMISSION CONIFER PLANTATION

4. If your premises have their own large grounds please state the nature of these grounds eg. gardens, woodland, large car parks etc.
GROUNDS COMPRISE OPEN LAWNS, SHRUBBERY AND WOODLAND
GOLF COURSE ETC.

5. To the best of your knowledge how long have feral (wild) cats been living on the premises ?
Please tick the appropriate box below. Do not include occasional stray cats or cats kept as pets.

| | | | |
|---|---|---|---|
| Less than 6 months | | 1 to 2 years | |
| 6 months to 1 year | | 2 to 5 years | |
| | | Longer than 5 years | ✓ |

Fig.3.1. Questionnaire used in the survey of feral cat colonies. (Second version).

6. Approximately how many feral cats live on the premises NOW? Please tick the appropriate box below.

| 1 - 10 | | 11 - 20 | | 21 - 50 | ✓ | More than 50 | |
|---|---|---|---|---|---|---|---|

7. Over the last 12 months has the number of adult feral cats increased, decreased, or remained fairly stable? Please tick the appropriate box below.

| Decreased | | Remained Stable | ✓ | Increased | |
|---|---|---|---|---|---|

8. Have any feral cats been removed from the premises? Please tick the appropriate box below.

| YES | | NO | ✓ |
|---|---|---|---|

9. If feral cats have been removed from the premises please indicate who was responsible by placing as many ticks as necessary in the boxes below.

| | | | |
|---|---|---|---|
| R.S.P.C.A. | ✓ | Private Pest Control Firm. | ✓ |
| Environmental Health Dept./Public Health/ Town Hall/Council etc. | ✓ | Persons normally employed to work on your premises. | ✓ |

Other (please state). ____________________

10. Are feral cats considered to be a problem on the premises? If so, please indicate the nature of the problem by ticking as many of the boxes below as necessary. Also indicate, by ticking the appropriate box, any problems that have been experienced in the past.

| Cats are a problem | ✓ | Cats are not a problem | |
|---|---|---|---|

| Nature of problem | When ? | |
|---|---|---|
| | PAST | PRESENT |
| Fleas | | |
| ~~Faeces~~/smells | ✓ | ✓ |
| Dead cats found on premises | | |
| General nuisance/inconvenience | ✓ | ✓ |
| Staff allergic to cats | | |
| Problem created by large numbers | ✓ | |

Other - please state. ____________________

Is the presence of feral cats on the premises considered to be of advantage in any way? If so, what.

No

Fig. 3.1. (Continued).

11. What food sources are available to the cats ? Please indicate all food sources with a tick below.

| | | |
|---|---|---|
| Food from waste bins | ✓ | Food stored on the premises |
| *Food provided by people living/working on the premises. | | ✓ |

Other - please state. HOSPITAL IN-PATIENTS FEED SOME OF THE CATS REGULARLY WITH TABLE SCRAPS

12. Is it possible to identify places used by the cats for shelter? If so please list these places (eg. basements of buildings, heating ducts, etc).

THE MAIN HOSPITAL BUILDING IS OVER 100 YEARS OLD AND CONTAINS MANY NOOKS AND CRANNIES ACCESSIBLE TO CATS. THEY ALSO USE HEATING DUCTS, WORKSHOPS AND OUTHOUSES

13. If you have received any assistance from the R.S.P.C.A., the Environmental Health Dept., or a private pest control firm could you please summarise here any measures that these people have suggested that you should take in order to control or reduce the cat population.

IN THE PAST THE R.S.P.C.A SUGGESTED THAT, IF THE CATS WERE TRAPPED, THEY WOULD BE WILLING TO DESTROY THEM HUMANELY. HOWEVER, DUE TO HOSTILITY FROM THE PATIENTS AND CERTAIN STAFF THIS PLAN WAS ABANDONED.

14. Has the possibility of sterilization been considered ? Please tick the appropriate box below.

| | | | |
|---|---|---|---|
| YES | ✓ | NO | |

15. If any measures have been taken to control the cats please indicate how successful(or otherwise)they have been, for your purposes,(eg have cat numbers been reduced to an acceptable level, removed completely, etc).

16. Please give the name and address of any other premises known to have a feral cat population.

17. NAME. P.M. REES POSITION. DISTRICT ADMINISTRATOR ARGYLL & BUTE DISTRICT ARGYLL & CLYDE HEALTH BOARD.

THANK YOU.

Fig. 3.1. (Continued).

When the collection of information was completed the colonies reported were divided into two categories, 'cofirmed' and 'unconfirmed', depending upon the reliability of reports:

1. Confirmed colony

(i) Reported by at least two independent informants.

(ii) Questionnaire completed and returned.

(iii) Colony visited during the course of the study.

2. Unconfirmed colony

(i) Reported by a reliable informant but the existence of the colony was denied by the authorities at the premises concerned.

(ii) Reported by a reliable informant but a questionnaire was either:

(a) sent and not returned.

or (b) not sent as survey period had elapsed.

The 'unconfirmed' colonies may have included some extinct colonies. Colonies definitely reported as extinct were excluded from the study. Visits were made to a number of colonies in order to confirm their existence and to examine their suitability for further study (see Section 5.1.).

A four figure map reference was obtained for the location of each cat colony based on information provided in reports. The distribution of colonies has been mapped in 10 kilometre squares of the National Grid. In a small number of cases the information provided was insufficient to locate a colony. These colonies have not been mapped. Colonies reported from London were assumed to be located in the 10 kilometre square which contains the City of London (5317) unless information was available to the contrary. Colonies reported from islands were not generally mapped but have been listed. The distribution maps of mammals presented by Arnold (1978) contain many historical records, some from before 1900. Only feral cat colonies which were extant at the time this survey was undertaken have been mapped because many colonies are transitory in nature and the inclusion of old reports may have distorted the present distribution pattern.

Details of the number of cats received by the R.S.P.C.A. annually were made available for analysis by Mr. J.M. Woodhouse, Deputy Clinics Manager ( R.S.P.C.A. Headquarters) and Secretary to the Feral Cat Working Party. Similar information for the Liverpool Branch of the R.S.P.C.A. was provided by the Secretary and Administrator, Major W.H. Stabback. This branch was of interest because of its large size and extensive historical records.

## 3.3. THE NUMBER OF COLONIES REPORTED AND QUESTIONNAIRES RETURNED

A total of 704 feral cat colonies were reported between October 1977 and June 1979. Of these, 339 (48.2%) were 'confirmed' , including 287 (40.8% of the total) for which questionnaires were completed and returned. Forty-one (14.3%) of the questionnaires returned were the first version distributed and the remainder were the revised second version. Approximately 466 questionnaires were distributed and this therefore represented a total return of approximately 60%.

As the second version of the questionnaire contained more questions than the first version, more information was received for some colonies than for others. The percentage of all the questionnaires returned which contained each question and the number of responses to each question expressed as a percentage have been calculated (Table 3.1.). Three questions which appeared on the second version of the questionnaire did not appear on the first version. The responses to four of the questions have not been examined as they were not specific enough to lend themselves to a simple analysis. A request for information about other colonies was made at the end of the questionnaire. The responses to this request provided further addresses to which questionnaires were sent but the number of questionnaires which contained entries here has not been examined. The questionnaires which could have contained a response to any particular question did contain a response in over 90% of cases. It is interesting that questions asking about the stability of the colony, whether or not sterilisation of the cats had been considered, and whether or not cats were considered beneficial were those which were most frequently unanswered.

Table 3.1.

Summary of the questions asked on the first and second versions of the questionnaire. The number of responses received to each question is expressed as a percentage of all questionnaires which contained the question.

| Question | Percentage asked | Percentage of responses |
|---|---|---|
| Description of the premises | 100 | 100 |
| Full address | 100 | 100 |
| Nature of the surrounding land | 100 | 96.2 |
| Nature of grounds | - | - |
| Age of colony | 100 | 98.6 |
| Size of colony | 100 | 97.6 |
| Stability of colony * | 85.7 | 94.7 |
| Removal of cats Yes/No | 100 | 98.3 |
| Organisations responsible | 100 | 100 |
| Do cats cause problems? Yes/No | 100 | 99.3 |
| Nature of problems | 100 | 100 |
| Are cats beneficial? Yes/No * | 85.7 | 91.9 |
| Food sources | 100 | 98.6 |
| Nature of sheltering places | - | - |
| Assistance/advice received | - | - |
| Has sterilisation been considered? * | 85.7 | 94.3 |
| Have control attempts been a success? | - | - |
| Address of other known colonies | - | - |
| Position of person who completed questionnaire | 100 | 100 |

- = Not analysed

* = Question absent from first version of questionnaire

Most of the questionnaires were completed by persons living or working on the premises occupied by the colonies concerned (80.5%). Almost all the remaining questionnaires were completed by Environmental Health Departments (17.8%) but a small number was returned by members of the public with knowledge of particular colonies (1.7%). It is important to bear these figures in mind when considering the responses made to questions about the problems caused by feral cats. Since most questionnaires were completed by persons in official positions it is likely that their attitudes were biased against the cats.

The responses given to each question have been expressed below as a percentage of all questionnaires which contained a response to that question.

## 3.4. THE ECOLOGY OF FERAL CAT COLONIES

### 3.4.1. Habitat types occupied by feral cat colonies

Information is available for 695 colonies on the nature of the habitat occupied (Table 3.2.). Hospitals, industrial sites and private residential properties were the three habitat types most frequently reported. Together they comprised 69% of all colonies and 79.1% of the colonies surveyed by questionnaire. Hospitals were probably over-represented in the sample for which questionnaires were available. This was partly due to the systematic way in which hospital authorities were investigated. Hospital administrators were generally co-operative because of

Table 3.2.

Habitat types occupied by feral cats. Similar habitats have been grouped together for convenience. The types of habitat utilised by the colonies for which questionnaires were available are indicated.

| | Habitat Type* | All | | Questionnaire received | | Questionnaire not received | |
|---|---|---|---|---|---|---|---|
| | | No. | % | No. | % | No. | % |
| 1 | Hospital | 304 | 43•2 | 186 | 64•8 | 118 | 28•3 |
| 2 | Industrial site | 108 | 15•3 | 26 | 9•1 | 82 | 19•7 |
| 3 | Private residential property | 74 | 10•5 | 15 | 5•2 | 59 | 14•1 |
| 4 | Large residential property | 35 | 5•0 | 6 | 2•1 | 29 | 7•0 |
| 5 | Docks/Harbour/Shipyard | 26 | 3•7 | 7 | 2•4 | 19 | 4•6 |
| 6 | Shopping centre | 24 | 3•4 | 5 | 1•7 | 19 | 4•6 |
| 7 | Open land | 20 | 2•8 | 9 | 3•1 | 11 | 2•6 |
| 8 | Military property | 18 | 2•6 | 6 | 2•1 | 12 | 2•9 |
| 9 | Derelict land/building | 15 | 2•1 | 6 | 2•1 | 9 | 2•2 |
| 10 | Commercial premises/Public building | 15 | 2•1 | 3 | 1•0 | 12 | 2•9 |
| 11 | Power station | 11 | 1•6 | 6 | 2•1 | 5 | 1•2 |
| 12 | Temporary residence | 10 | 1•4 | 4 | 1•4 | 6 | 1•4 |
| 13 | School/University/Nursery | 10 | 1•4 | 2 | 0•7 | 8 | 1•9 |
| 14 | Farm | 9 | 1•3 | 2 | 0•7 | 7 | 1•7 |
| 15 | Unidentified | 9 | 1•3 | 2 | 0•7 | 7 | 1•7 |
| 16 | Refuse tip | 6 | 0•9 | 1 | 0•3 | 5 | 1•2 |
| 17 | Prison | 5 | 0•7 | 1 | 0•3 | 4 | 1•0 |
| 18 | Airport | 3 | 0•4 | - | - | 3 | 0•7 |
| 19 | Abbatoir | 2 | 0•3 | - | - | 2 | 0•5 |
| | TOTAL | 704 | | 287 | | 417 | |

*Notes on Habitat Type.

2 Factories, workshops, builders' yards etc.
3 Individual houses, groups of houses, housing estates.
4 Orphanages, Homes for the Elderly, Halls of Residence, hotels.
5 Includes Naval dockyards.
6 Includes individual shops.
7 Allotments, public gardens, woodland, golf courses, zoological gardens, car parks.
8 Barracks, military airfields, and tracking stations, but excluding Naval dockyards.
10 Offices, laboratories, churches, museums.
12 Caravan sites, building site construction villages.
13 Includes a leisure centre.
15 Habitat type could not be determined from the available information.
17 Includes open prison, borstal, and rehabilitation centre.

the implications of the presence of cats on hospital property.

Most of the habitat types used by feral cats were associated with human activity and concern has been expressed about the possible transmission of disease from cats to man (see Chapter 13 ). In view of the possibility of rabies entering Britain it is particularly disturbing that 26 colonies have been reported from docks, harbours and shipyards around our shores and also at three airports.

### 3.4.2. Land-use in the vicinity of sites occupied by feral cats

Housing was the commonest type of land-use found associated with feral cat colonies (73.2%). This may be indicative of the origin of many of these colonies. Agricultural land, woodland, industrial land, and derelict land were associated with 46.7%, 32.2%, 27.9% and 23.9% of all colonies respectively.

### 3.4.3. Size, stability and age of colonies

Small colonies were much more common than large colonies. (Fig. 3.2.). Only twenty colonies (7%) were considered to consist of more than 50 cats: 15 hospitals, four docks / harbours / shipyards, and one industrial site. Most colonies were considered to be more than five years old (74.6%) and only 1.4% were less than six months old (Fig. 3.3.). The number of cats in the colony remained stable during the 12 months preceding the date of completion of the questionnaire in 50.6% of all colonies. An

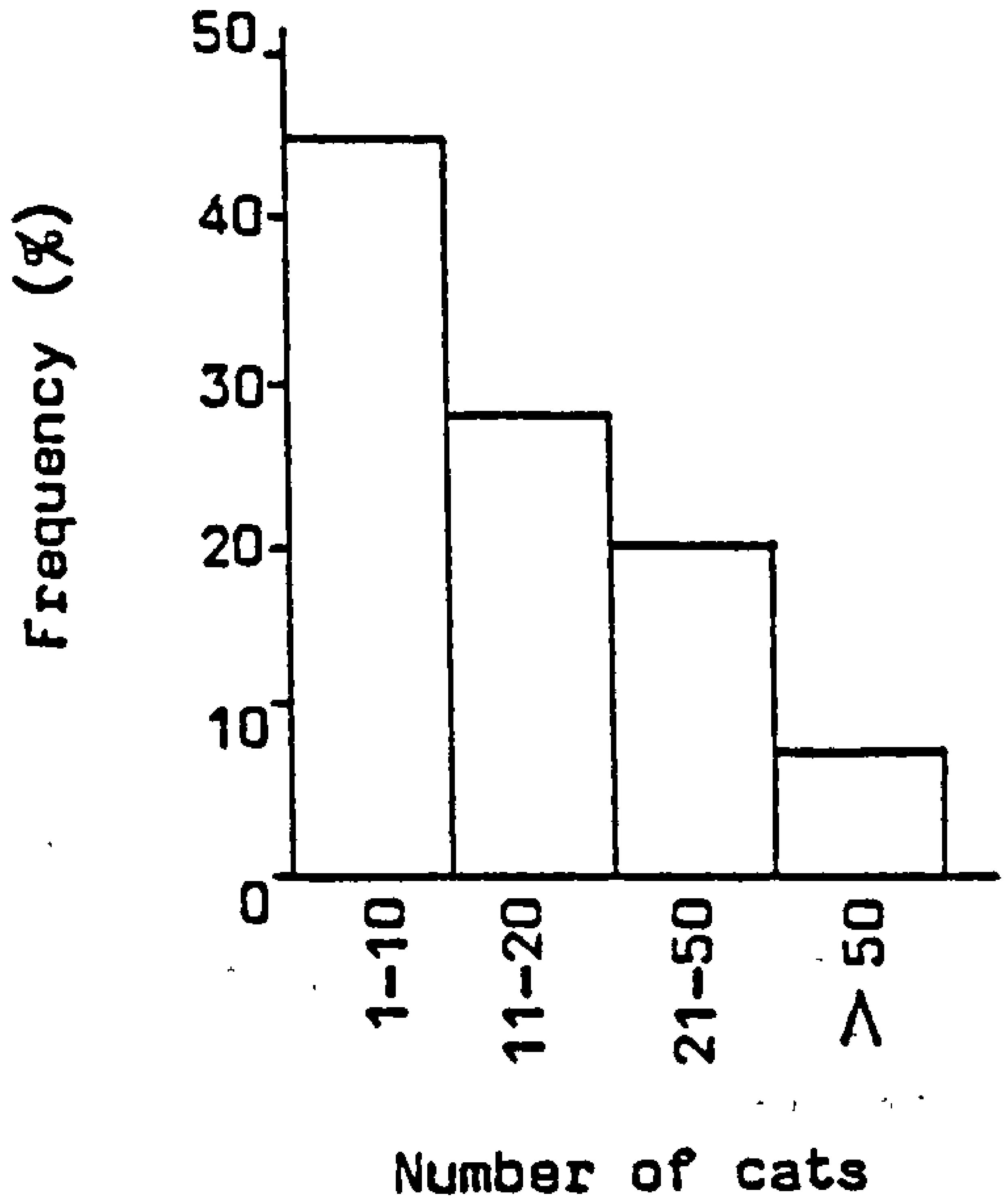



Fig.3.2. Size of colonies.

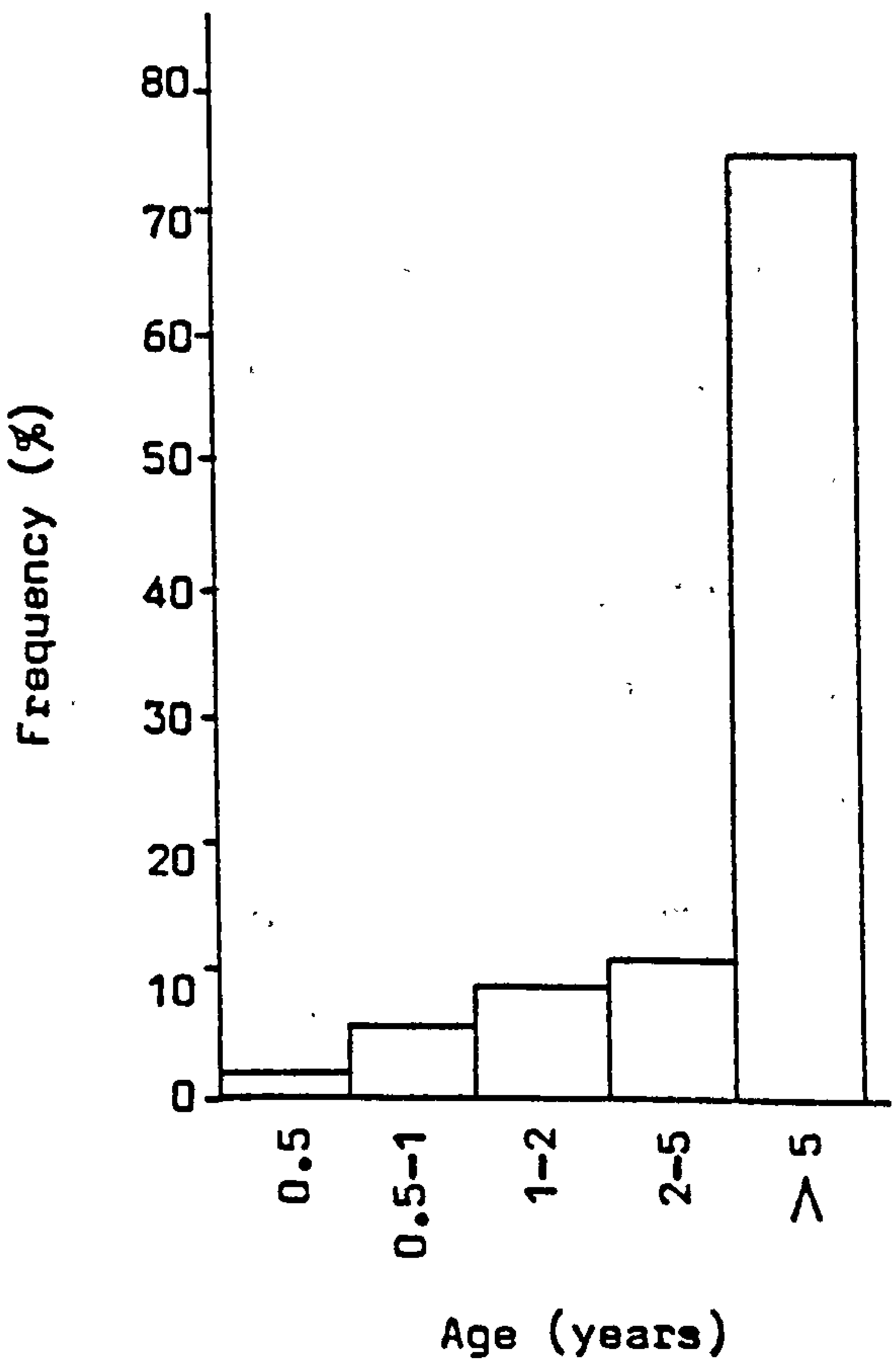



Fig.3.3. Age of colonies

increase was recorded in 33.9% and a decrease in 15.5% of all colonies.

Colony size, stability and age were difficult to investigate. Often, because of their positions, the persons who completed the questionnaires were unlikely to have detailed knowledge of the cats. This information could probably only have been obtained from persons who regularly fed the animals and only occasionally was it possible to send a questionnaire to such a person. Nevertheless it is interesting that most colonies were considered to be small, stable in number, and more than five years old. It is likely that many small colonies are founded by stray cats but are removed before the animals become established and have therefore not been detected by the survey.

### 3.4.4. Removal of cats

Cats had been removed from a high proportion of the colonies investigated (84.4%). The R.S.P.C.A. removed cats from 45.6% of these colonies. Employees working on the premises occupied by cats were responsible for removals from 43.1% of colonies. Pest control firms removed cats from 33.5% and Environmental Health Departments from 15.9% of colonies. In many cases more than one agency had been involved in removal operations, often the R.S.P.C.A. worked in conjunction with employees. The Blue Cross was reported to have removed cats from one colony.

### 3.4.5. Problems and benefits associated with the presence of cats

Cats were considered to cause problems in 84.8% of the colonies investigated. The frequency of reports of each type of problem, expressed as a percentage of all colonies reporting problems was : general nuisance 81.7% , faeces / smells 63.0% , dead cats 47.2% , problem caused by numbers 46.4% , fleas 39.8% and staff allergic to cats 10.0%. A small number of other problems, such as noise, were reported but have not been analysed. Some hospitals considered cross-infection to be a possible problem (see Chapter 13).

The presence of cats was considered to be a definite or possible benefit to 46.0% of premises occupied by a colony. The usual benefit reported was the possible 'control' of rats and mice , and in some hospitals cats were thought to have a therapeutic value for the patients, particularly psychiatric and geriatric cases.

### 3.4.6. Food sources of feral cats

The cats in 91.9% of the colonies were actively fed by persons working or living on the premises concerned (including members of the public). Waste bins provided food for cats in 66.4% of the colonies. Only 7.4% of the colonies gained access to stored food and this appeared to be a relatively unimportant food source. Reports were received of cats taking wildlife (rodents and birds) but they were usually presumed rather than observed to utilise this food source.

### 3.4.7. Sterilisation of feral cat colonies

The use of neutering as a control measure had been considered for 25.9% of the colonies investigated. This method had been used for 9.5% of colonies, (36.7% of the colonies for which it had been considered). The types of premises concerned were: hospitals 13 (59.1%), docks / harbours / shipyards 2 (9.1%), large residential properties 2 (9.1%), open ground 2 (9.1%), industrial sites 2 (9.1%) and a shopping centre (4.5%).

## 3.5. THE DISTRIBUTION AND ABUNDANCE OF FERAL CATS IN GREAT BRITAIN

Precise locations were obtained for 686 colonies of feral cats (97.4% of all colonies reported) in England, Wales and Scotland (Fig. 3.4.). In addition a small number of colonies was reported from islands: Isle of Wight, Lundy, Orkney (Mainland), Shetland (Mainland), Monarch Islands (Outer Hebrides) and North Uist (Outer Hebrides).

The distribution revealed by this survey is discontinuous and indicates a number of regions where the population appears to be concentrated:

1. Greater London and the South East of London.
2. Greater Manchester, Lancashire, Merseyside, Yorkshire

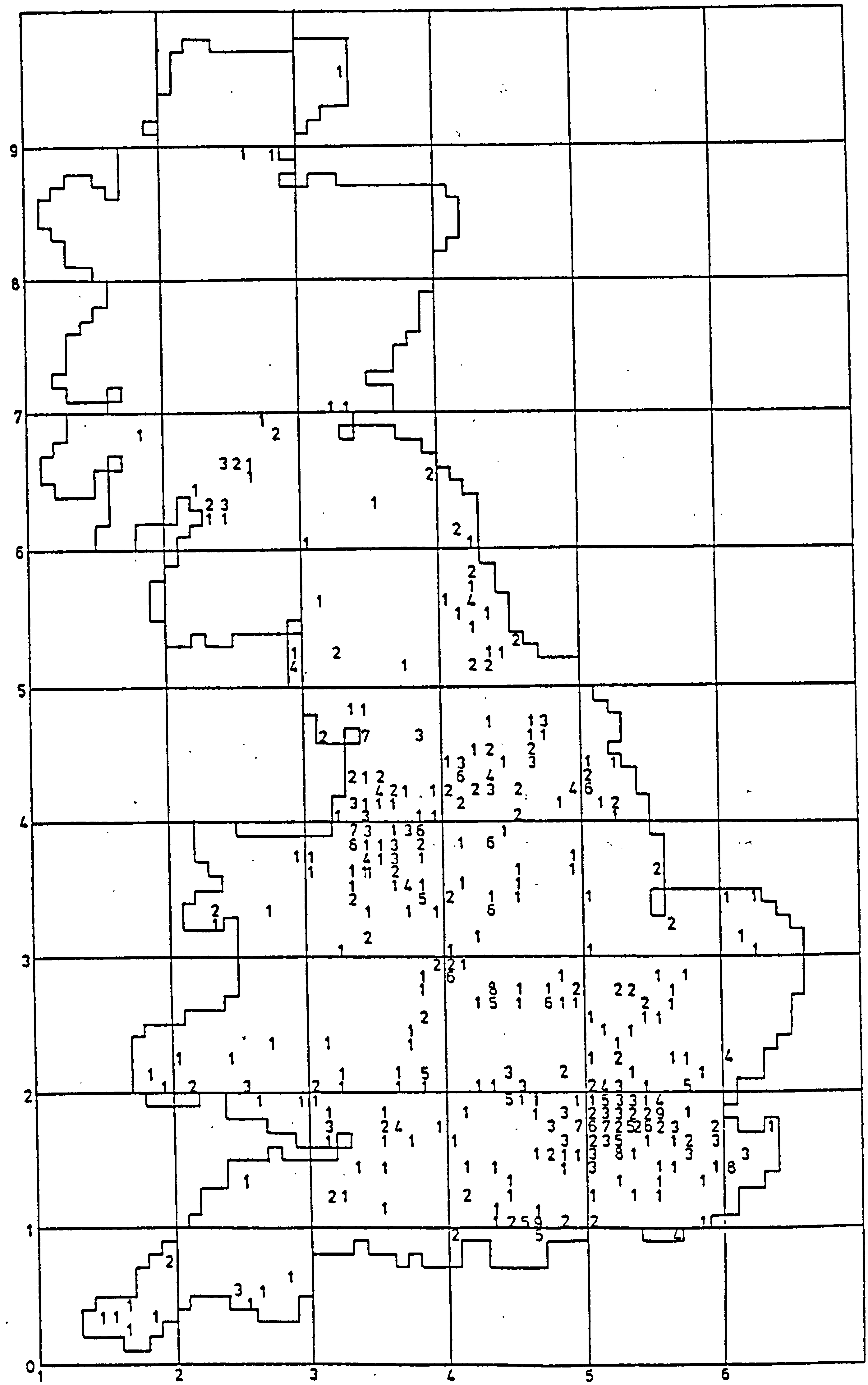


Fig.3.4. Distribution and abundance of feral cat colonies in Great Britain. Numbers represent the number of colonies located in 10km squares of the National Grid.

(North, South and West), and Humberside.

3. Northumberland, Durham, Tyne and Wear, and Cleveland.

4. The Midlands.

5. South Wales.

6. Central Lowlands of Scotland.

These areas of concentration correspond with the seven conurbations of human population recognised in Britain after the 1971 census with the exception of the lowlands of Scotland: Greater London, South East Lancashire, the West Midlands, South East Wales, West Yorkshire, Merseyside, and Tyneside.

Approximately 24% (166) of all colonies were located in the 100 kilometre square (51) of the National Grid which contains Greater London. The 10 km square, (5317), London, contained 52 colonies, the highest number recorded in a single square. Of the 2591 ten kilometre squares representing Britain, 315 were occupied by cat colonies (approximately 12.2%).

The distribution of colonies between 10 kilometre squares was clumped (Fig. 3.5.). Approximately 56% of all colonies occurred in a square from which no other colony was reported. The mean number of colonies per 10 kilometre square was 0.26 ($\underline{s}^2$ = 1.81, $\underline{N}$ = 2591) and the distribution of these colonies was clumped (Index of dispersion, I = 6.84, $\chi^2$ = 17715.6, $\underline{d.f.}$ = 2590, $\underline{P}$ = 0.01).

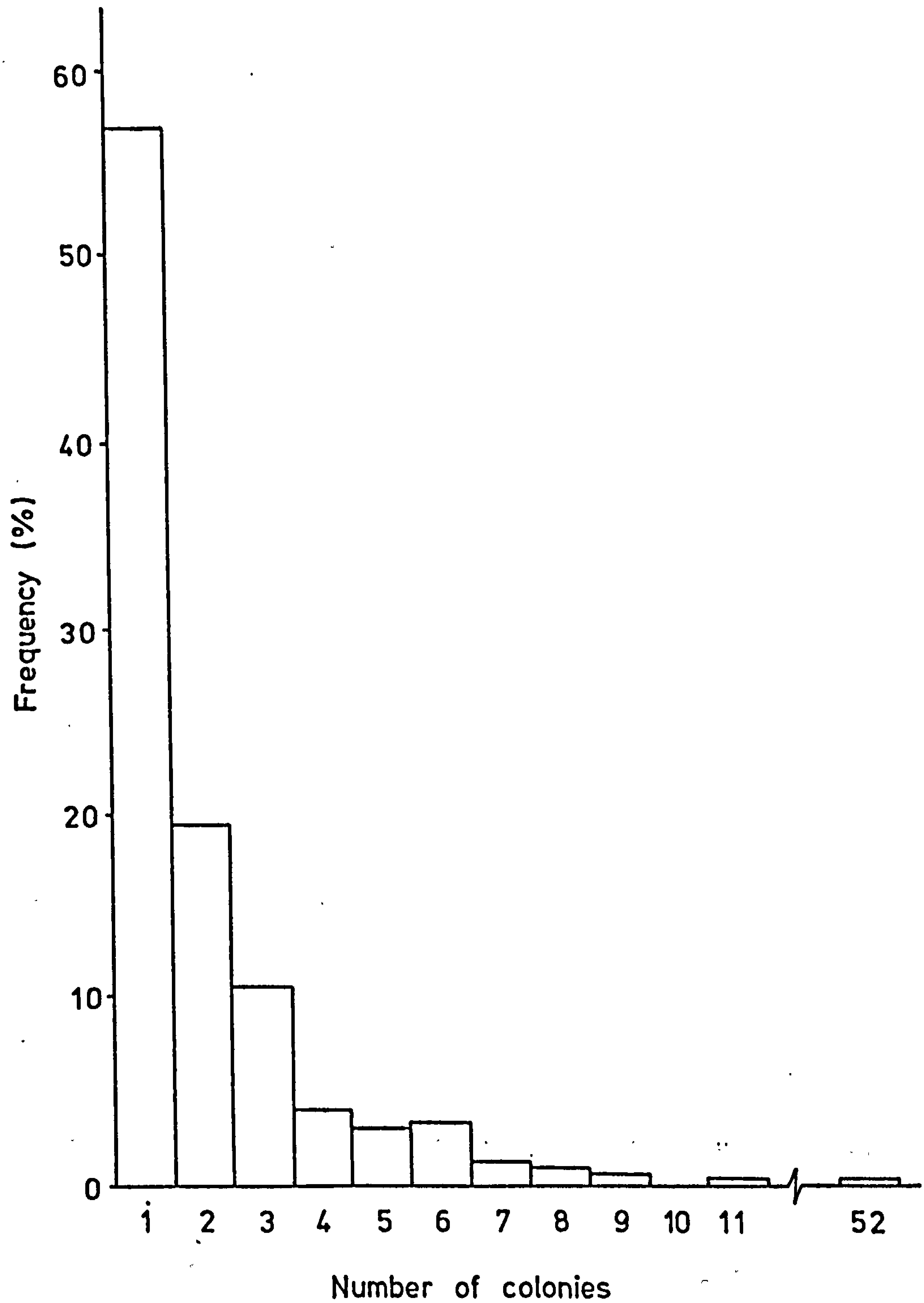



Fig. 3.5. The percentage of occupied 10km squares of the National Grid which contain different numbers of colonies.

Estimates of the number of cats in 280 colonies have been presented above (Fig. 3.2.). Class intervals of 1-10, 11-20, 21-50 and greater than 50 cats were used to define colony size. Using the mid-value of the first three of these class intervals (5.5, 15.5, 35.5) and 50 for the last class, and multiplying the number of colonies in each class by the appropriate value, an estimate of 4893 cats is obtained for the total number of cats living in 280 colonies (with a mean of 17.5 cats per colony). Assuming that all 704 colonies located by the survey exhibited the same distribution of sizes as the sample from which questionnaires were available, the total number of feral cats located was approximately 12,302.

Mr. Henry Arnold, the Biological Records Centre, has produced maps from data collected by this survey showing the presence or absence of feral cat colonies in 10km squares of the National Grid. Three maps have been produced showing 'confirmed' colonies only, 'unconfirmed' colonies only (see Appendix I) and both of these types together, with the presence of a 'confirmed' colony in any square taking priority over that of an 'unconfirmed' colony (Fig. 3.6.). It is clear that the distributions of 'confirmed' and 'unconfirmed' colonies are very similar and these maps indicate equivalent concentrations of colonies to those described above for Fig. 3.4.

## 3.6. TOTAL NUMBER OF CATS RECEIVED BY THE R.S.P.C.A.

Cats received by the R.S.P.C.A. are usually either re-homed or destroyed and it is possible that the number of cats dealt

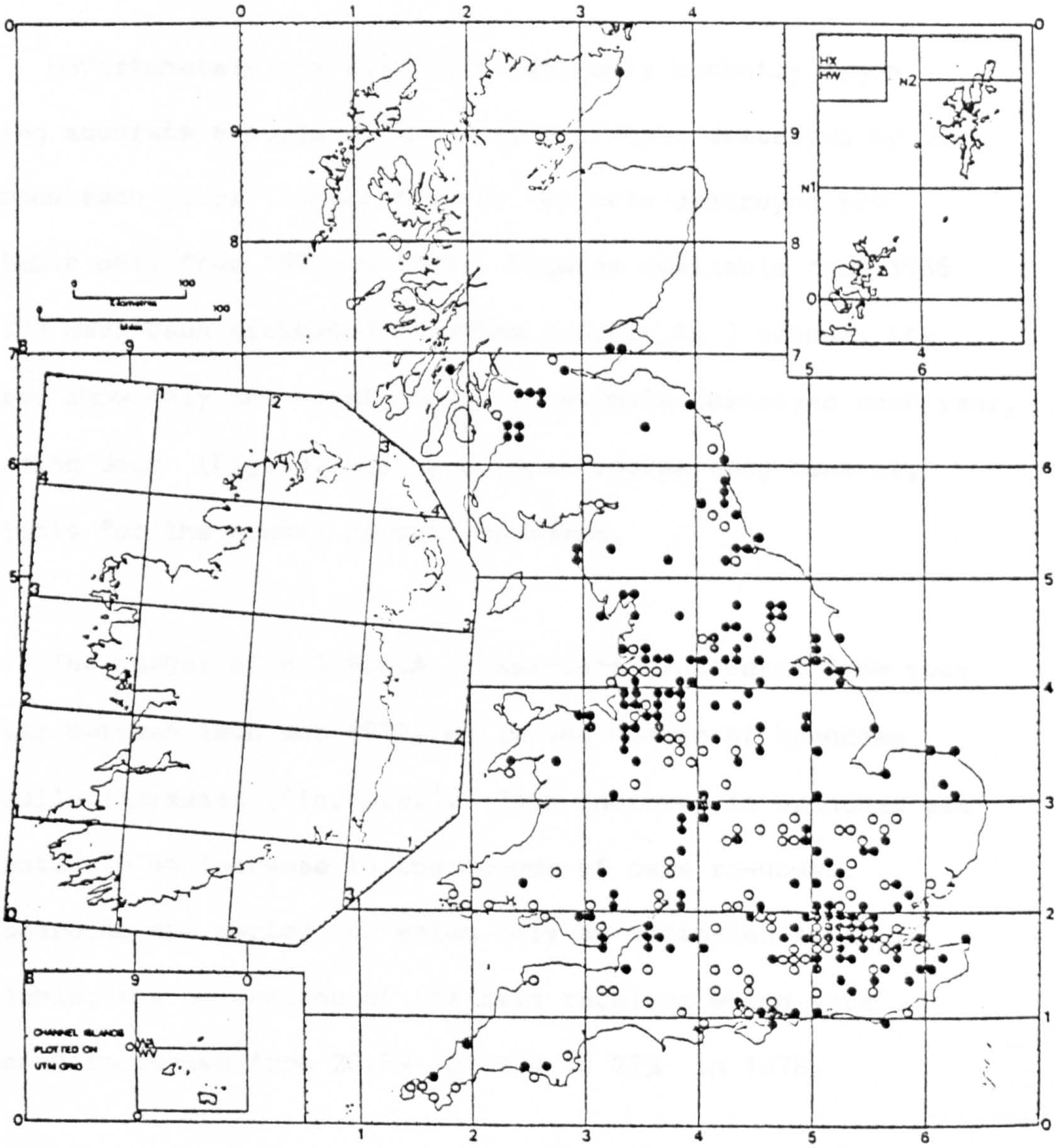



Fig.3.6. Distribution of 'confirmed' (closed circles) and 'unconfirmed' (open circles) feral cat colonies in 10km squares of the National Grid. Where both types of colony occur together a 'confirmed' colony is indicated.

with in any year is a function of the number of Inspectors or the number of branches in operation.

Unfortunately the R.S.P.C.A. has only recently begun keeping accurate records of the number of cats destroyed by its branches each year. Annual figures for cats destroyed are available only from 1973 to 1979. Figures available from 1966 to 1972 have been estimated ( by the R.S.P.C.A. ) because its records show only the total number of animals destroyed each year, including dogs (Fig. 3.7.). Seperate figures are, however, available for the number of cats re-homed.

The number of R.S.P.C.A. Inspectors fluctuated from year to year between 1966 and 1979, while the number of branches gradually increased (Fig. 3.8.). This increase in branches was reflected in an increase in the number of cats re-homed. Disregarding the period for which only an estimated total is available, the percentage of the cats received which were re-homed increased from 20.5% in 1973 to 27% in 1978.

The total number of cats received since 1972 appears to have decreased, but all of the figures for the total number of cats received up to and including that for 1972 include estimates of the numbers destroyed. The figure of approximately 184,000 cats received in 1972 may therefore be inaccurate and the apparent subsequent decrease may not have occurred. The more reliable figures available from 1973 onwards show a fluctuation in the total

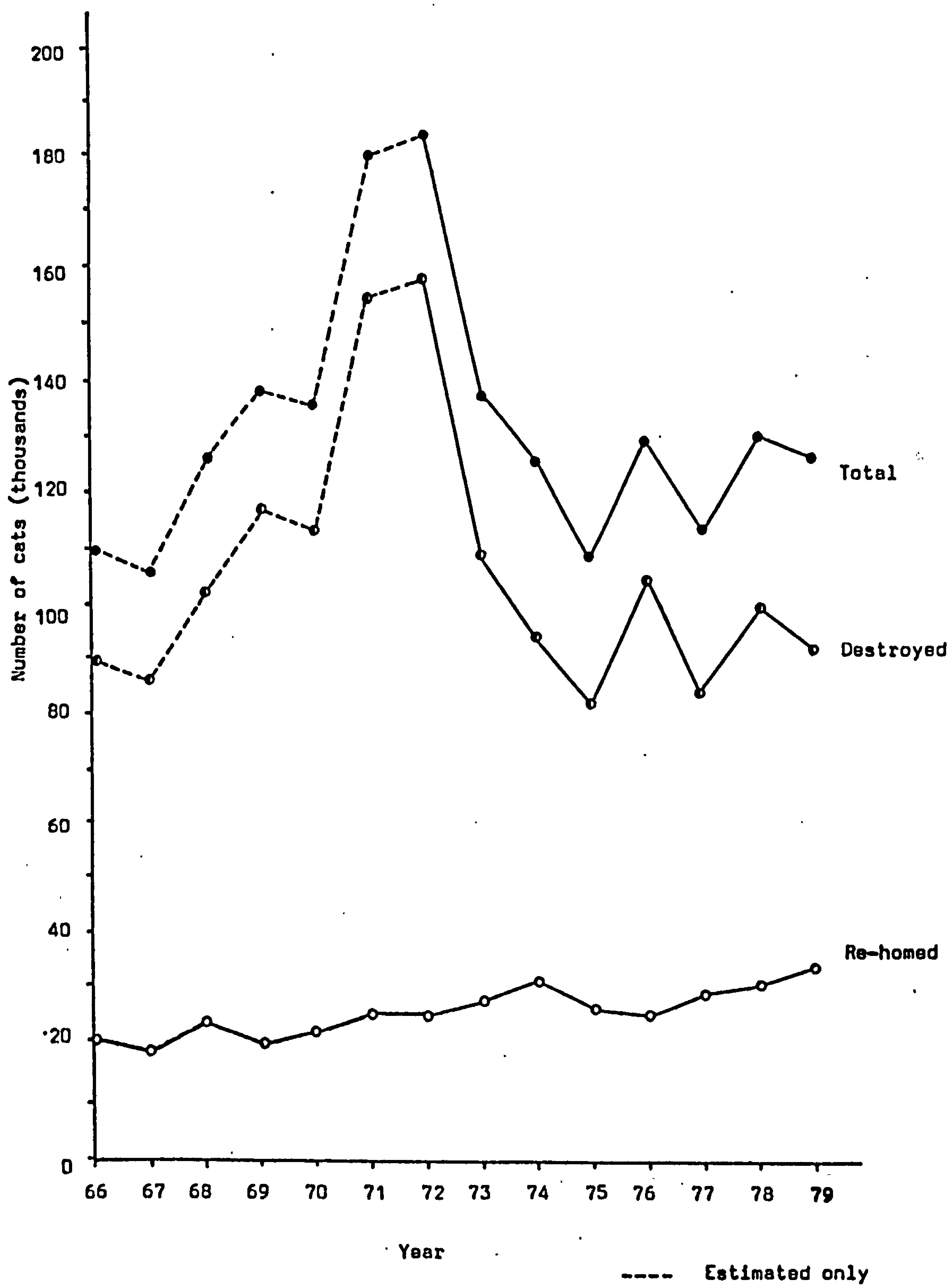



Fig. 3.7. The total number of cats received by the R.S.P.C.A. in Great Britain and the number destroyed and re-homed from 1966 to 1979.

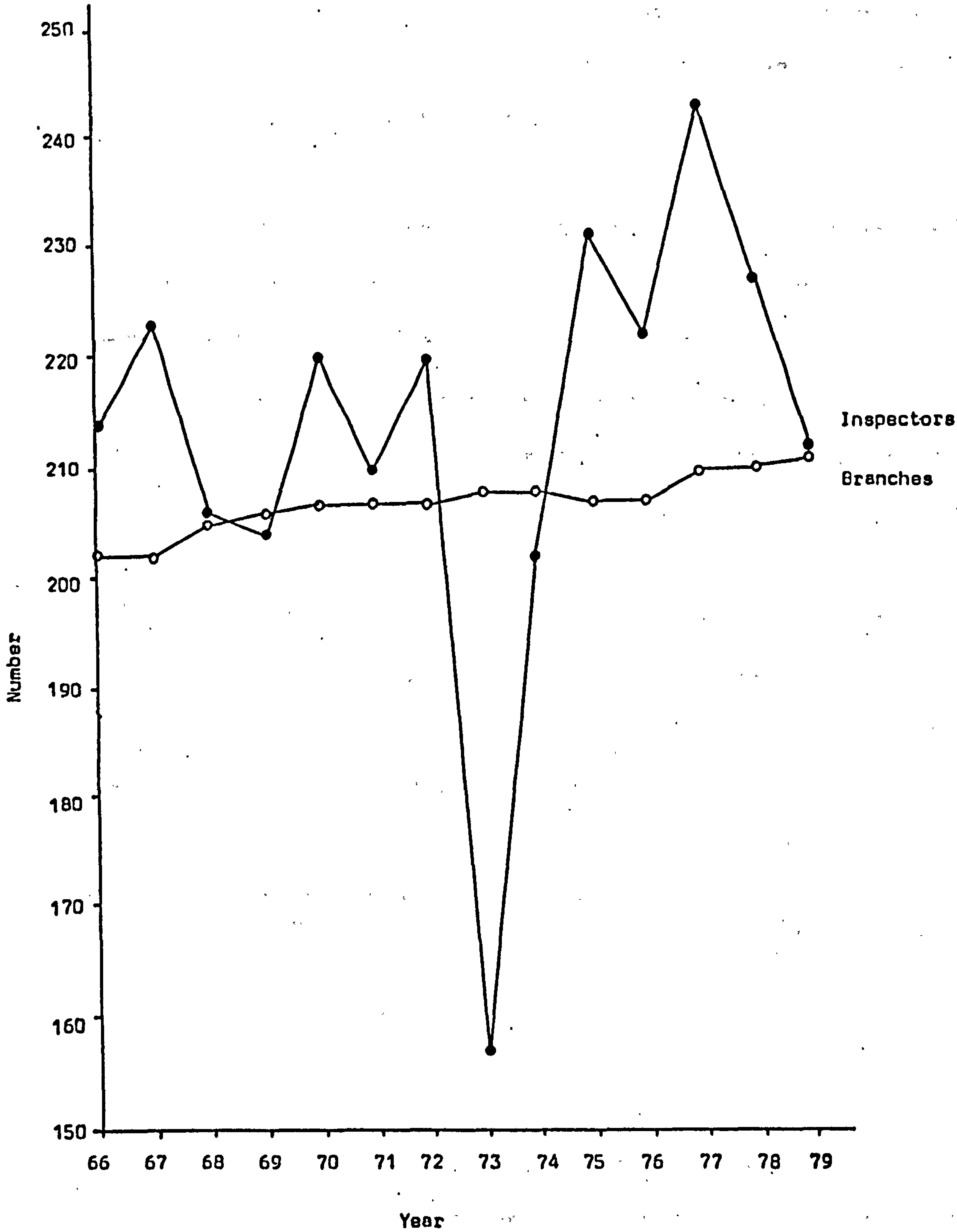



Fig. 3.8. Changes in the number of R.S.P.C.A. Inspectors and branches in Great Britain between 1966 and 1979.

number of cats received each year between 109,137 and 137, 499. Fluctuations in the number of cats destroyed appear to closely follow the changes observed in the total number of cats received. There does not appear to be any close relationship between the total number of cats received or the number destroyed and the numbers of Inspectors or Branches.

No statistical treatment of the relationships between these data has been attempted. It is likely that the numbers of cats re-homed and destroyed ( and therefore also the totals ) contain considerable errors as they relied upon annual returns made by individual R.S.P.C.A. officials whose records were likely to be incomplete.

During 1978 and 1979 the R.S.P.C.A. kept separate figures for feral and domestic cats destroyed by Inspectors:

| | | 1978 | 1979 |
|---|---|---|---|
| Destroyed by Inspectors | Domestic and stray cats | 27,801 | 22,240 |
| | Feral cats | 18,605 | 17,831 |
| All cats destoyed at branch clinics and catteries, London clinics and hospitals | | 53,454 | 52,615 |
| Total destroyed | | 99,860 | 92,686 |

R.S.P.C.A. Inspectors considered that 40% and 44% of the cats that they destroyed were feral in 1978 and 1979 respectively. Inspectors could not always have been certain of the status of these animals. It seems unlikely that they could have distinguished between feral cats and uncollared entire strays so the figures presented here can at best only be considered broad guides.

## 3.7. CATS RECEIVED BY THE LIVERPOOL BRANCH OF THE R.S.P.C.A. (1917 - 1979)

Figures are available for the number of cats received annually by the Liverpool Branch of the R.S.P.C.A. between 1917 and 1979 (Fig. 3.9.). Matheson (1944) quoted some of these totals (from 1930 to 1942) but refers to the branch as the 'Liverpool Cats' Shelter. He noted that these earlier records included some dogs but pointed out that cats were also taken to the Liverpool Dogs' Home. The totals include a small number of 'boarders' and cats which were restored to their owners.

It appears that the number of cats received by the R.S.P.C.A. in Liverpool was low at the end of World War I. (1918) and then showed a four-fold increase, reaching a peak of 37,352 in 1935. During World War II the number of cats received fell to half of this peak value ( about 18,300 in 1942) but by the end of the war (1945) this had increased again to over 29,500.

It is possible that the bomb damage sustained by Liverpool during World War II left many cats as well as people homeless. Since figures are not available for the years prior to 1917 the possible effect of the social hardships caused by World War I on cat numbers in Liverpool cannot be examined.

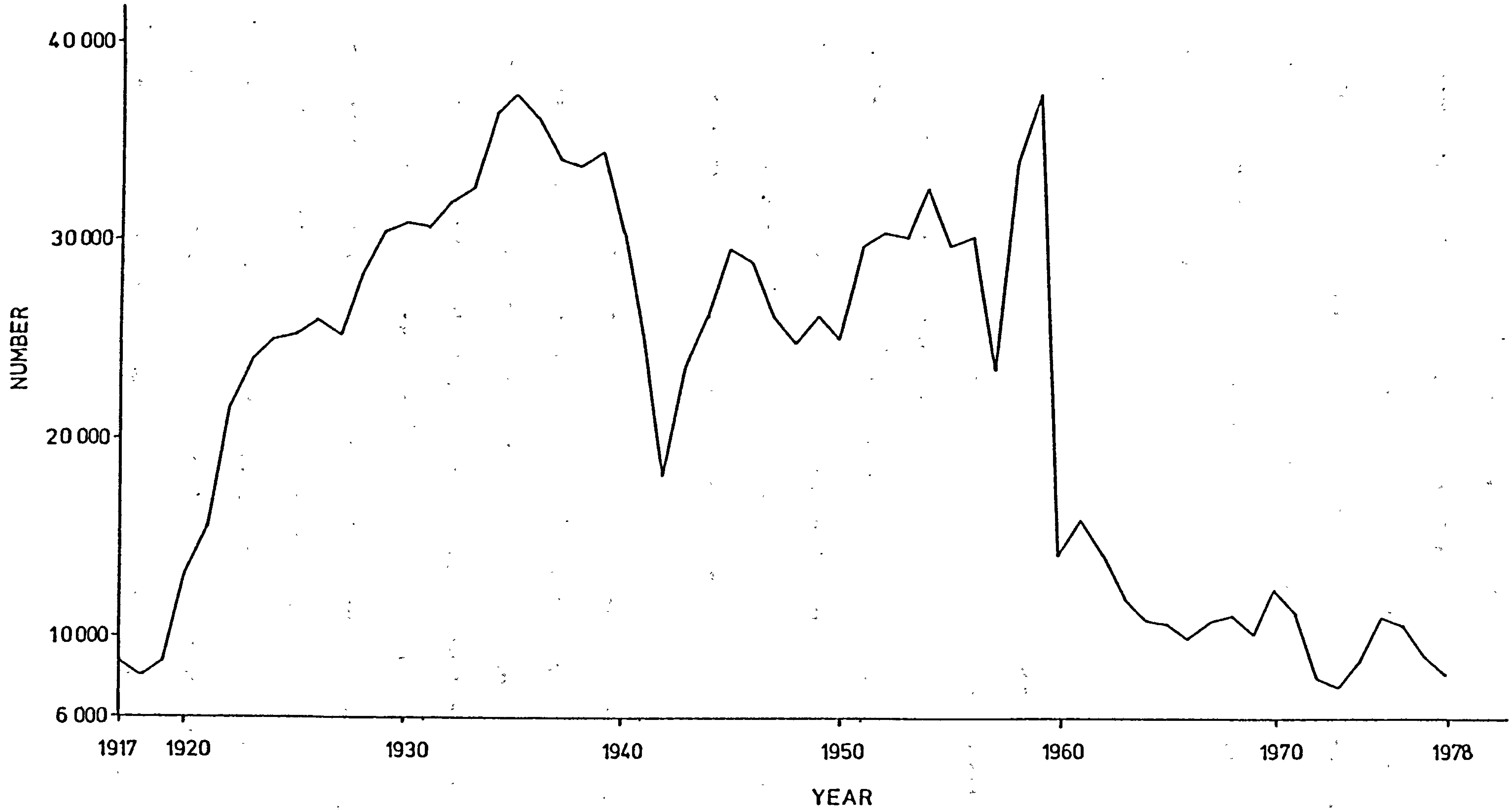



Fig.3.9. The number of cats received by the Liverpool Branch of the R.S.P.C.A. between 1917 and 1978. Drawn from data supplied by Major W.H. Stabback, Secretary of the Liverpool Branch of the R.S.P.C.A.

A second peak in numbers was reached in 1959 (37,479), almost identical in magnitude to the first peak, but in the next year the number of cats received fell by over 23,000 to around 14,300. In the subsequent 17 years this figure decreased by approximately one half, to around 8,000. The lowest number of cats received by the Liverpool branch of the R.S.P.C.A. between 1917 and 1978 was 7,568 in 1973.

Of the 746,748 cats received by the whole of the R.S.P.C.A. between 1973 and 1978 approximately 7.4% were received by the Liverpool branch. This appears to be a rather high proportion of the total and is probably a reflection of the large size and efficient running of this branch. At one time the Liverpool branch included a team of operators whose time was entirely devoted to catching cats. It is possible that if more large branches existed more cats would be collected.

Unfortunately the figures available for Liverpool include unwanted domestic cats, strays and feral cats and it is not possible to determine the extent to which the changes recorded in the total number of cats received annually reflect changes in the size of the feral cat population. In addition the area of Merseyside covered by the Liverpool Branch of the R.S.P.C.A. has changed periodically over the years as the Society's boundaries have been altered. The effect that this has had on the number of cats received is not known. Nevertheless, the trends exhibited in Liverpool are interesting, particularly the relatively small numbers of cats received since 1960.

## 3.8. ESTIMATING THE FERAL CAT POPULATION OF GREAT BRITAIN

In 1977 the Liverpool branch of the R.S.P.C.A. re-homed 768 cats and destroyed 7,882, a total of 8650 cats. In 1978 the human population of Liverpool was approximately 539,700 . There was therefore one unwanted cat for every 62.4 people in the city, if all of the cats received are considered to have been unwanted originally.

Assuming a human population of 56 million in Britain and that the same relationship exists between the human and cat populations throughout the country, the unwanted cat population is estimated to have been approximately 900,000 in 1977. If approximately 42% of these animals were feral, then the feral population would have been approximately 380,000.

These figures are likely to be under-estimates. Some feral cats and strays are taken to animal welfare organisations other than the R.S.P.C.A. and others are destroyed by pest control firms. Large numbers of feral cats are not recorded because they live in colonies from which animals have not been removed. Clearly, none of these cats are included in R.S.P.C.A. figures.

This survey has located approximately 12,300 feral cats in 704 colonies (see section 3.5.). Many other colonies have undoubtedly remained undetected. If the survey has only detected 10% of the population, then the size of the total population would be approximately 123,000. If it has only detected 1% then the total would be more than 1.2 million.

## 3.9. DISCUSSION

The majority of feral cat colonies in Great Britain appear to be associated with man's places of work and his dwellings, particularly in urban areas. Most colonies are small and probably relatively permanent in nature ( since about 75% were considered to have existed for over five years). Almost all the colonies reported had been subjected to removal operations but the types of problems caused by the presence of cats were usually not of a serious nature and almost half of the colonies were thought to be of some benefit.

There is a clear conflict of interests between the many people who feed feral cats and those who would have them completely removed. This conflict has undoubtedly contributed to the persistence of many colonies and reports were received of cat traps being damaged and employees being threatened with dismissal for feeding cats from a variety of premises. A similar conflict was noted by Dards (1979) between some dockyard workers and the authorities in Portsmouth dockyard. It is interesting that a very high proportion of the colonies examined by this survey were actively being fed but had also been subjected to removal operations.

Many of the problems caused by the presence of feral cats are made worse by the ease with which they gain access to buildings. The type of building which is most easily accessible to cats is an old brick complex with air grids at ground level, large basements and underground ducting systems which may be entered via small wooden doors and covers. Many of the hospitals and industrial buildings in Britain are of this type and are often so poorly maintained that there are innumerable places where cats can enter the basements through broken grids and doors. Often when cats are removed from premises of this type they are re-colonised within a short time because the buildings are still accessible and the cat feeders are still present. In some cases even if buildings are repaired the cat-lovers will make them accessible to cats again. These problems appear to be rare in new building complexes where basements are absent and concrete floors are common. It is interesting that of approximately 2,300 hospitals in England some 40% were originally erected before 1891 and about 20% before 1861 (Southam, 1981).

Cat colonies produce a seasonal problem because of the large number of kittens produced in the spring and summer months. It is probably during these months that most colonies are brought to the attention of the authorities responsible for pest control on the premises concerned and some attempt is made to reduce the numbers. Most small colonies could probably be completely removed quite easily but complete removal appears to only occur rarely. There are probably several reasons for this. First, unless each individual cat can be identified or all the cats can be seen together it is not possible to determine exactly how many cats live in any colony. Repeated births add to this problem. It is therefore unlikely that anyone trapping the cats will know when he has caught them all. Second, no single authority is responsible for trapping feral cats. The Environmental Health Departments have limited man-power and time, and often no traps. The R.S.P.C.A. have a similar man-power shortage and do not enjoy working as pest control operators. This leaves the private pest control firms who have a vested interest in not catching all of the cats and are very expensive to employ.

Much of the information presented here has come from hospitals. There is undoubtedly a strong bias against the presence of cats on premises of this nature and this is reflected in the responses received in the questionnaires. It may be that if many other types of premises were investigated the proportion in which problems were caused by cats would have decreased. Nevertheless, although hospital authorities were contacted directly many of the reports of hospital cat colonies were received from Environmental Health Departments and R.S.P.C.A. Inspectors and the high incidence of feral cat colonies in hospitals is an inescapable fact.

The distribution of feral cats in Britain is unlike that of other feral species of mammals such as the goat (Capra sp.) or escaped species such as the Coypu (*Myocastor coypus* Molina) and Red-necked Wallaby (*Macropus rufogriseus* Desmarest). These species are confined to specific small areas (Arnold, 1978) because they originated from a relatively small number of sources, whereas feral cats by definition are descended from the domestic cat population and this is widespread.

The distribution and abundance of feral cat colonies appears to be similar to the distribution and abundance of the human population in Britain. Colonies are common in urban areas but it is difficult to know the extent of their occurrence in rural areas. It is always a problem in surveys of this type that the distribution described may reflect more closely the distribution of the persons who reported the colonies than that of the colonies themselves. Since the authorities contacted by this survey were necessarily based in centres of human population it was difficult to avoid this bias. Attempts to solicit reports by publishing requests for information produced very little response. Macdonald & Apps (1978) have reported observing aggregations of over 40 cats on Oxfordshire farms and there may be a substantial rural feral cat population which has not been detected by this study. The distribution maps presented here must therefore be considered as provisional as there is clearly a need for much more information, particularly from rural areas.

The distribution of feral cat colonies must change considerably from year to year. Colonies are continually being removed and new colonies are being formed. It is likely that many of the colonies located at an early stage of this survey (especially the very small colonies ) had disappeared by the time it was completed. While these changes will affect the actual location of colonies they are unlikely to greatly alter the general distribution of colonies throughout Britain. The rural population of feral cats is probably fairly stable whereas the urban population with its greater nuisance value, is subjected to frequent removals and because of the higher density of domestic cats in urban areas (Tabor, 1981) the formation of new colonies here is probably quite a common event.

It has been suggested that the 'feral cat problem' has developed since the end of the Second World War (Jackson, O.F., 1981). The evidence from Liverpool does not support this (assuming that the figures presented in Fig.3.9. reflect the abundance of feral cats ) since the number of cats received by the R.S.P.C.A. was almost identical in 1935 and 1959.

Although there have been suggestions that feral cats are a relatively recent 'problem' there is evidence for the existence of large numbers of unwanted cats in urban areas in Britain and the U.S.A. in the past (Table 3.3.).

It is difficult to determine the current size of the feral cat population in Britain from the information available. It is

Table 3.3.

Estimates of cat populations and numbers of cats destroyed by animal welfare organisations.

| Sources | Year | Area | Cats/year destroyed | Cat population | Cats as % of human population | Status of cats |
|---|---|---|---|---|---|---|
| Hudson (1898) | 1898 | London | | $5-7.5\times10^{5}$ | | Total population |
| | | London | | $8\times10^{4}$ | | 'Ownerless' cats |
| Matheson (1944) | 1905–14 | Boston, USA | $2.1\times10^{4}$ | | 3.0 | |
| | 1931–40 | Liverpool | $3.3\times10^{4}$ | | $>$ 3.0 | |
| | 1936 | Glasgow | $2.27\times10^{4}$ | | 2.0 | |
| | 1938–43 | Edinburgh | $4.45\times10^{3}$ | | 1.0 | |
| | 1944 | Cardiff | | $2.35\times10^{4}$ | 10.4 | Pets |
| | 1938–43 | Cardiff | $6.6\times10^{3}$ | | 3.0 | Strays |
| | 1944 | Cardiff | | $> 3\times10^{4}$ | | Total |
| McWhirter (1969) | 1969 | Great Britain | | $6\times10^{6}$ | | |
| Macdonald (1977) | 1977 | Great Britain | | $6\times10^{6}$ | | |
| McWhirter (1980) | 1980 | Great Britain | | $4.9\times10^{6}$ | | |
| Anon ($1979_a$) | 1975–77 | USA | | $2.31-2.56\times10^{7}$ | | Pets |
| Hodge (1979) pers.comm. | 1979 | USA | $7.25\times10^{6}$ | | | Impounded |
| McWhirter (1980) | 1980 | | | $2.3\times10^{7}$ | | |
| Van Aarde (1978) | 1975 | Marion Island | | 2 137 | | |

likely that at any one time more feral cats are at large than are captured, and there are organisations other than the R.S.P.C.A. receiving cats. Bearing this in mind it seems likely that the total feral and 'unwanted' cat population of Great Britain is close to one million.

# 4. SURVEY OF A DOMESTIC CAT POPULATION

## 4.1. INTRODUCTION

Feral cats have ultimately originated from domestic stock and it is therefore of relevance to consider the abundance of this originating stock. The size of the feral cat population in any area may depend upon the number of domestic cats in that area and the extent to which these domestic cats have been neutered.

This survey is an attempt to determine the abundance, sex ratio and reproductive potential (whether neutered or entire) of the domestic cats in a localised urban area. This was undertaken by means of a questionnaire which was distributed to all pupils attending Marple Hall School, Marple, Stockport. The school's catchment area includes Marple, Marple Bridge, Romiley, Bredbury, Bramhall, Hazel Grove and other areas in south Stockport.

The potential of the population of domestic cats in this area as a source of feral cats is examined and compared with other studies of domestic cat populations.

## 4.2. METHODS

Marple Hall School is a large comprehensive school catering for pupils from 11 to approximately 18 years old. A questionnaire (Fig. 4.1.) was distributed to all of the pupils in the school in November 1979 by the form teachers. The teachers were requested

SURVEY OF DOMESTIC CAT POPULATION. 340.

Sections 1,2, and 3 must be completed by all pupils.
Please use block letters throughout this questionnaire.

1. NAME CATHERINA MARIE ................../...GURLEY..............
(Christian Names) (Surname) Form..L6A.....

ADDRESS ..DANLEY. HOUSE,..LIGHT..ALDERS...LANE,.DISLEY,.....
..........CHESHIRE.......................................

Do you have any brothers or sisters at this school? If so please give their names and forms below.

Name ...................................Form.................
Name ...................................Form.................

Please put a ring around the appropriate answer to the questions below.

2. How many people in all live permanently at the address you have given? (INCLUDING YOURSELF).

1 2 3 4 5 6 7 8 9 10 If more please state ..........

3. Do you have any pet cats at this address? YES NO

4. How many cats of each sex do you have? If more than 10 please state.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Number of males | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | .......... |
| Number of females | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | .......... |
| Total number of cats. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | .......... |

5. Have any of these cats been neutered(ie castrated, sterilised, doctored) ?
YES NO

6. How many cats of each sex have been neutered?

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Number of males | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | .......... |
| Number of females | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | .......... |
| Total number of cats neutered | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | .......... |

7. If you have a neutered female (or females) did she have any kittens before you decided to have her neutered?
YES NO

8. Where did your cat(s) originally come from? Write the number of cats obtained from each source.

| Pet shop | Breeder | RSPCA | A relative or A Friend | Stray | Number of cats. |
|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | Other............. |

PLEASE COMPLETE SECTIONS 1,2, AND 3 EVEN IF YOU DO NOT HAVE ANY CATS.

Fig.4.1. Questionnaire used in the survey of a domestic cat population.

to ask their pupils to obtain the required information a few days before the distribution of the questionnaires so that they could be completed at the school. Many of the pupils, however, were allowed to take the questionnaire home and as a result some were not returned.

When the questionnaires were returned they were sorted into forms and arranged alphabetically by surnames. Those containing inconsistent, inappropriate or obviously exaggerated responses were ignored and checks were made to ensure that no information was duplicated as a result of more than one questionnaire being returned from a single household.

No information was available on the socio - economic groups represented by pupils attending the school. However, the catchment area included a range of housing types from council estates to high quality private property and was assumed to be reasonably representative of urban areas in Britain.

## 4.3. ABUNDANCE OF DOMESTIC CATS

The exact number of questionnaires distributed was not known as this depended upon the number of pupils present on the day of distribution. Similarly, the number of questionnaires which were not returned could not be determined but this was considered to be quite low.

A total of 1321 questionnaires were returned. Of these

Table 4.1.

Number of questionnaires returned, ignored and analysed.

| | Number of questionnaires | Number of households represented |
|---|---|---|
| Returned | 1321 | 1042 |
| Ignored | 28 | 22 |
| Analysed | 1293 | 1022 |

Table 4.2.

Number of persons, households and cats studied by the survey

| | Number of households | Number of persons | Number of cats |
|---|---|---|---|
| With cats | 334 | 1460 | 464 |
| Without cats | 686 | 2959 | - |
| Total | 1020 | 4419 | 464 |

1293 were analysed, representing 1020 households (Table 4.1.). Only a small proportion (2.1%) was ignored due to improper completion.

The 1020 households studied included a total of 4419 persons and 464 domestic cats (Table 4.2.). There was therefore one cat for every 9.5 people. The mean number of cats per household was 0.45 ( $\underline{s}^2 = 0.8$, $\underline{N} = 1020$ ) and 32.7% of these households possessed at least one cat (Fig. 4.2.). Most of the households with cats had only one, but one household had a total of ten cats (Table 4.3.).

Assuming a human population in Great Britain of 56 million the domestic cat population would be approximately 5.9 million.

## 4.4. SEX RATIO AND REPRODUCTIVE POTENTIAL

In the households studied 43.5% of the cats were males and 56.5% were females. This is significantly different from a 1:1 ratio ($\chi^2 = 7.76$, $\underline{d.f.} = 1$, $\underline{P} < 0.01$). A significantly higher proportion of females (83.6% ) than males (70.8% ) were neutered ($\chi^2 = 10.16$, $\underline{d.f.} = 1$, $\underline{P} < 0.01$ with Yates' correction). Neutered cats comprised 78% of the total population. (Table 4.4)

If the proportion of cats neutered in the population as a whole is the same as that calculated in this study the unneutered

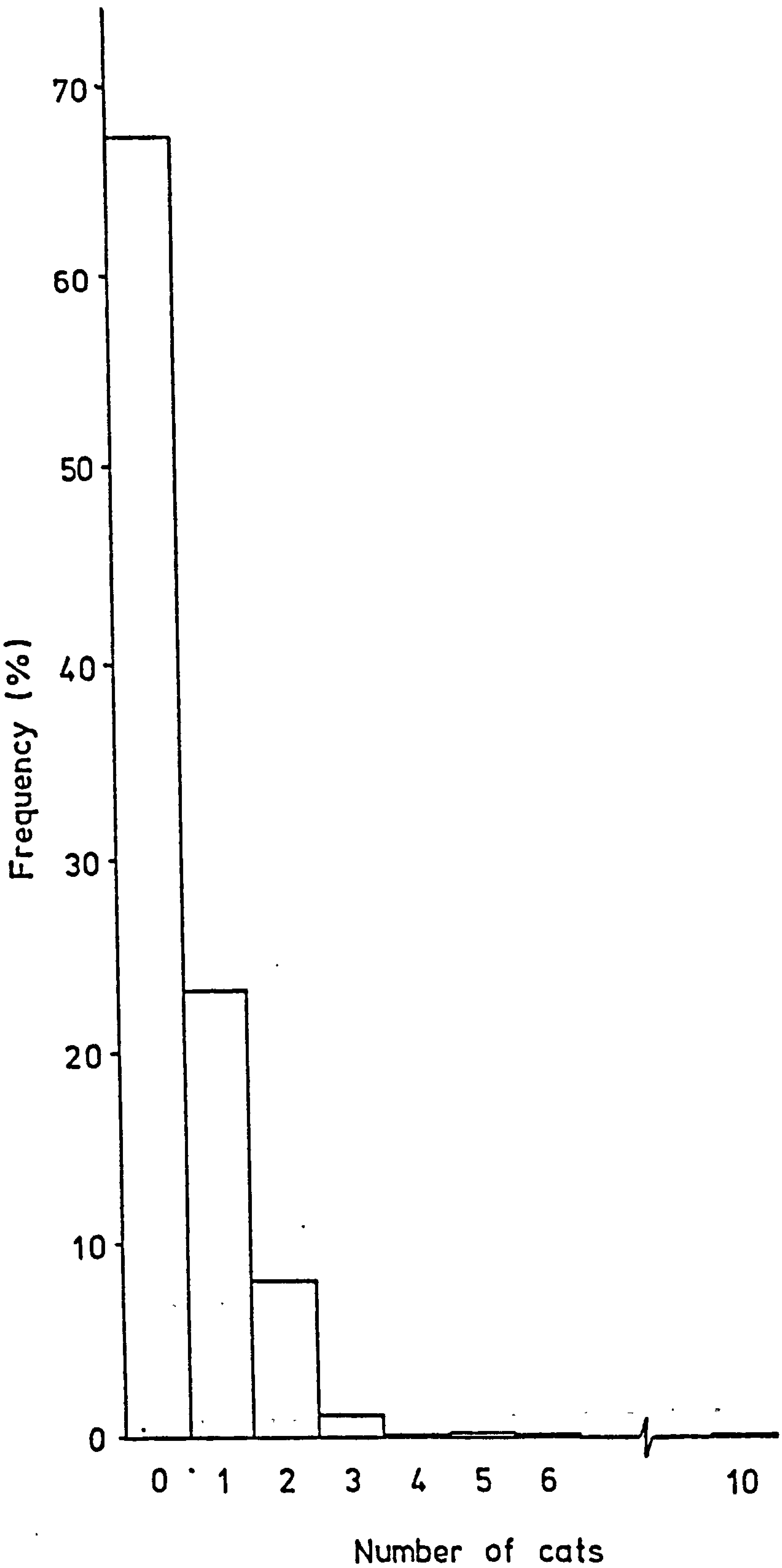



Fig. 4.2. The distribution of cats between all households examined by the survey.

Table 4.3.

Distribution of cats between households with cats.

Households without cats are excluded (see Fig.4.2).

| Number of cats | Number of households | Percentage of all households with cats |
|---|---|---|
| 1 | 236 | 70.7 |
| 2 | 81 | 24.3 |
| 3 | 12 | 3.6 |
| 4 | 1 | 0.3 |
| 5 | 2 | 0.6 |
| 6 | 1 | 0.3 |
| 10 | 1 | 0.3 |

Table 4.4.

Reproductive status of male and female domestic cats.

| Status | Number of cats | | |
|---|---|---|---|
| | Males | Females | Total |
| Neutered | 143 | 219 | 362 |
| Entire | 59 | 43 | 102 |
| Total | 202 | 262 | 464 |

domestic cat population in Britain would consist of 1.3 million cats : 0.8 million males and 0.5 million females. The unneutered population is therefore predominantly male even though female cats appear to be more common than male cats.

Responses to question 7 and 8 on the questionnaire were not analysed. These questions were difficult to answer clearly when more than one cat was involved, and often the origin of the animals was not known. Consequently these questions were frequently either ignored or answered unclearly.

## 4.5. DISCUSSION

In the area examined by this survey pet cats were common, occuring in approximately one third of all households. There were more females than male cats and a higher proportion of females than males were neutered. Overall, a high proportion of the population was neutered, nevertheless the actual and potential importance of unneutered domestic cats as contributors to the feral population should not be underestimated.

Some of the factors affecting the size of domestic cat populations in different areas and the degree to which they have been neutered may be examined by reference to other studies. Matheson (1944) collected data on the domestic cat population of Cardiff by surveying children at 13 schools representing all areas of the city. He obtained further information from four schools in Newport. In Cardiff as a whole there was one cat for every 9.6 people and in Newport the ratio was one cat to 8.2 people. In the present study and that of Matheson the data may be biased since both studies only examined households with children of particular ages. This study probably produced a slight underestimate of the cat population because the questionnaires which were not returned were most likely to have been taken home by children who had cats. Matheson (1944) considered that the cat population of Cardiff in 1944 may have been low because of the shortage of food. However, it is interesting that both studies obtained almost identical figures for the ratio of cats to people.

Matheson (1944) found that domestic cats were more common in some areas than others. He found that there was one cat per 6.6 people in the dockland areas of Cardiff and one cat per 18.1 people on the newer corporation estates; the percentage of households with cats in these areas being 74.1% and 30.6% respectively. Matheson (1944) suggested that cats may have been more common in the older areas of the city because of the need to control rats here. A similar situation was found in Newport: one cat per 6.9 people in the older parts of the town (where 76.2% of households kept cats ) and one cat per 15.6 people on the newer municipal housing estate (where only 26.2% of households kept cats).

Howes (1980a) found that of 373 cats studied in a national survey of the prey of domestic cats in Britain, 46.1% were males and that of these 92.4% were neutered compared with 95% of the females. Of the farms included in his study 93% kept cats (with a mean of 4.8 cats per farm), 39% of which were male. Only 8.7% of the farm population was neutered.

During a discussion at the Universities Federation for Animal Welfare Symposium on the Ecology and Control of Feral Cats in September 1980 Howes (1980b) stated that in studies made in Yorkshire he had found that 49% of domestic male cats were neutered in suburban areas, but this figure fell to 44.3% in rural areas. Overall, he found that in suburban areas 80% of domestic cats were neutered, but only 42% were neutered in rural areas. In the same discussion Wells (1980) quoted apparently contradictory figures from a study made in Reading. He found that on council estates and in suburbia 56% of domestic cats were neutered, but in villages 74% were neutered.

It is difficult to reconcile these data. It may be that the variations observed in the proportion of cats neutered between areas were a result of social or economic differences in these areas. The suburban areas examined in this study and those investigated by Howes may have contained more prosperous households than the areas examined by Wells, which included some council estates. This may account for the lower proportion of neutered cats recorded by Wells in suburban areas compared with the other studies.

A survey conducted in 1975 by 'National Analysts' on behalf of the Pet Food Institute indicated that 69% of the pet cat population of the United States of America had been neutered (Wilbur, 1976). Levinson (1974) found that in the U.S.A. 31% of female cats and 38% of male cats were neutered. He suggests that there is a psychological resistance to the neutering of pet cats.

In order to examine the domestic cat population further it would be necessary to undertake detailed surveys of rural, urban, and inner city areas in a number of geographical regions, covering households at random using a standardised method. Clearly comparisons made between the results of surveys conducted in different areas by different methods are likely to be invalid. It would be interesting to compare the results obtained by different survey methods for the same area at the same time in order to assess the effects of bias.

Domestic cats undoubtedly play an important part in the founding of new feral cat colonies. The only effective method of reducing the reproductive potential of domestic populations is to neuter individual animals. A high proportion of domestic cats appear to have been neutered in the populations studied, especially in suburban areas. Entire strays from such areas are likely to find habitats suitable for the support of a feral colony. Farm cats are probably relatively insignificant as contributors to feral populations because most farmland is isolated from suitable urban habitats.

In order to encourage the neutering of a higher proportion of the domestic population two problems must be overcome: the psychological resistance to neutering and the high cost of the operations. Education would probably solve the first problem. The cost of neutering must be considered in the light of estimates of the number of cats involved and the control strategy to be adopted. Most households with cats have only one (70.7%) so the cost to any individual household would not be great. An intensive education programme might be adequate to encourage individuals to pay for their cats to be neutered.

There are probably approximately 1.3 million unneutered domestic cats in Great Britain. Assuming that neutering a single cat costs £20 (Hammond, 1981) the total cost of neutering them all would be £26 million. It would be undesirable to neuter all domestic cats since some are needed for breeding. Nevertheless, the cost of significantly increasing the proportion of neutered cats in the domestic population would be high. Neutering males would be less cost - effective than neutering females. The neutering of a very high proportion of all pet female cats would greatly reduce the number of births, but neutering a large number of males would have relatively little effect since one male can mate with many females. Neutering all of the unneutered females in Britain would cost approximately £10 million. This would seem a sensible strategy to adopt because female strays are more likely to be important in founding new colonies than males, and unneutered females appear to be less common than unneutered males. Methods of managing cat populations are discussed in detail in Chapter 14.

# PART III

## THE EFFECT OF NEUTERING ON THE ECOLOGY, BEHAVIOUR AND SOCIAL ORGANISATION OF A FERAL CAT COLONY

# 5. THE NEUTERING EXPERIMENT

## 5.1. INTRODUCTION

Neutering of feral cat colonies is widely practiced by animal welfare organisations as a method of population management. However, the effectiveness of this method has not been studied in detail. The aim of this experiment was to examine the effect of neutering on a colony of feral cats living in a typical habitat. The colony selected for study was living in the grounds of Winwick Hospital : a large psychiatric unit in Cheshire.

The purpose of neutering, from the point of view of animal welfare organisations, is to prevent the production of kittens, many of which normally die. This is generally considered to make the presence of cat colonies more acceptable. This experiment examines the effectiveness of trapping, neutering and releasing feral cats in controlling population size. It also examines various aspects of the ecology, behaviour and social organisation of the animals when entire and attempts to assess the biological consequences of neutering.

The behaviour of cats in the laboratory has been widely studied (Kling _et al_, 1969) but field studies are rare. Neutering involves the removal of the ovaries in the female and the testes in the male and it is useful to examine laboratory studies of the effects of the removal of these organs on the behaviour of cats and other mammals.

In most mammals sexual behaviour is either abolished or greatly reduced by removal of the ovaries or testes, the effect being less marked in the more advanced species (in evolutionary terms). The effects of neutering on adults tend to be less important then the effects on individuals which have not reached puberty, in which case sexual behaviour is less likely to develop. The particular hormones present in the adult are not the only cause of maleness or femaleness of behaviour. The basis of sex differences in behaviour is determined in infancy. For example, if testosterone is circulating during a few crucial days at around the time of birth then the animal is more likely to show male behaviour than female behaviour later on. The relationships between hormones and sexual behaviour have been discussed by Slater (1978).

A receptive female cat placed with a male characteristically shows a posture called lordosis : the back is bowed, hind quarters raised and tail deflected to one side. This makes it easier for the male to mount, but if the ovaries are removed the female fails to exhibit lordosis. The hypothalamus is sensitive to oestrogen and its absence reduces receptivity by changing behaviour.

Testosterone plays a vital part in determining the primary sexual characteristics. If testosterone is present in the embryo male genitalia develop, if it is absent growth of female organs occurs. Sex determination of both the reproductive system and the hypothalamus depends largely on the presence or absence of this hormone during critical periods of development.

Administration of testosterone will restore sexual behaviour to males after castration. It is likely that this hormone affects the pre - optic region of the brain.

The decline in sexual behaviour in male cats after castration has been investigated by Rosenblatt & Aronson (1958). They found that the degree to which a male cat's sexual behaviour persists after castration depends to a great extent upon how much sexual experience it had previously: the greater their experience the more persistent the behaviour. Males castrated before reaching puberty did not develop sexual behaviour.

Steinach (1894) has reported fighting between a castrated male rat and an entire male rat in which the castrate came off worse. The effect of castration in the male of a variety of mouse species is to severely reduce aggression (Dimond 1970). Karli (1958) found that neither the administration of testosterone nor castration had any effect on the propensity of rats to kill mice placed in the same cage.

This suggests that the effect of the hormone may relate only to intraspecific aggression and possibly to that shown primarily in sexual competition.

The suggestion that castration reduces intraspecific aggression in male animals is not supported by observations made by Schenkel (1966) on lions (*Panthera leo* L.). He reports that two lionesses and one sub - adult lion were killed by two adult lions in Nairobi National Park. The stronger of the two aggressors was then castrated by the park authorities as he was considered 'abnormal'. However, the same two adult males subsequently killed two more lionesses. These fights appear to have been territorial in nature.

Slater (1978) suggests that some of the ways in which males and females differ may be due to hormonal differences between the sexes, for example sex differences in mental skills in man. Hormones may influence a wide range of activities which are not related to reproduction. Within females many aspects of behaviour vary from one stage of the oestrous cycle to another. Female rats, for example, are much more active when they are receptive than at other times (Bermant & Davidson, 1974).

In this study emphasis has been placed on the quantification of specific ecological and behavioural characteristics of the cats in an attempt to identify changes which occurred as a result of neutering. Social organisation has also been treated in a mathematical manner. Previous studies of social organisation have been descriptive in nature (for example, Schaller, 1972; Dards, 1979). A mathematical treatment, as used in recent studies in behavioural ecology (Krebs & Davies, 1978) and theoretical ecology (May, 1981), allows a more analytical approach.

## 5.2. SELECTION OF THE STUDY SITE

A large number of sites occupied by feral cats were located by the survey of feral cat colonies (Chapter 3). Twenty - two of these were considered as possible study sites (Table 5.1.) and were visited between October 1977 and October 1978. The sites were located in North and West Yorkshire, Greater Manchester, Merseyside and Cheshire (Fig.5.1.).

In selecting a site suitable for conducting the neutering experiment the following criteria were considered:

(i) The number of cats. The colony needed to contain sufficient cats to make the experiment worthwhile (some contained only two or three), but not so many that it would be impossible to trap them all.

(ii) The habitat. This had to be typical of many

Table 5.1.

Feral cat colonies visited during the study. Colonies which were considered for detailed study are indicated with an asterisk (*).

| | Location of colony | Description |
|---|---|---|
| 1. | St. Luke's Hospital, Bradford, W. Yorkshire. | Small general hospital near the city centre. |
| 2. | Middleton Hospital, Ilkley, N. Yorkshire. | Small hospital in a rural area. |
| 3. | High Royds Hospital, Menston, W. Yorkshire. | Large psychiatric unit with extensive grounds. Located in rural area. |
| 4. | Halifax General Hospital, Halifax, W. Yorkshire. | Small general hospital located in urban area. |
| 5.* | Staincliffe General Hospital, Dewsbury, W. Yorkshire. | Small general hospital located in urban area. |
| 6.* | County Hospital, Wakefield, W. Yorkshire. | Small hospital located in urban area, adjacent to derelict old people's home. |
| 7.* | Pinderfields General Hospital, Wakefield, W. Yorkshire. | Small general hospital with extensive grounds. Located in urban area. |
| 8.* | Stanley Royd Hospital, Wakefield, W. Yorkshire. | Psychiatric hospital with extensive grounds. Adjacent to colony 7. |
| 9. | Scalebor Park Hospital, Burley-in-Wharfedale, W. Yorkshire. | Large hospital with extensive grounds, in rural area. |
| 10. | Storthes Hall Hospital, Huddersfield, W. Yorkshire. | Large hospital with extensive grounds, in rural area. |
| 11. | G.K. Herron & Son Ltd., Bradford, W. Yorkshire. | Wool mill near city centre. |

Table 5.1. (Continued).

| | Location of colony | Description |
|---|---|---|
| 12.* | Menwith Hill U.S. Station, Harrogate, N. Yorkshire | U.S. government installation on Ministry of Defence property in rural area. See Chapter 14. |
| 13. | Margaret McMillan Hall of Residence, Bradford, W. Yorkshire. | Students' hall of residence located near city centre. |
| 14.* | Winwick Hospital, Warrington, Cheshire. | Large psychiatric unit with extensive grounds. See Section 5.3. |
| 15.* | Warrington General Hospital, Warrington, Cheshire. | Large general hospital located in urban area. |
| 16.* | Eccleston Hall Hospital, St. Helens, Merseyside. | Very small hospital, located in urban area. |
| 17.* | Broadgreen Hospital, Liverpool, Merseyside. | Large general hospital, located in urban area. |
| 18.* | Sefton General Hospital, Liverpool, Merseyside. | Small general hospital near city centre. |
| 19.* | Clatterbridge Hospital, Wirral, Merseyside. | Very large general hospital, with extensive grounds. Located in rural area. |
| 20.* | Prestwich Hospital, Manchester. | Large psychiatric unit with extensive grounds in urban area. |
| 21. | Port of Manchester, Salford Docks, Greater Manchester. | Extensive area of docks, warehouses etc., many derelict. |
| 22. | Rowbotham & Millet Ltd., Stockport, Greater Manchester. | Fish & game merchant in town centre |

colonies and cats needed to be readily observable.

(iii) Accessibility. Free access to all parts of the site was required in order to locate the animals.

(iv) Co - operation from the authorities at the site. This was essential for access to the site, to guarantee that the cats would not be removed during the study, and to allow the neutering operation to take place.

Some of the sites appeared to have no cats when they were visited, while at others no cats were seen even though they were reported to be present. Other sites were inaccessible and in some cases it was clear that attempts were being made to remove cats. These sites were not visited again.

Twelve of the original 22 sites were visited on a varying number of occasions in an attempt to determine the number and distribution of cats and to examine the suitability of each colony for detailed study (Table 5.1.). By October 1978 it was clear that only two of these colonies were likely to be suitable for long - term study, bearing in mind the criteria listed above. Of the sites eliminated at this stage Warrington General Hospital had been visited most frequently ( 13 visits).

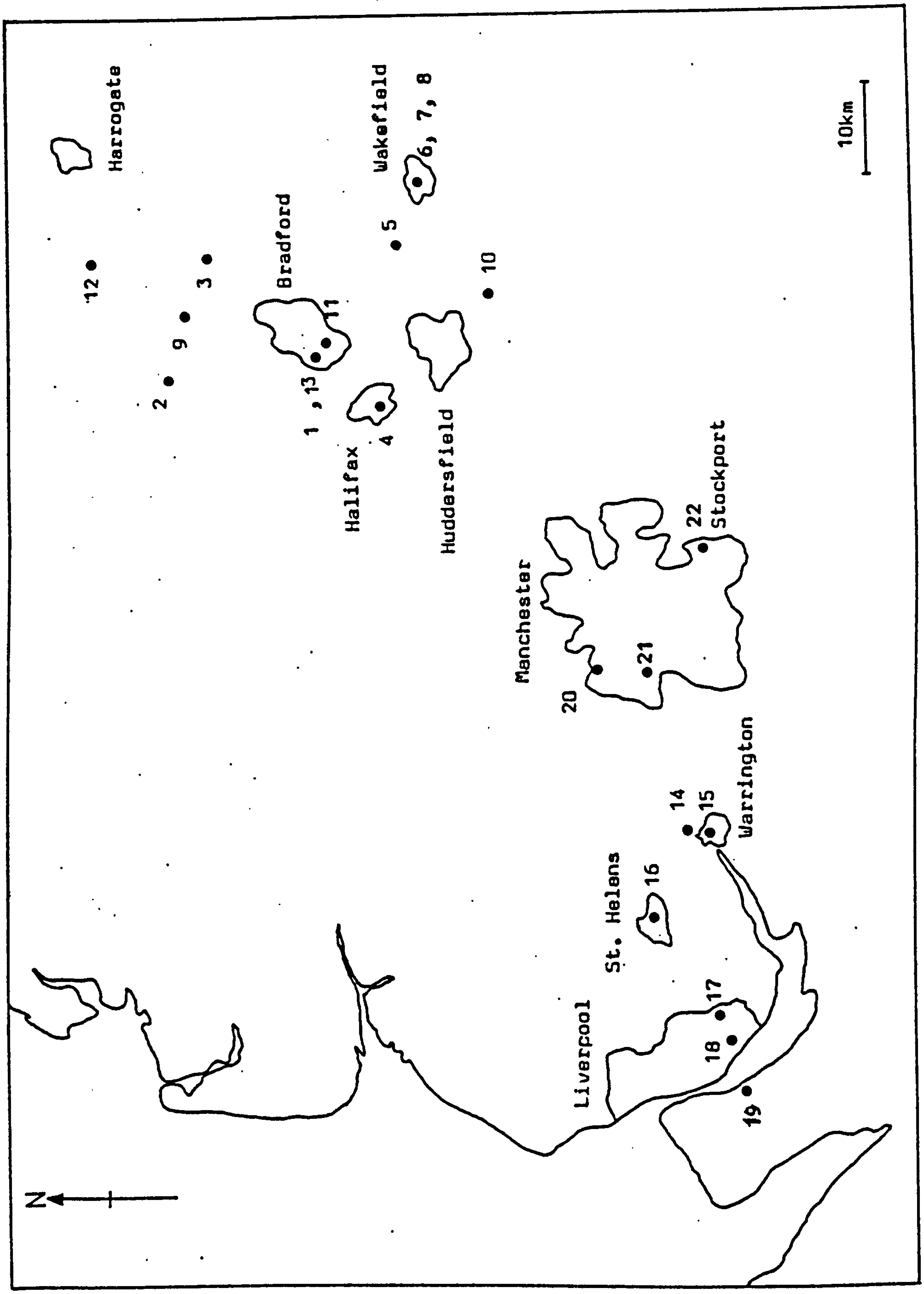



Fig.5.1. The location of feral cat colonies visited during the study. See Table 5.1. for a description of the sites to which the numbers refer.

The two remaining colonies were at Winwick Hospital and Menwith Hill U.S. Station. The former was selected for detailed study. The colony at Menwith Hill was unsuitable because access to the site was restricted (see Section 14.4.).

## 5.3. WINWICK HOSPITAL

### 5.3.1. Buildings and grounds

Winwick Hospital is a large psychiatric unit with a maximum capacity of approximately 2000 beds. It is occupied by male and female psychiatric and geriatric patients, and functions as an entirely self - contained unit.

The hospital is situated approximately four kilometres north of Warrington in Cheshire, near the junction of the A49 road with the M6 motorway. Its grounds are extensive and surrounded by farmland to the north, south and west, with a large housing estate to the east (Plates 1 - 4). These grounds are bounded by stone walls (Plate 5) , iron railings and wire fences, around most of the periphery. The western boundary is not clearly demarcated and here the hospital gardens merge imperceptibly into farmland (Plate 6). There is no effective boundary to the movements of cats between the hospital and the adjacent areas since neither the walls nor the fences surrounding it are sufficiently tall or secure to contain or exclude cats.

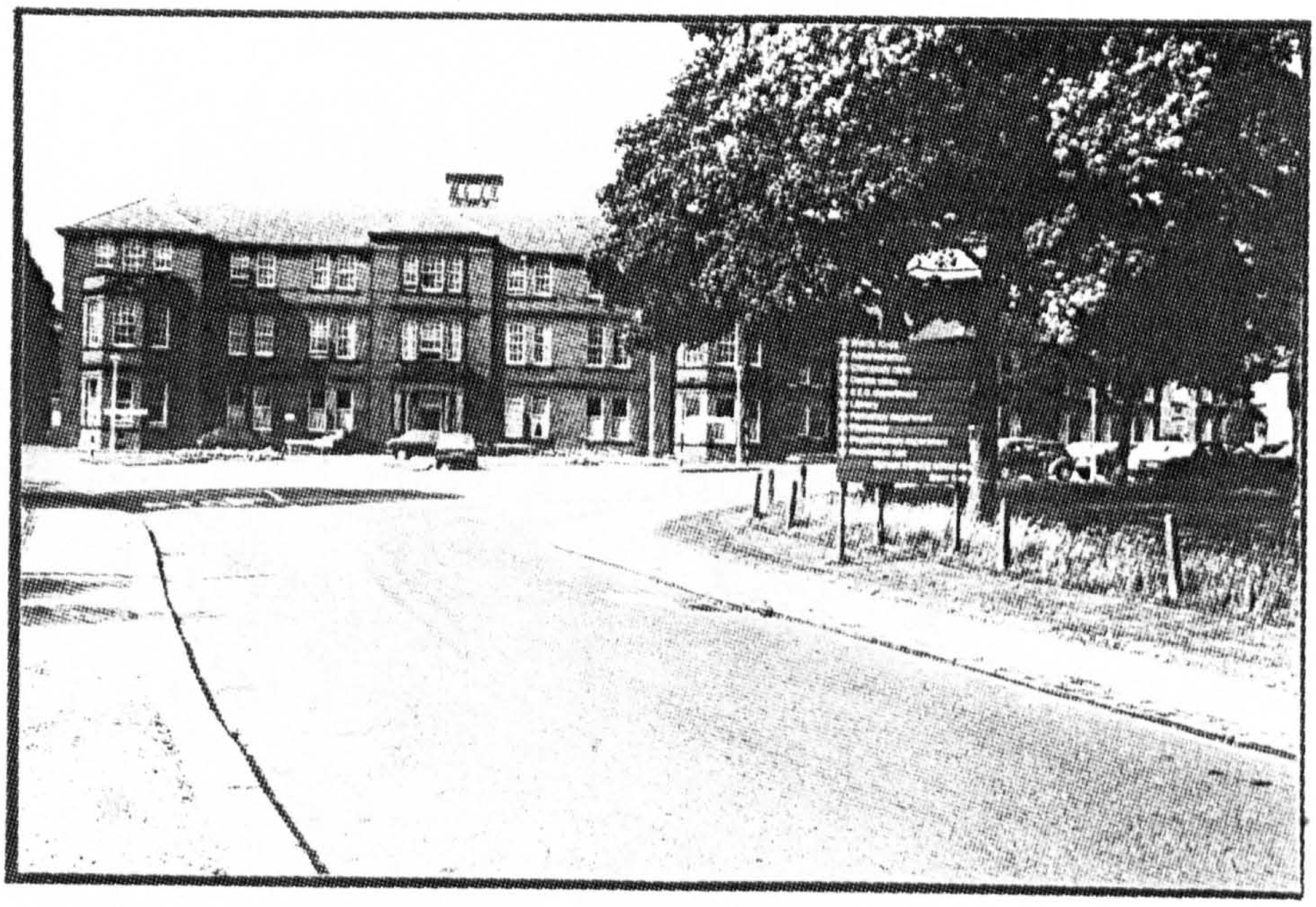


Plate 1. Front entrance and administration building of Winwick Hospital seen from the south. Cats were never observed in this area.

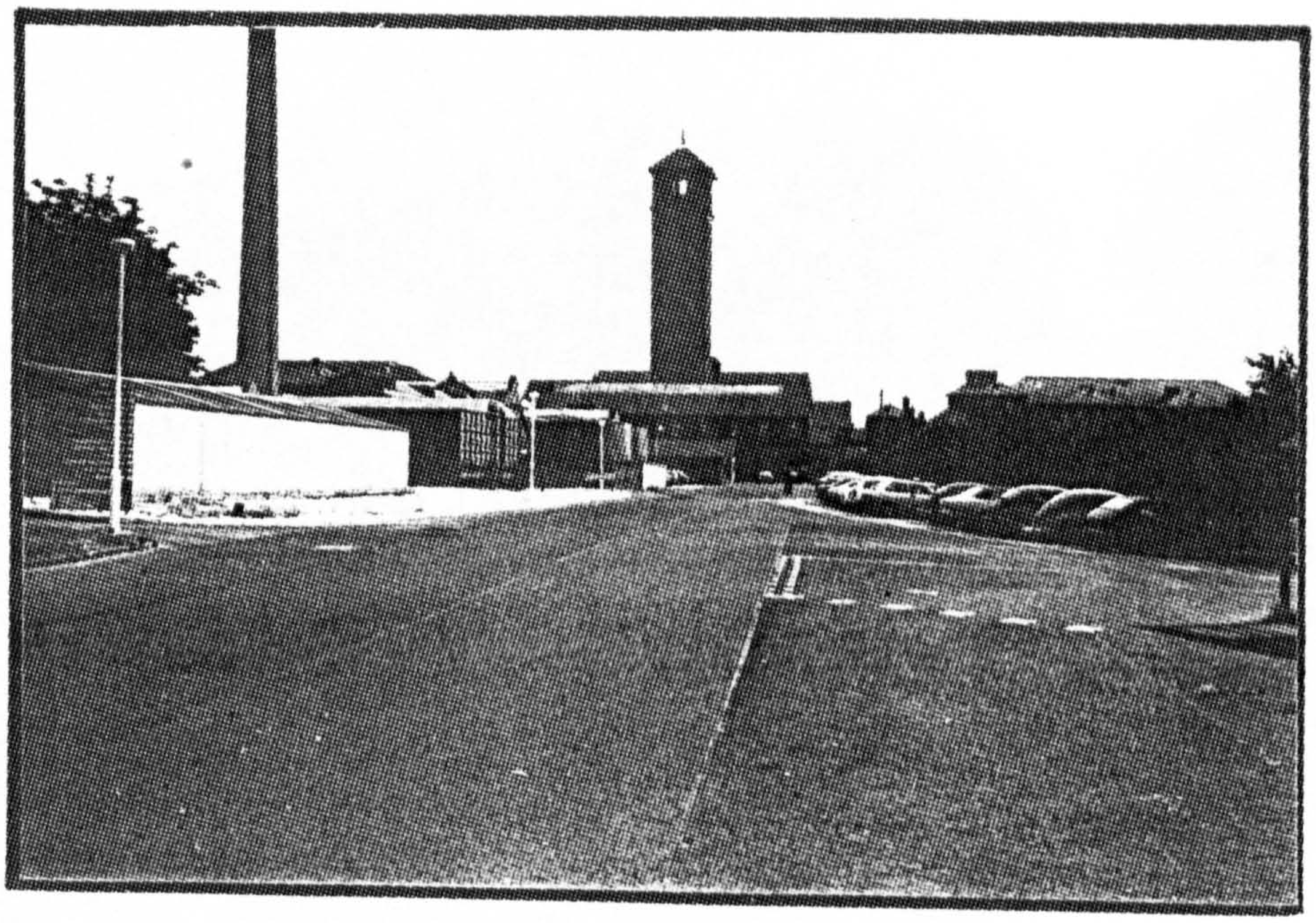


Plate 2. Rear entrance of Winwick Hospital seen from the north. The buildings visible are the water tower (centre) and boiler house (left).

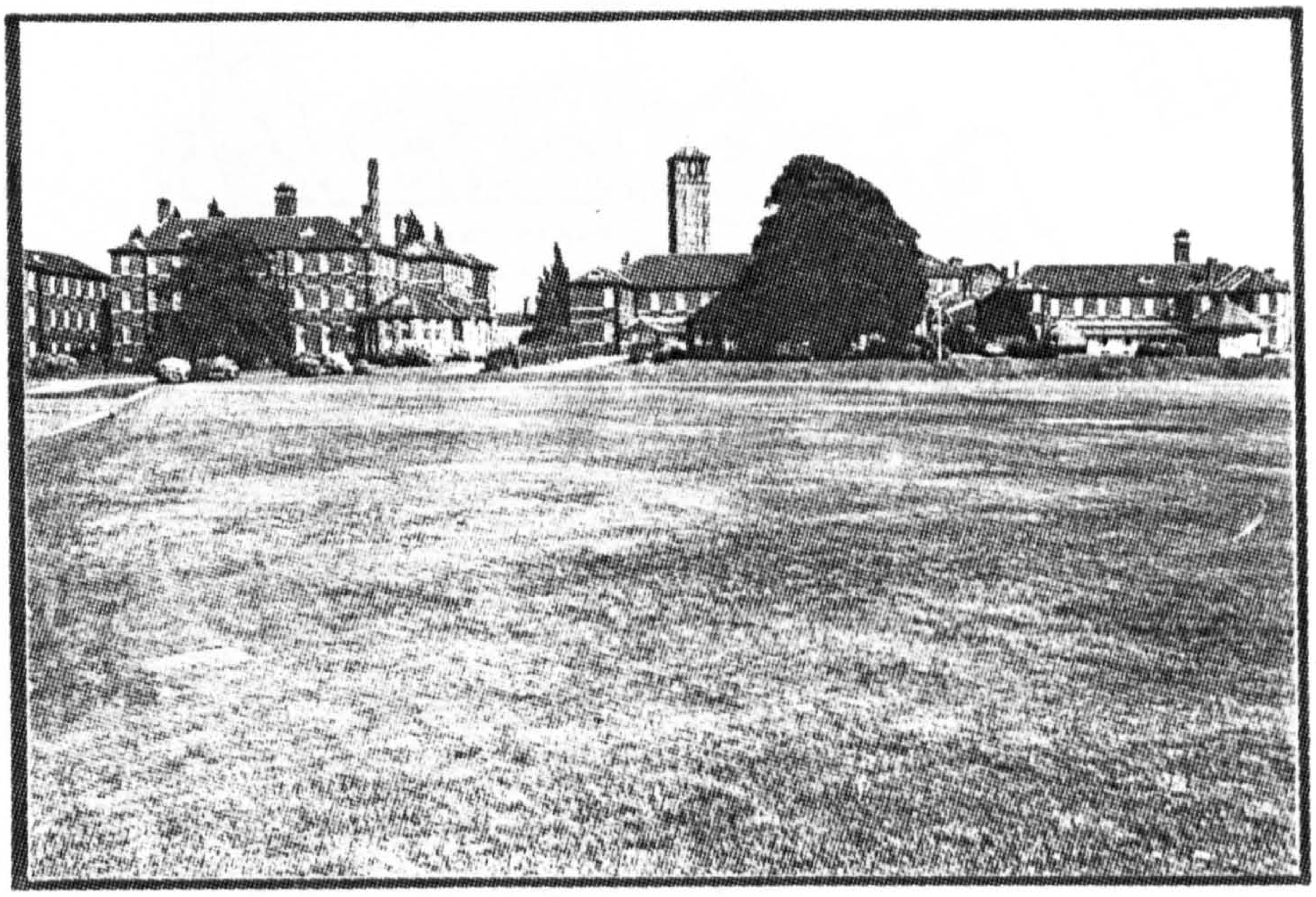


Plate 3. Winwick Hospital seen from the west. The green in the foreground was used for recreation including sports during the summer months. It is separated from the hospital buildings by the perimeter road.

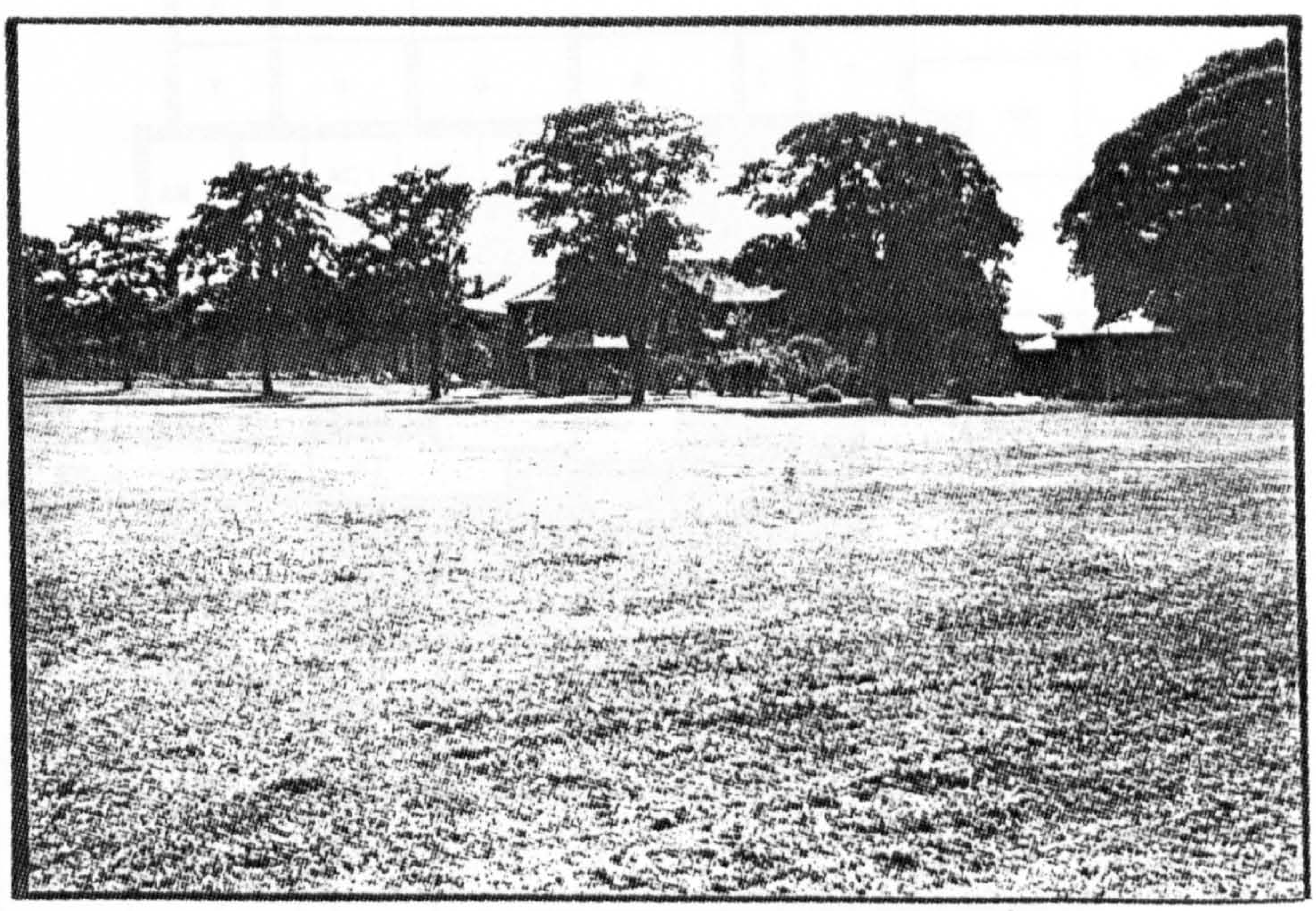


Plate 4. Winwick Hospital seen from the east. The playing-field in the foreground was used primarily for football. The position of the perimeter road is marked by the line of trees.

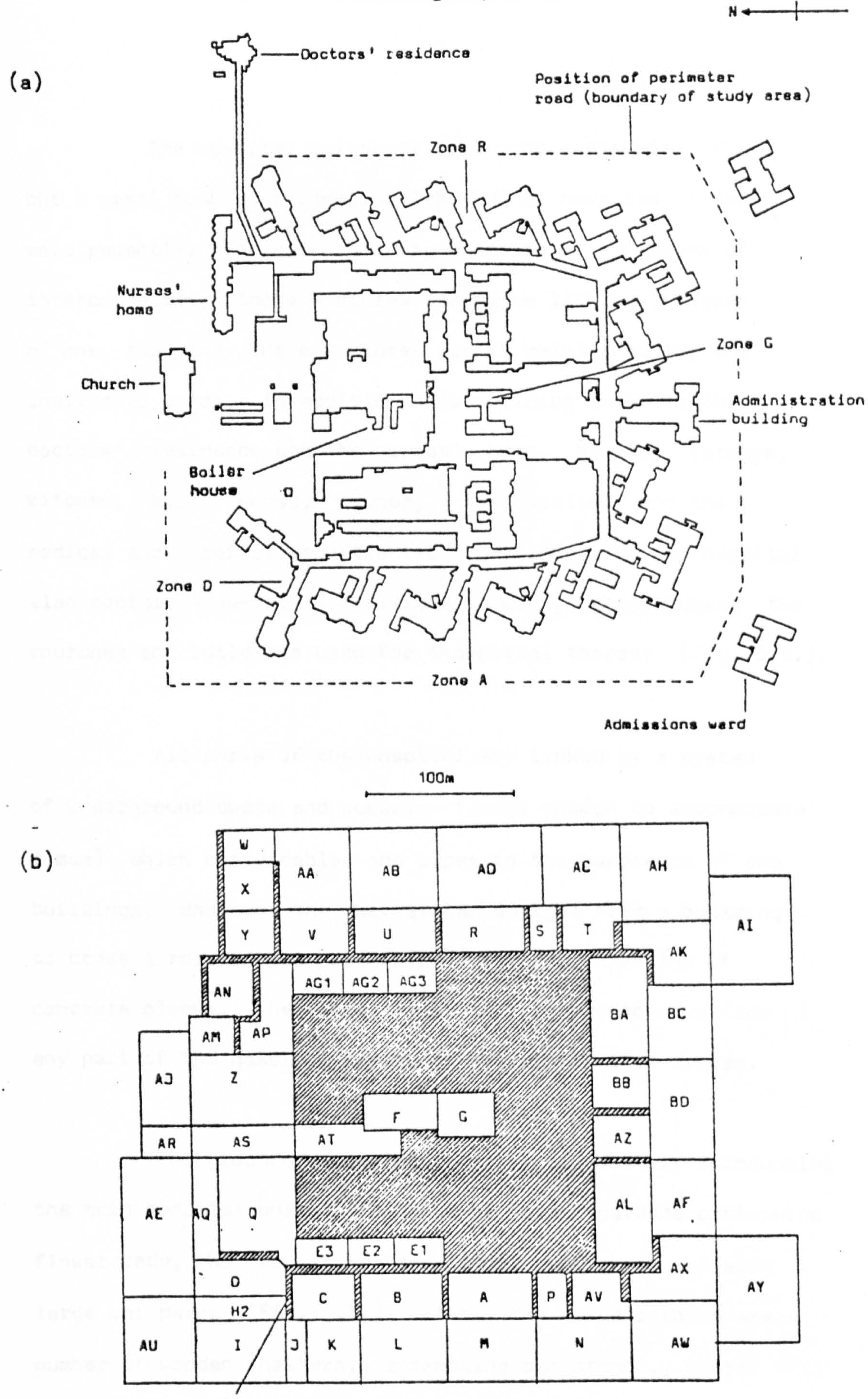



Fig. 5.2. Plan of Winwick Hospital (a) and the zones into which the habitat is divided for the purposes of studying home range (b). The hatched area represents buildings and inaccessible areas within the hospital.

The hospital buildings were constructed in 1902, but a small number of additional buildings have been added more recently. The main building consists of a network of interconnecting single - storey corridors linking a series of one, two and three - storey blocks mainly housing the individual wards. In addition this building includes the doctors' residence and the nurses' home, stores, garages, kitchen, boiler house, laundry, fire station and the medical and surgical departments. The grounds of the hospital also contain a number of individual houses, greenhouses, two churches and buildings used for industrial therapy (Fig. 5.2.).

All parts of the hospital are linked by a system of underground ducts and subways (large enough to accommodate a man) which carry cables and pipes to the basements of the buildings. Wherever the duct system emerges from a building to cross a road or car park it is covered by a series of concrete blocks. Theoretically it is possible to move from any part of the hospital to any other part in this system.

The grounds occupying the area immediately surrounding the main hospital building consist of formal gardens containing flower beds, bushes, trees and lawns, and there are also large car parks (Fig. 5.3.). Within the gardens there are a number of wooden shelters, resembling bandstands, where patients may sit. These gardens are broken up into smaller areas by the presence of an interconnecting series of

Plate 5. The eastern boundary of the hospital. A stone wall is located just beyond the line of trees.

Plate 6. The western boundary of the hospital. The road leads to the hospital's incinerator (Plate 8). The hospital buildings are located to the left and to the right are fields used as pasture for cattle.

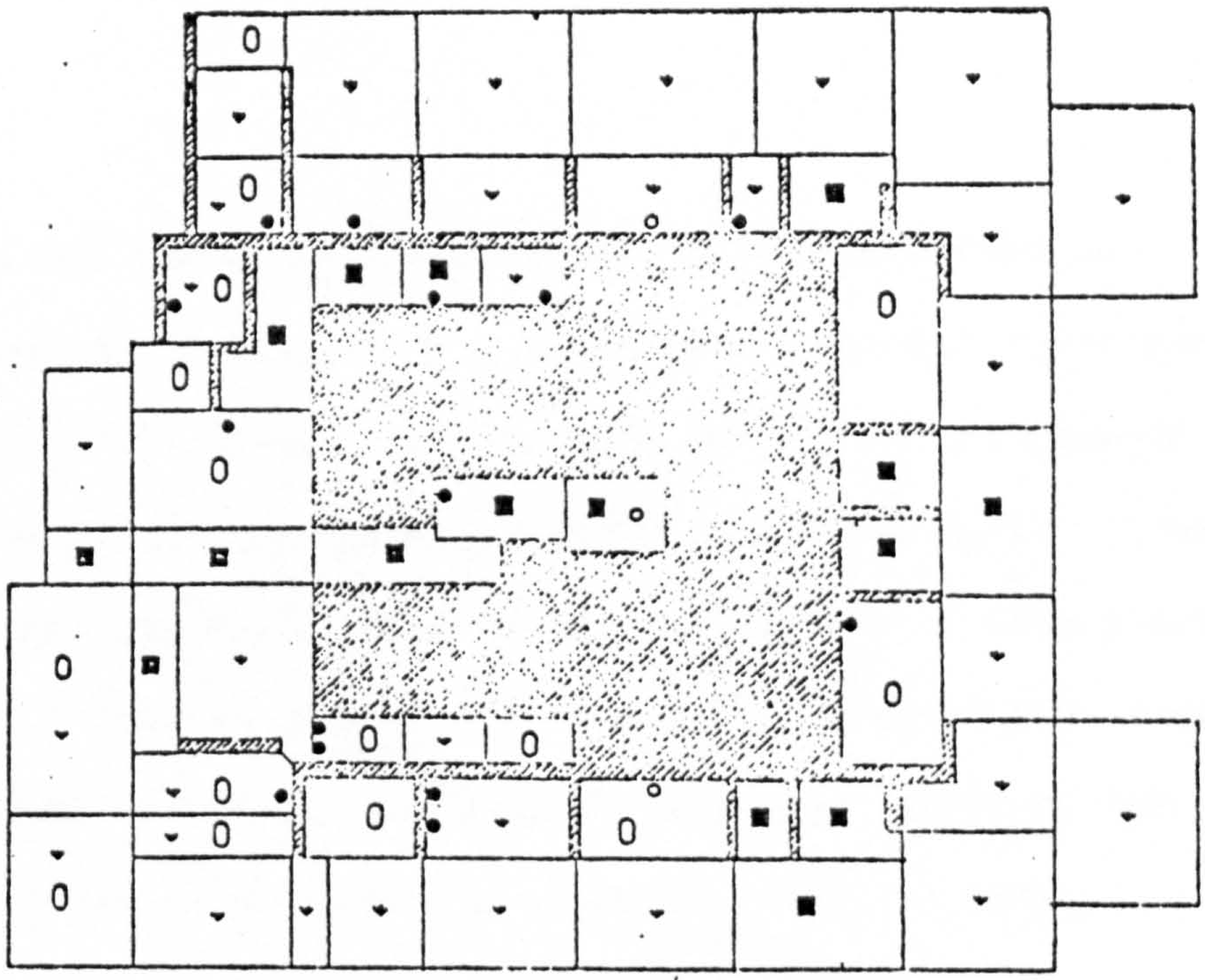


Fig. 5.3. Nature of the habitat in each zone.

- Buildings.
- Car parks and roads.
- Lawns.
- 0 Bushes.
- o Point of access to building above ground.
- • Point of access to basement or underground duct.

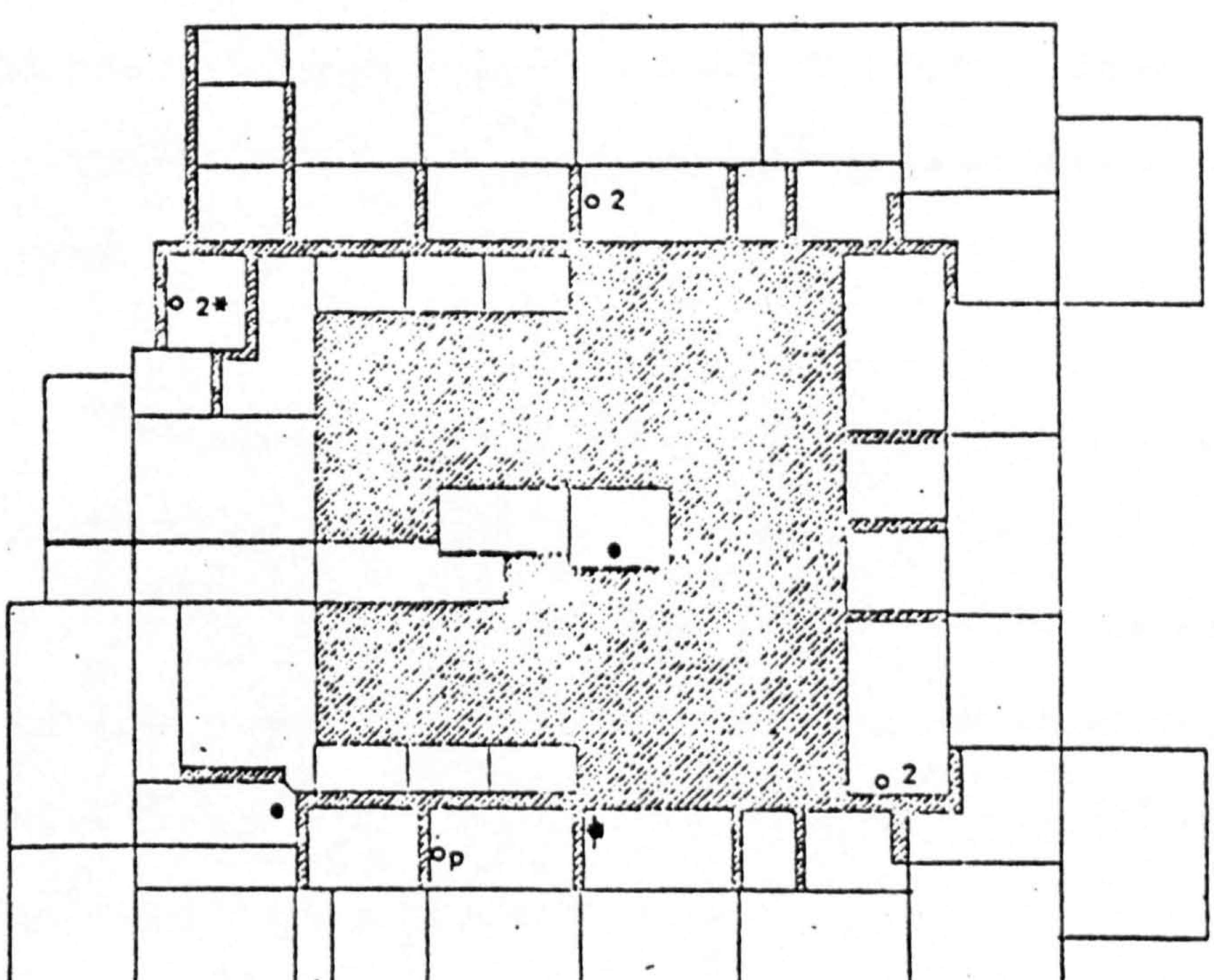



Fig. 5.4. Location of major feeding places.

• food from bins, o food provided, ϕ both. Sites marked with a '2' were important in the second year of the study only. The site marked '2*' was only identified in year 2 but was probably important in year 1, and the sits marked 'p' was periodically important throughout the study.

tarmacadamed roads and rubble roads which give access to individual buildings, from a perimeter road which encircles the main building (Plate 7.). The area covered by the grounds and buildings within the perimeter road was approximately 17 ha. Beyond this perimeter road the grounds consist of open playing fields, a cricket pitch, tennis courts, a patient's cemetary, and a plant nursery. At the south - western corner of the grounds there is an incinerator and an extensive refuse dump (Plate 8.).

### 5.3.2. The hospital as a habitat for feral cats

Most of the cats seen at the hospital were found near the main buildings. For this reason the study was conducted almost entirely within the perimeter road surrounding these buildings and the formal gardens described above. Other parts of the grounds were difficult to examine because they were heavily vegetated.

The central area of the hospital building is largely inaccessible from the outer areas since it consists of a large number of small enclosed yards many of which appear to serve no particular purpose and for this reason they remain locked. No cats were considered to be resident in these yards but some were observed to pass through them.

Most of the cats observed in the colony were seen

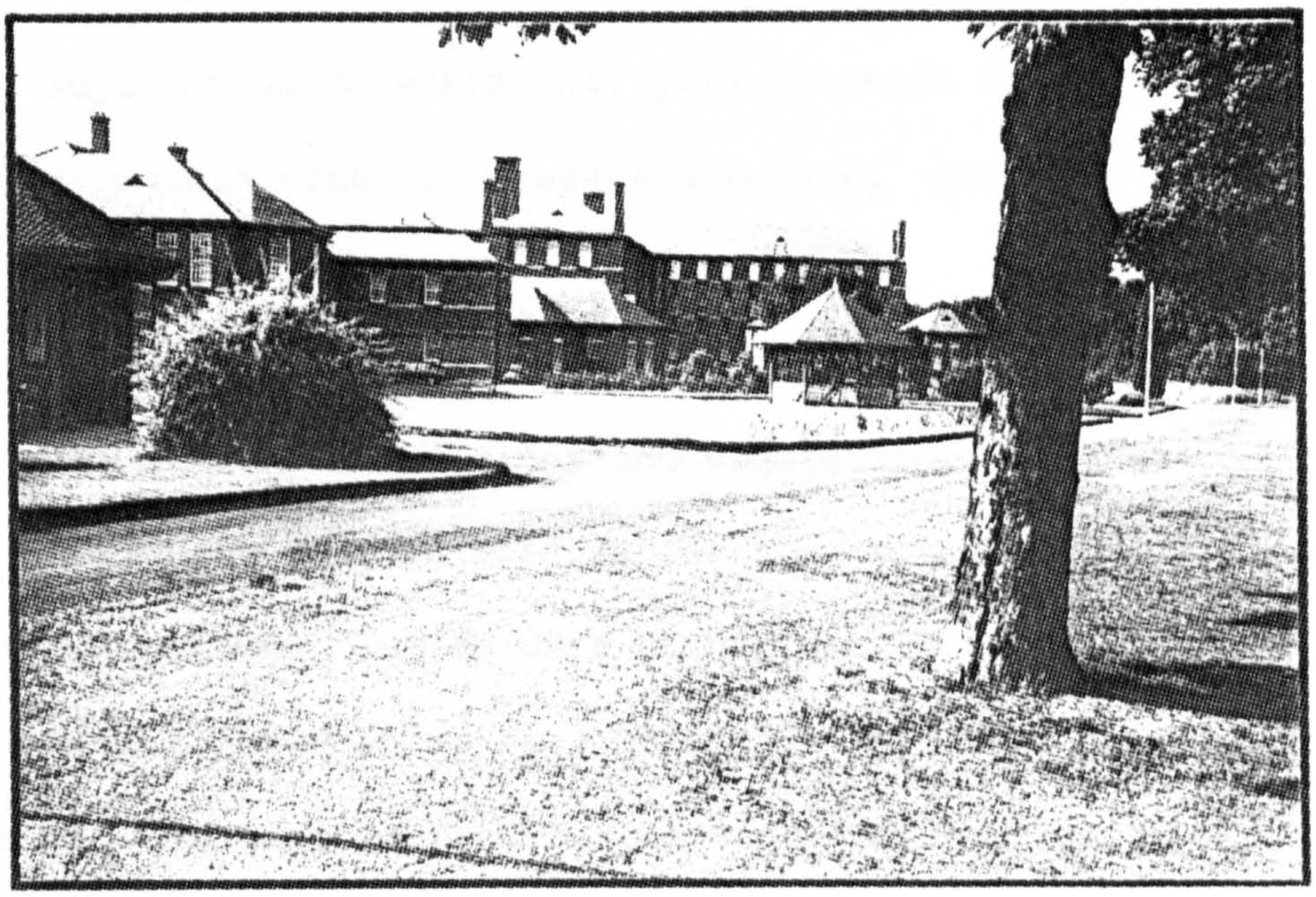


Plate 7. Part of the perimeter road on the east side of the hospital. This road encircles the main buildings and marks the boundary of the study area.

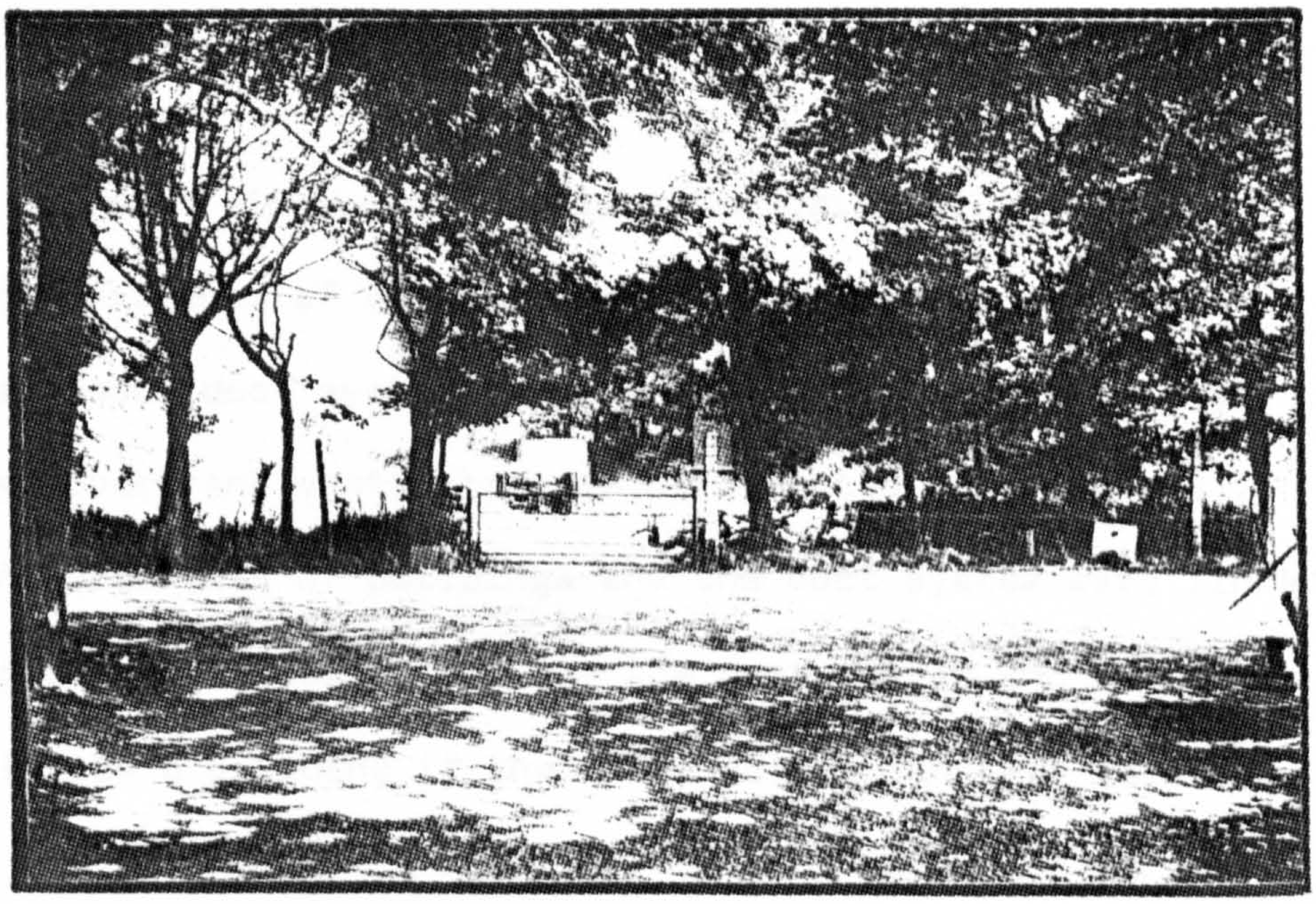


Plate 8. Entrance to the hospital's incinerator and refuse dump. This was outside the study area.

around the outside of the main buildings, often in the yards formed by adjacent wards where they join the main corridor. These yards contain areas of grass and bushes, and also areas of tarmacadam .

The cats used buildings and vegetation cover for shelter. They were able to gain access to wards and outbuildings via doors and windows, which were either broken or periodically left open. Cats could enter some buildings by a hole in the roof. Some animals moved from one part of the hospital to another by walking along the corridors and passing through doorways as the doors were opened by staff or patients (Plate 9). In some cases cats were attracted inside by patients with food (Plate 10). Occasionally cats were observed moving over the roofs of the lower buildings, sometimes to inaccessible areas of the hospital.

Broken windows and ventilation grids allowed cats to enter the basements of many buildings. Similarly, access to the underground duct system was gained via broken or missing concrete covers and ventilation grids (Plates 11. and 12). Since the basements of buildings and the duct system were linked, it was possible for cats to enter the duct system and sometimes appear inside a building if the floor boards had been removed.

The state of repair of the duct system covers, basement windows, and ventilation grids was generally poor.

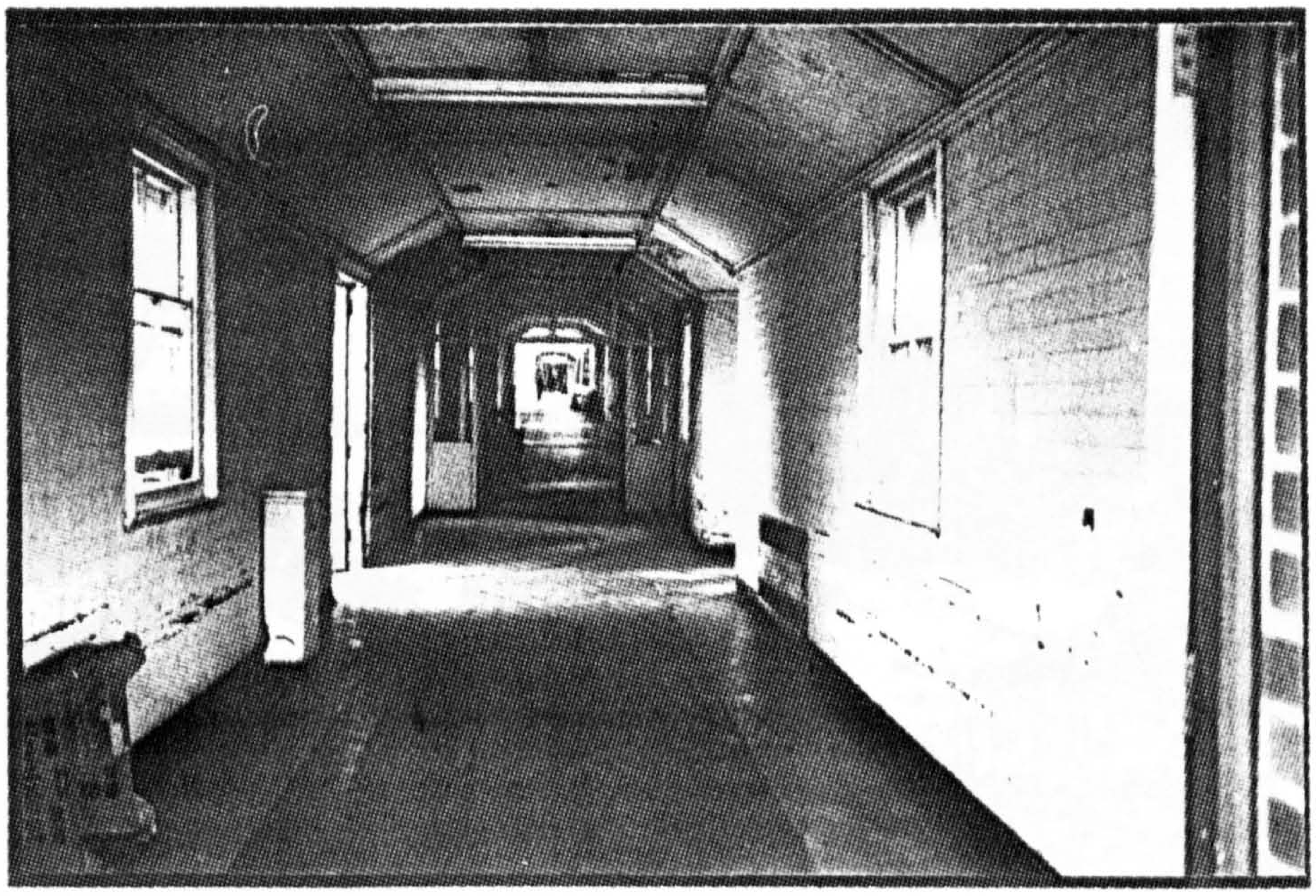


Plate 9. View along part of the main hospital corridor from the entrance in zone D (Plate 16). Cats walked through this corridor to reach other zones.

Plate 10. A patient feeding cats in zone D.

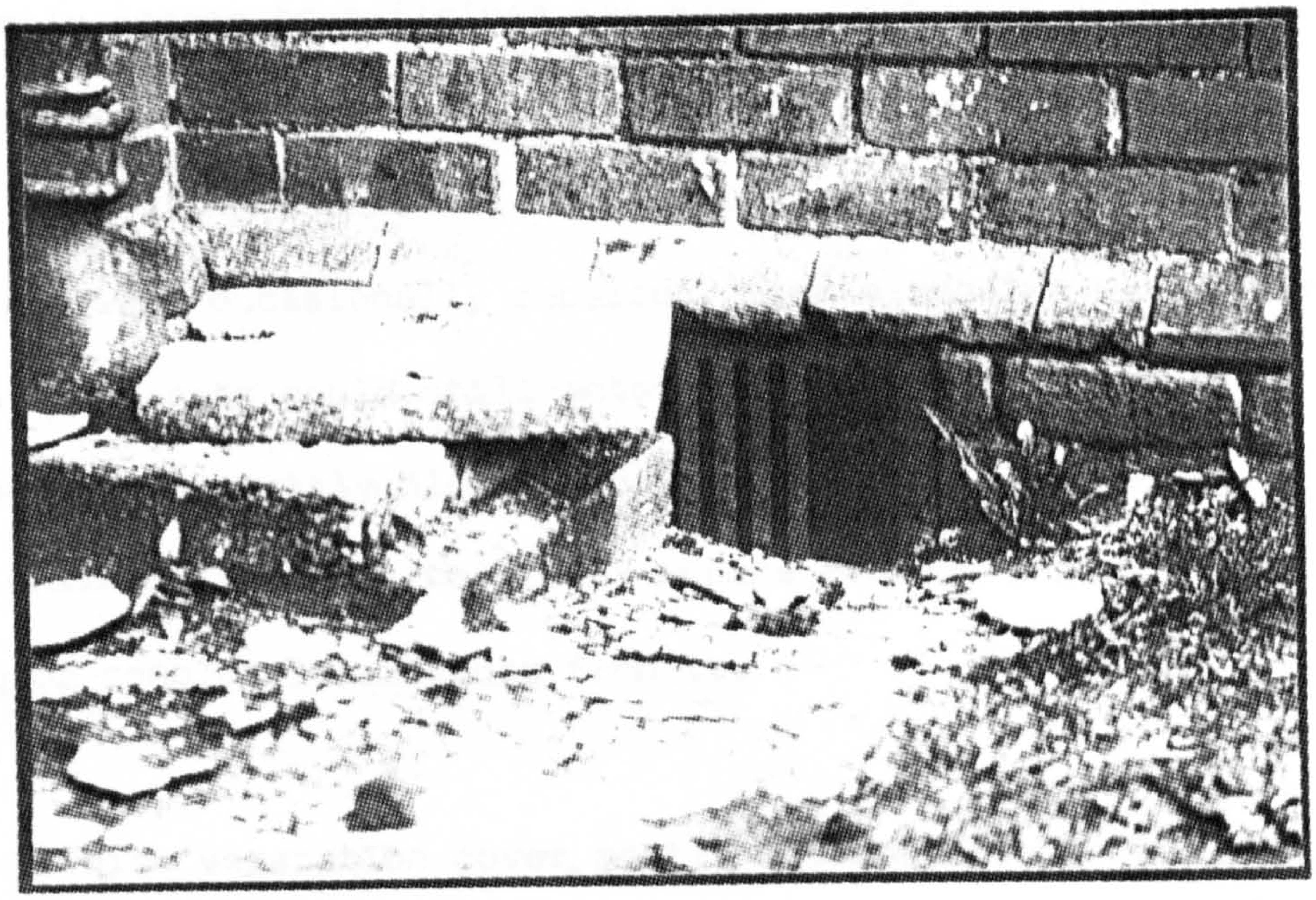


Plate 11. Broken ventilation grid used by the cats for access to the basement of the building in zone D (Plate 16). Periodically throughout the study this hole was covered with a concrete slab in an attempt to keep the cats out.

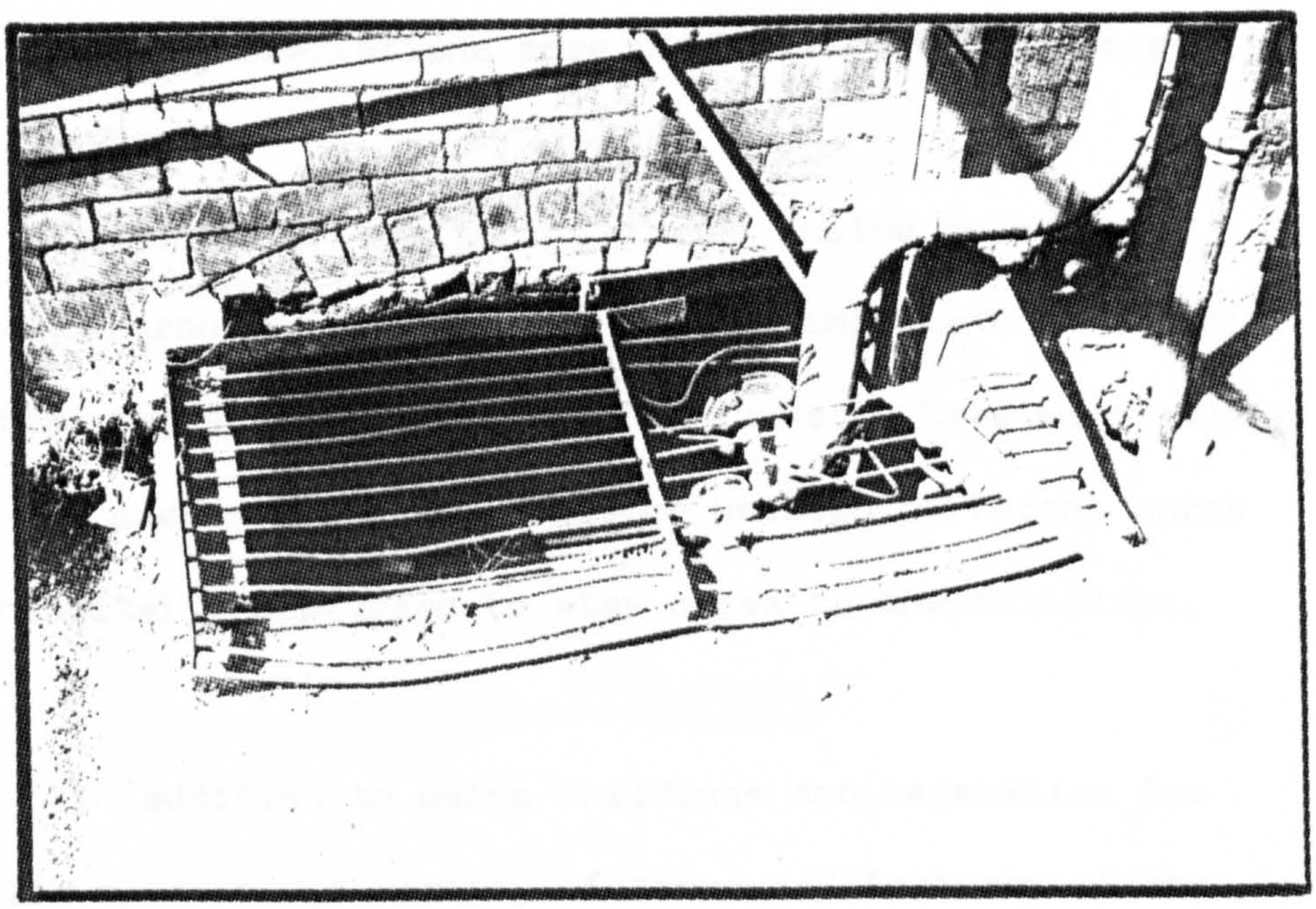


Plate 12. Ventilation grid providing access to the basement of the boiler house in zone F. Cats were seen walking along the pipes here in order to enter the underground duct system.

Consequently access to buildings was easy. Cats were attracted to these areas to breed since they were warm and dry due to the presence of heating pipes. Although holes in the walls and duct covers were occasionally repaired, these repairs were often inadequate and cats could still enter the buildings. Even if a hole became completely blocked the large number of other holes made it unlikely that any cats ever became trapped inside a building or completely excluded from it.

Thick vegetation cover, mostly *Rhododendron ponticum* L., was used by the cats for shelter in a number of places in the hospital grounds (Plate 13.). In some places this cover was reduced periodically by gardeners. The seasonal growth patterns of the plants, particularly Lupin (*Lupinus nootkatensis* L.), also drastically altered the nature of certain areas of the grounds, making observations more difficult during summer.

In general, sheltering places inside buildings, usually underground, appeared to be more important to the cat colony than the presence of vegetation cover. Cats were rarely seen in the open and even when moving between different parts of the hospital, preferred to stay close to the buildings.

In addition to using buildings and vegetation for cover cats also used a variety of temporary features of the environment. Waste bins and rubbish tips were important in many of the small yards in the hospital and parked cars made

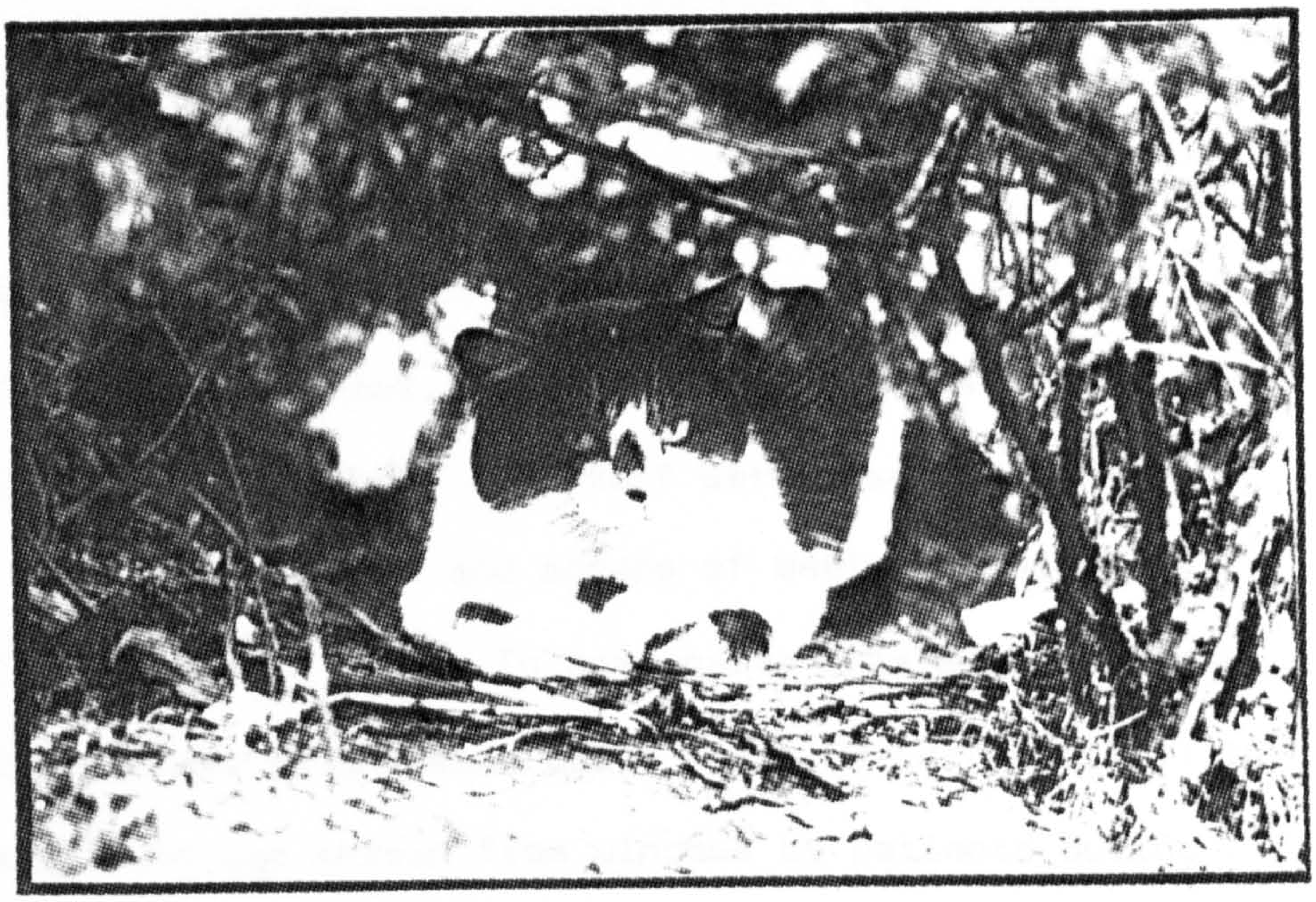


Plate 13. Adult male (63m) resting in vegetation in zone D.

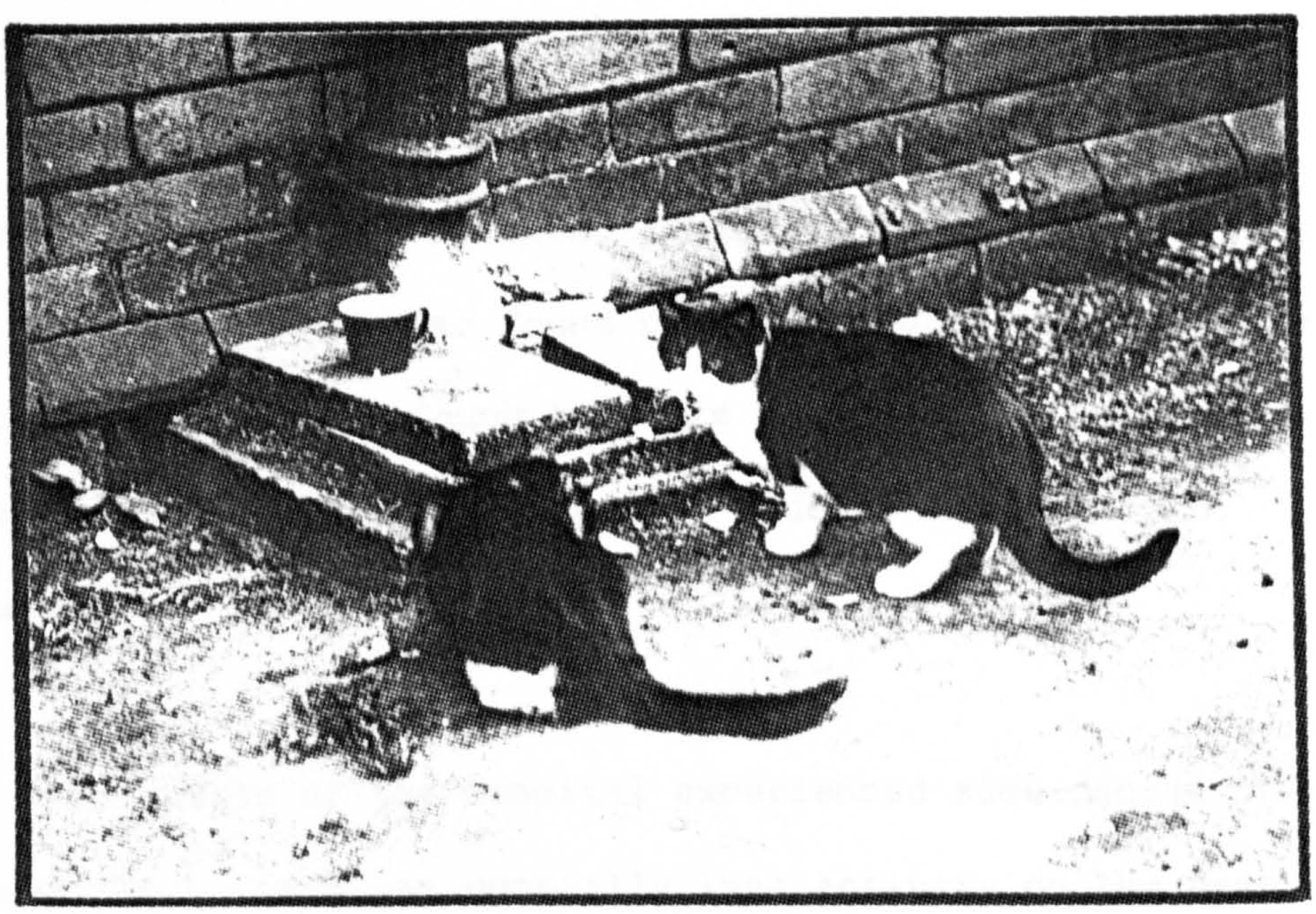


Plate 14. Female 10f (left) and male (44m) feeding on scraps provided by a patient in zone D.

useful hiding places for cats crossing large open areas.

The main sources of food for the colony appeared to be of human origin. Waste bins containing some food were present outside many wards, and in bins and skips outside the hospital kitchen. Patients and staff were observed providing food in the form of milk, and scraps of meat, and some pet food (Plates 10 and 14). In some cases this appeared to be regularly provided in the same place for a period of time. In other cases food was thrown from windows by patients during their meals, on a less regular basis. Food sources were not always constant in supply or position and the appearance and disappearance of feeding places may have had an effect on the distribution and abundance of cats in different parts of the hospital (Fig. 5.4.). The hospital buildings were used as roosts by a large number of starlings (Sturnus vulgaris L.) and a number of dead individuals were found which appeared to have been partially eaten by cats. A small number of blackbirds (Turdus merula L.) were also found partially eaten. The remains of one small mammal were found but this could not be identified. Cats were seen drinking from rainwater puddles and some milk was provided by feeders.

All parts of the hospital experienced some degree of human activity. There was generally less activity on the east side of the hospital than elsewhere mainly because few vehicles visited this side (Plate 7). Apart from the movement of vehicles other activity included movements of patients, visitors and staff, all of whom spent more time in the grounds during periods of good weather. Gardeners caused considerable disturbance to the cats in the spring and summer months in particular. Decorators and maintenance men working on the outside of the building also affected the activity of the cats, especially when this work generated noise. All staff did not enter the hospital at the same time so there were no regular periods of intense activity.

Human attitudes towards cats in the hospital varied. Some people fed the cats regularly and expressed concern for their welfare. Others considered them to be pests and frequent attempts were made to exclude them from the hospital buildings and ducts.

The exact age and origin of the Winwick Hospital feral cat colony could not be determined although the Head Porter of the hospital indicated that cats had been present in the grounds for the thirty years that he had been employed there. It may be that the colony is considerably older than this.

Some wards in the hospital keep pet cats. This is common practice in many hospitals and it is possible that such animals were the original founders of the feral colony at Winwick. The proximity of the hospital to a housing estate makes it likely that stray cats may have been encouraged to take up residence in the hospital by patients or staff providing food. In addition reports were received of unwanted cats being dumped in the hospital grounds in the past. All of these sources of animals may have been important in the original establishment of the colony, and its persistence.

Some of the hospital staff suggested that the colony had previously been much larger than its present size. There is no evidence for this but many cats had been removed from the colony in recent years by the R.S.P.C.A. and several pest control firms. This may not have had any long term effect on the colony size because the reproductive potential of cats is high.

As far as could be ascertained no animals had been removed from the colony immediately prior to the beginning of this study. However, a newspaper article in the Warrington 'Evening Post & Chronicle' reported that cats were being removed from the hospital in November 1977. The hospital authorities were reported to be concerned about flea infestations on a number of wards. Such problems were undoubtedly the reason for many of the past attempts to exterminate the colony. The hospital authorities eventually agreed to have the colony neutered because these extermination attempts had failed.

Throughout the study records were kept of any significant changes which took place in the habitat, such as increased maintenance activity, removal or appearance of a feeding point, closure of a ward or the blocking of a place of access to the buildings, to determine the effect of such changes on the behaviour and ecology of the cat colony.

## 5.4. EXPERIMENTAL DESIGN

The aim of this study was to determine the effect of neutering on the ecology, behaviour and social organisation of a colony of feral cats. This was to involve the capture of the cats, neutering, removal of fleas, vaccination against feline infectious enteritis, and the return of the cats to their original habitat.

The effects of neutering could have been studied using a caged colony, as used by Leyhausen (1979) in his studies of cats, or by finding and studying a suitable colony in the field. It was decided that a field study would be most useful since this would be more likely to indicate the effectiveness of neutering as a method of control for natural colonies. It was appreciated that this approach would allow almost no control over the experimental animals, but a caged colony would have been too isolated from the various ecological factors which affect natural colonies, to yield useful information. Such factors would include human activity, fluctuations in food supply and the possibility of immigration and emigration of cats.

To examine the effect of neutering on a colony of feral cats in the field two basic approaches may be adopted.

Method 1.

Select two colonies of similar size, social structure and organisation, which occupy similar habitats. Leave one colony entire and neuter the other. Study both colonies at the same time and record any differences in their biology. Using this method the entire (unneutered) colony acts as a control.

Method 2.

Select one colony. Study the colony for a period of time before neutering. Neuter the cats and then study them for a similar period. Record any differences in their biology before and after neutering. This method uses each animal as its own control.

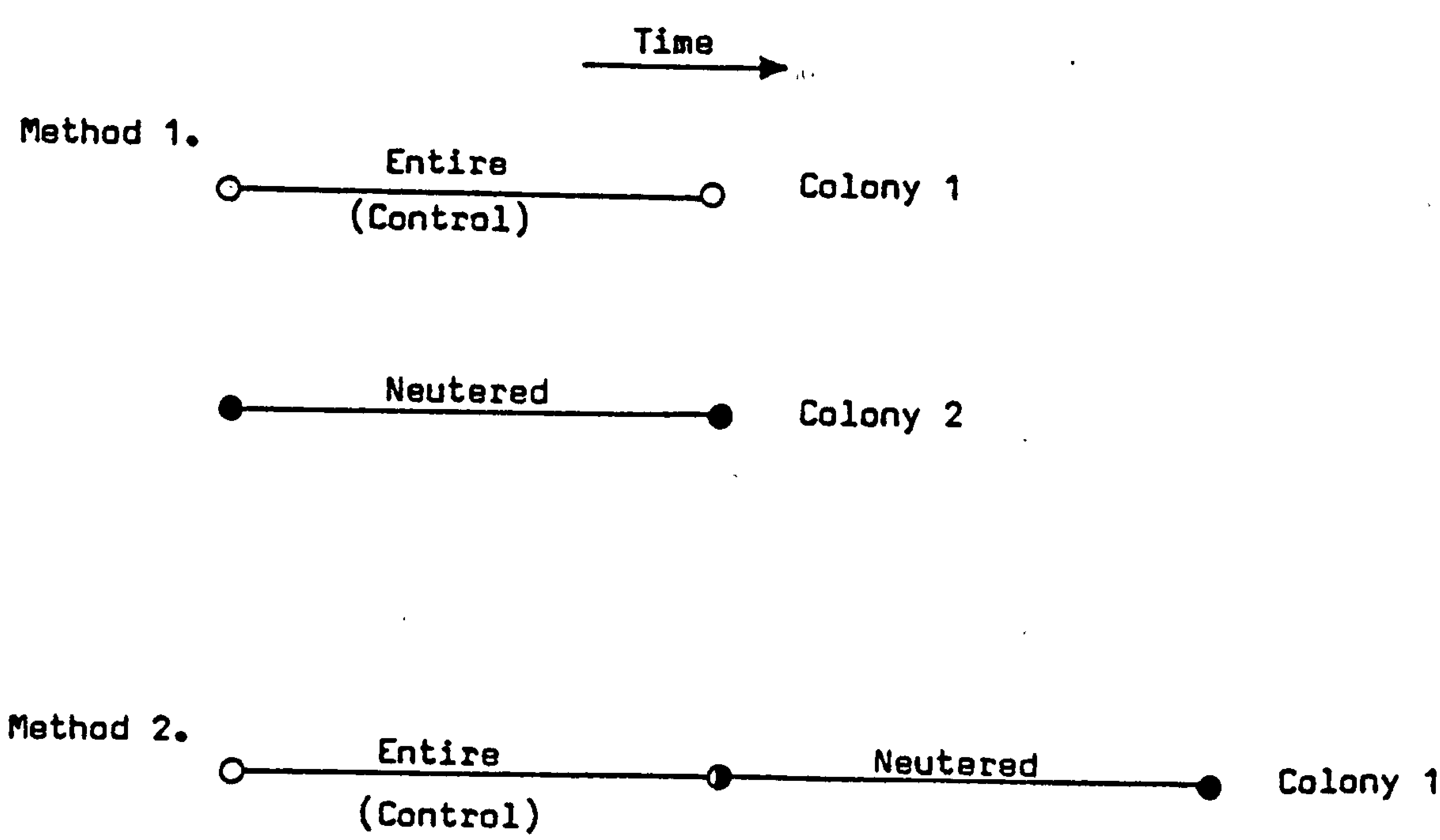



Fig.5.5. Two alternative experimental designs, using two colonies (method 1) and one colony(method 2).

Problems arise with both of these approaches. The first method requires two identical colonies and these would be very difficult to find. It also requires identicl ecological factors to be affecting both colonies and it takes no account of individual differences between the cats in the two colonies.

The second method requires twice as much time to make a comparison of the same duration as method 1 (Fig. 5.5.). It cannot determine whether or not changes occuring after neutering would have occurred anyway, and it assumes that the biology of an entire colony is consistent from one year to the next. This is unlikely, especially if the colony contains immature animals which eventually become adults.

Some of these difficulties could be overcome by combining the two study methods as indicated in Fig. 5.6. However, this

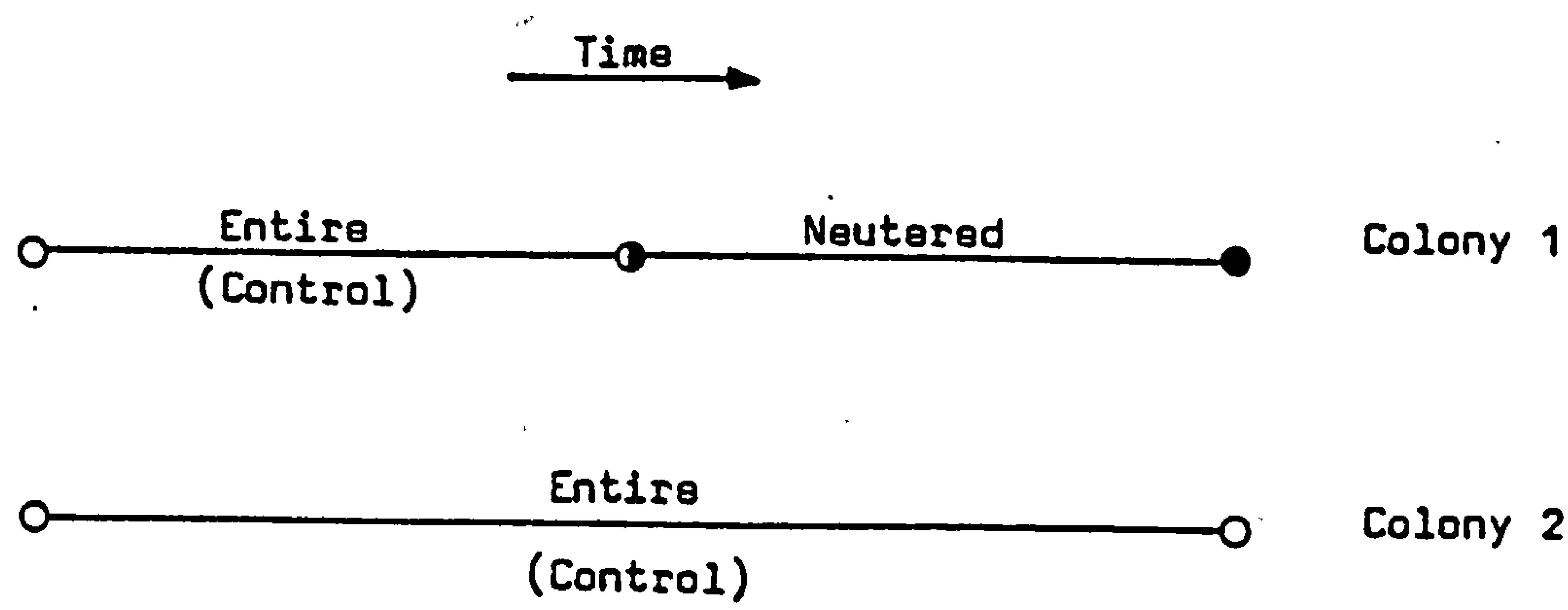



Fig.5.6. Experimental design using two controls.

would present the same difficulties as encountered in the first method, in that two similar colonies would be required.

The second method was used in this study for two reasons. First, it would have been impossible to find two colonies identical in all respects. Second, it was considered that by using each cat as its own control individual differences between cats could be eliminated.

The detailed and continuous monitoring of behavioural interactions between individual cats in the colony at Winwick Hospital was not undertaken. Working in almost ideal conditions Macdonald & Apps (1978) examined interactions between four adult cats living on a farm. The greatest interaction frequency observed was 6.8 $hr^{-1}$. In a highly disturbed environment such as Winwick Hospital such a study would have been impractical and the number of interactions observed would probably have been very low due to the heterogeneous nature of the environment. A much broader view was taken of the effects of neutering on the population.

The effects of neutering on a colony of feral cats may be considered from a number of different points of view. A neutering programme involves more than simply preventing reproduction by surgical means. It involves the removal, by trapping, of cats from the habitat in which they normally live; a surgical operation which will not only remove reproductive organs but will also prevent the secretion of some sex hormones and may affect the development of immature animals; and the return of the animals to the habitat. In examining the effects of neutering the following questions may be asked:

1. Does the trapping, removal and return of the animals affect the distribution of the population, i.e. do the cats live in the same places after being disturbed by trapping?

2. What are the effects of cessation of reproduction on the survival and structure of the population?

3. Do entire cats tend to enter the colony when the residents are neutered?

4. Do the physiological effects of neutering cause any behavioural changes which affect social organisation or any other aspect of their biology?

5. Does the condition of the animals alter after neutering? If so, is this caused by the administration of drugs after neutering, physiological changes that occur after neutering, or a change in the relationships between individuals in the colony resulting in less stress and conflict?

This study seeks to find answers to these questions. However, in considering the effects of neutering on a colony of feral cats it must be remembered that if a change in some aspect of the biology of the cats was observed after neutering, there is no way of knowing whether or not this change would have occurred if the cats had not been neutered. Also, if changes are detected they may or may not be significant from the point of view of management of the colony.

In addition to examining the effect of neutering on a feral cat colony, the trapping of cats at Winwick Hospital also allowed a study of the response of the colony to trapping and the methods used by a professional trapper. While the cats were in captivity they were examined for parasites and their physical condition was assessed by veterinary surgeons. In addition, blood samples were taken to test for exposure to feline viral diseases (Part IV ).

Between March and June 1978 the colony was visited 15 times. During this preliminary study period the cats present were identified. From July 1978 to June 1979, 64 systematic visits were made to the colony (pre - neutering period). In July 1979 the cats were trapped and neutered, and then released. From July 1979 to June 1980 a further 64 visits were made to the colony (post - neutering period). The information collected during the first year of the study, when the cats were entire, was then compared with that collected in the second year, when the cats were neutered, in order to examine the effect of neutering on the biology of the animals. Four visits were made in the month after the end of post - neutering year , to determine which cats were still present. Eleven further visits were made between August 1980 and the end of January 1981.

## 5.5. FIELD METHODS

### 5.5.1. Identification of cats

During the course of population studies it is frequently desirable that individual animals should be identified. This is essential if the rôle of particular individuals in the population is to be examined. The marking of animals is useful in studies of very large populations in which the individual animals have no easily distinguishable features. Various marking methods have been discussed by Southwood (1978) and Stonehouse (1978).

A number of researchers have developed methods of recognising individuals in mammal populations without marking. Douglas - Hamilton (1972) compiled a collection of photographs of the individuals in a population of African elephants (*Loxodonta africana* Blumenbach ) from which he was able to determine the distinguishing features of each animal. Dards (1979) identified some 200 adult feral cats in Portsmouth dockyard using differences in their body form and coat colour.

It was considered unwise and unnecessary to mark the cats at Winwick Hospital. This would have caused disturbance to the colony at an early stage in the study and would have involved trapping each cat. If this had been done there was no way of determining whether or not it would be possible to catch each cat again at a later date, for neutering. The methods used by Dards (1979) were considered to be more than adequate to identify the relatively small number of cats in the Winwick Hospital colony.

Cats were identified primarily from differences in their coat colour and pattern. The distribution of small patches of colour on the coat was particularly useful in identification; for example, small ginger areas on a tortoise-shell cat, or black patches on a white cat. In black and white cats the exact distribution of the colours was important. The markings on the face and tail were very useful in distinguishing between these cats. Black cats were extremely difficult to identify except if they possessed small areas of white hair. In such cases features other than coat colour and pattern had to be used for identification. Coat length was used to distinguish between some cats of similar colour, particularly black cats and ginger cats. Coat condition was also important : some cats had good healthy coats whereas others had coats in poor condition with the skin visible through the coat in some cases.

The size of individual cats was important in their identification, but allowance had to be made for the growth of young cats, especially those that were rarely seen. The shape and size of the head were important in identification, as were the colour of the eyes and the size, shape and position of eyes and ears. The form and length of the tail were also characteristic. Tail length was variable, some tails were bushy, while others were thin with very short hairs. The position in which the tail was held could also be useful in identification. One female had a very thin tail which she held in a characteristically stiff, downward position.

At the beginning of the study identification of individual cats relied heavily upon the observable differences in coat colour, pattern and body form described above. However, as the study progressed, these features became less important and identification became an almost unconscious act based, not only on the physical appearance of the cat, but also on the way that it behaved. Many cats had characteristic gaits, postures and behaviour patterns which could only be recognised by the observer from experience. Familiarity with the cats eventually led to the ability to identify many of them from a distance without any need to examine the detailed features of their physical appearance.

Male cats could be distinguished from females by observation of the testes. However, this was not always possible so secondary sexual characters were also used. Males tend to have a heavier body form than females, especially the head. Males also tend to have a longer body than females. Physical features are not an infallible guide to sex especially in young cats. Male cats habitually spray urine posteriorly against walls and vegetation. This and other behavioural differences were useful indicators of sex. Sex - linked coat colours were initially helpful in sexing cats : for example ginger cats are more likely to be male than female, while the opposite is true of tortoise-shell cats. However, this is again, not infallible and a ginger female was present in the Winwick Hospital colony. Female cats were easily distinguished when seen with suckling kittens. The sex of each cat was confirmed by veterinary surgeons at the Liverpool Veterinary Hospital when the cats were captured.

It was impossible to determine a cat's age unless it was born during or immediately preceding the study period. Even then the exact date of birth could not always be determined so the week or month of birth had to be estimated. The younger the kittens were when they were first discovered the easier this was to do. Dards (1979) used records of when a cat was observed to be pregnant to assist in determining the time of birth of her kittens. This was occasionally found to be useful but often pregnancy was difficult to diagnose especially in heavily built cats and those with thick coats.

Cats were divided into adult males, adult females (more than six months old) and kittens (less than six months old).

Dards (1979) called cats between 6 months and one year old 'juveniles'. This age class is not used here because of the difficulty of determining the exact age of any animal and because it would have contained a very small proportion of the colony at Winwick Hospital at any one time. Many cats died before reaching the age of six months and for this reason cats less than six months old have been excluded from much of the study. This avoided including cats which were only temporarily part of the colony. Cats which were born during the study period were excluded from much of the analysis until reaching the age of six months. In the laboratory, male cats were found to show the first complete copulation at about eleven months of age (Rosenblatt & Aronson, 1958) while females showed the first behavioural signs of oestrus at six to eight months of age (Rosenblatt & Schneirla, 1962). It therefore seems reasonable to include cats of six months to one year of age as adults on the basis of their potential contribution to the productivity of the population, and their permanent position in the colony, compared with younger, more susceptible animals.

Cats were assigned a number according to the order in which they were first seen. The sex of each cat is indicated by the presence of 'm' (male) or 'f' (female) after its number . The identification number of kittens is followed by 'k'. A record sheet (Fig. 5.7.) was kept for each cat containing : a description and drawing of its coat colour and pattern including any distinguishing features; its sex and the age class (adult or kitten) to which it was assigned when first

No.

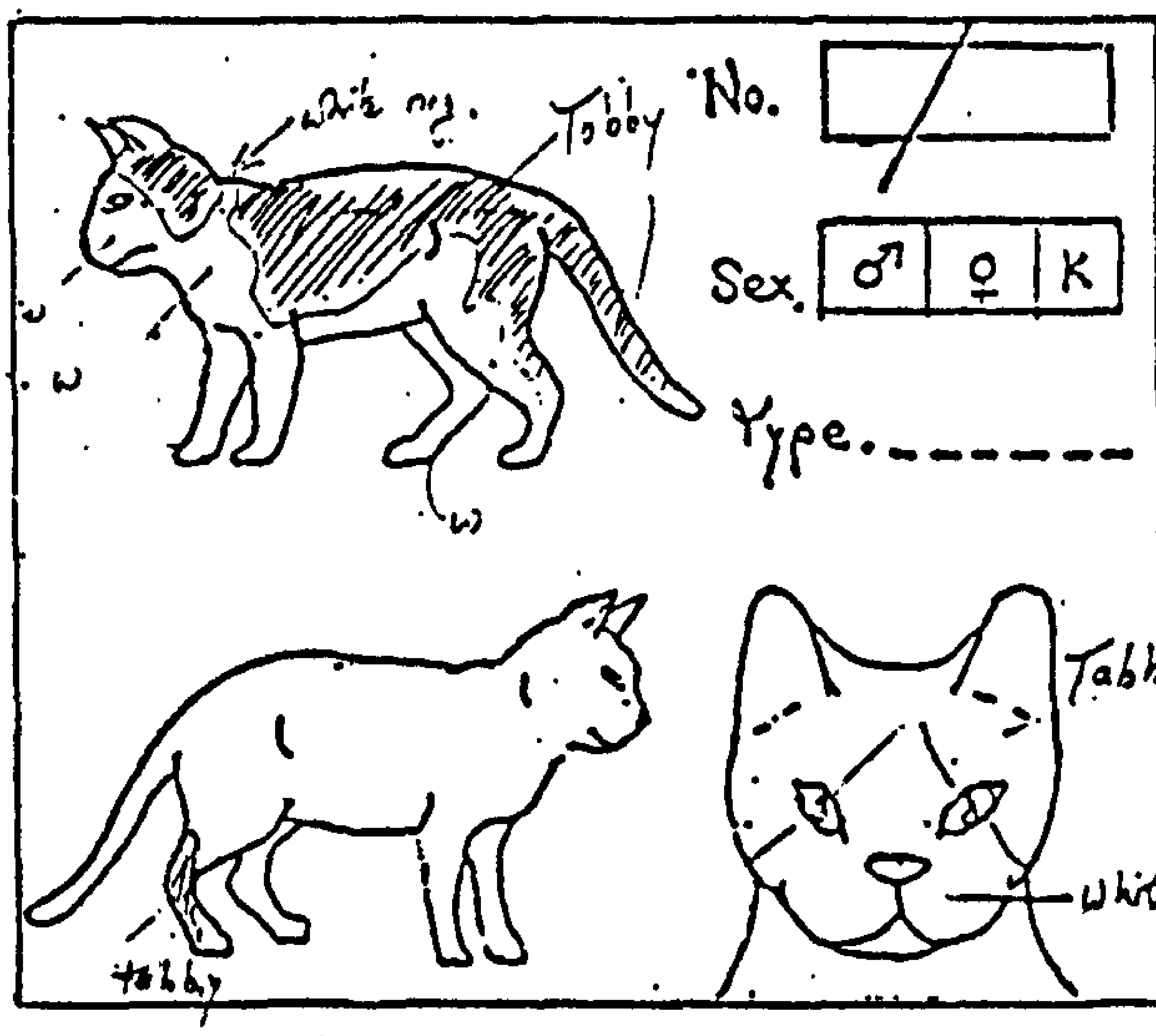
First Recorded: | 17 | 4 | 78 |

Colour: Tabby & White.

Type: B.

Hair: Short.

Distinguishing Features:
White ring around back of neck.




Sex/Age:

| ♂ | ♀ | | | |
|---|---|---|---|---|
| ✓ | | | | |

Adult

Fig.5.7. Record sheet.

seen; and the date on which it was first recorded. Initially all records of sightings of individual cats were kept in their record sheets.

### 5.5.2. Division of the habitat into zones

In order to record the location of cats seen within the hospital the study area was divided into zones. Some zones were distinct areas such as the yards between wards, some were bounded by walls, and others were less distinct areas such as gardens or car parks delimited by the position of roads or hedges (Plates 15 - 18). Zones were selected so as to divide the habitat into ecologically useful units rather than maintaining consistency of size. Consequently some zones were much larger than others.

Each zone was assigned a letter code, alphabetically in the sequence A to Z, and then AA, AB, AC and so on to BB. When it was considered to be ecologically useful to divide an existing zone into several smaller zones, each new zone was assigned a number in addition to its original letter code. For example, zone E was divided into zones E1, E2 and E3 , when it became clear that several cats were utilising different parts of the original zone.

During the first year of the study 56 zones were recognised in the study area. In the second year three additional

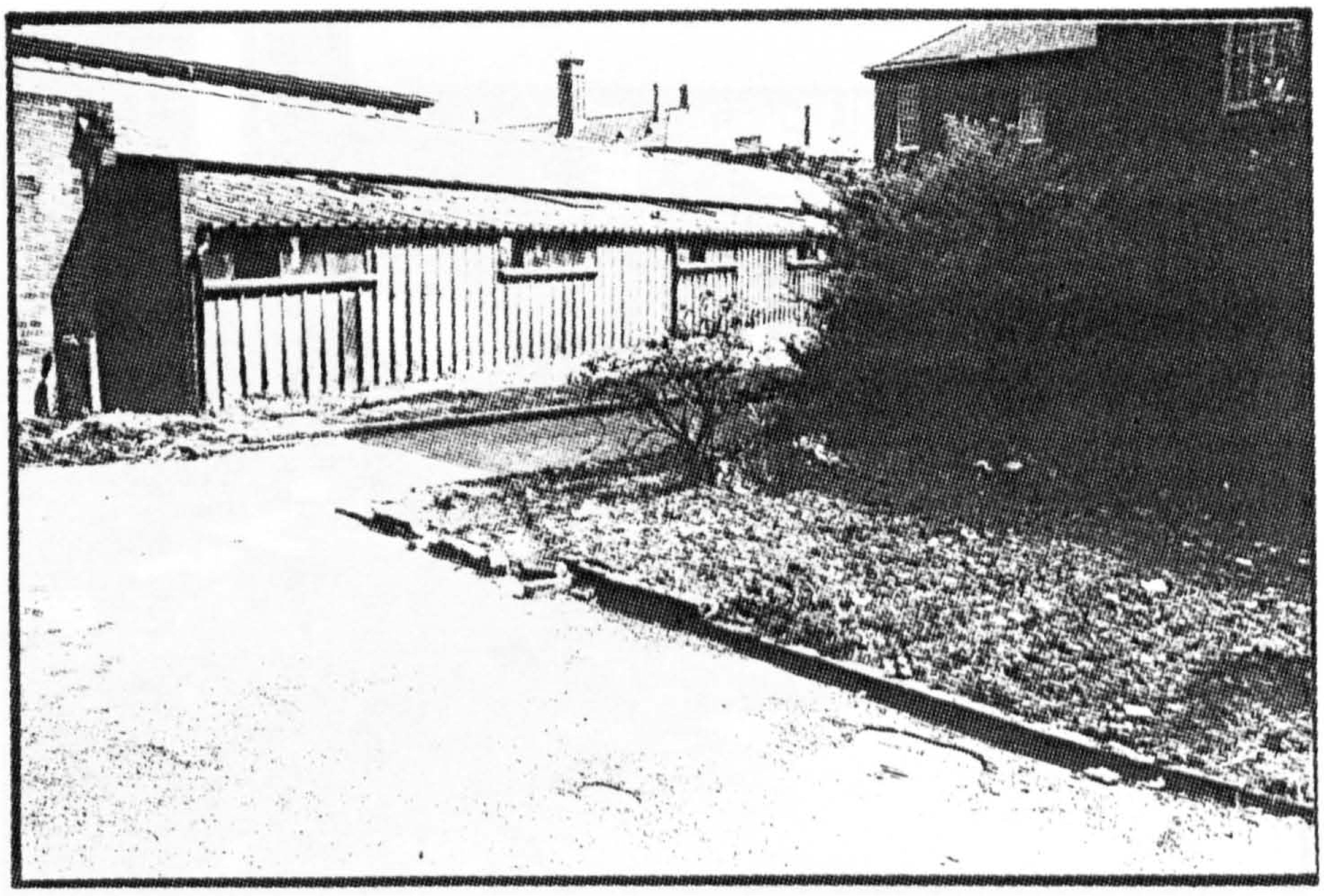


Plate 15. Part of zone A. The derelict shed in the background was used as a sheltering place by the cats in group A. Access was gained via the broken windows and holes in the roof. Many litters of kittens were found here.

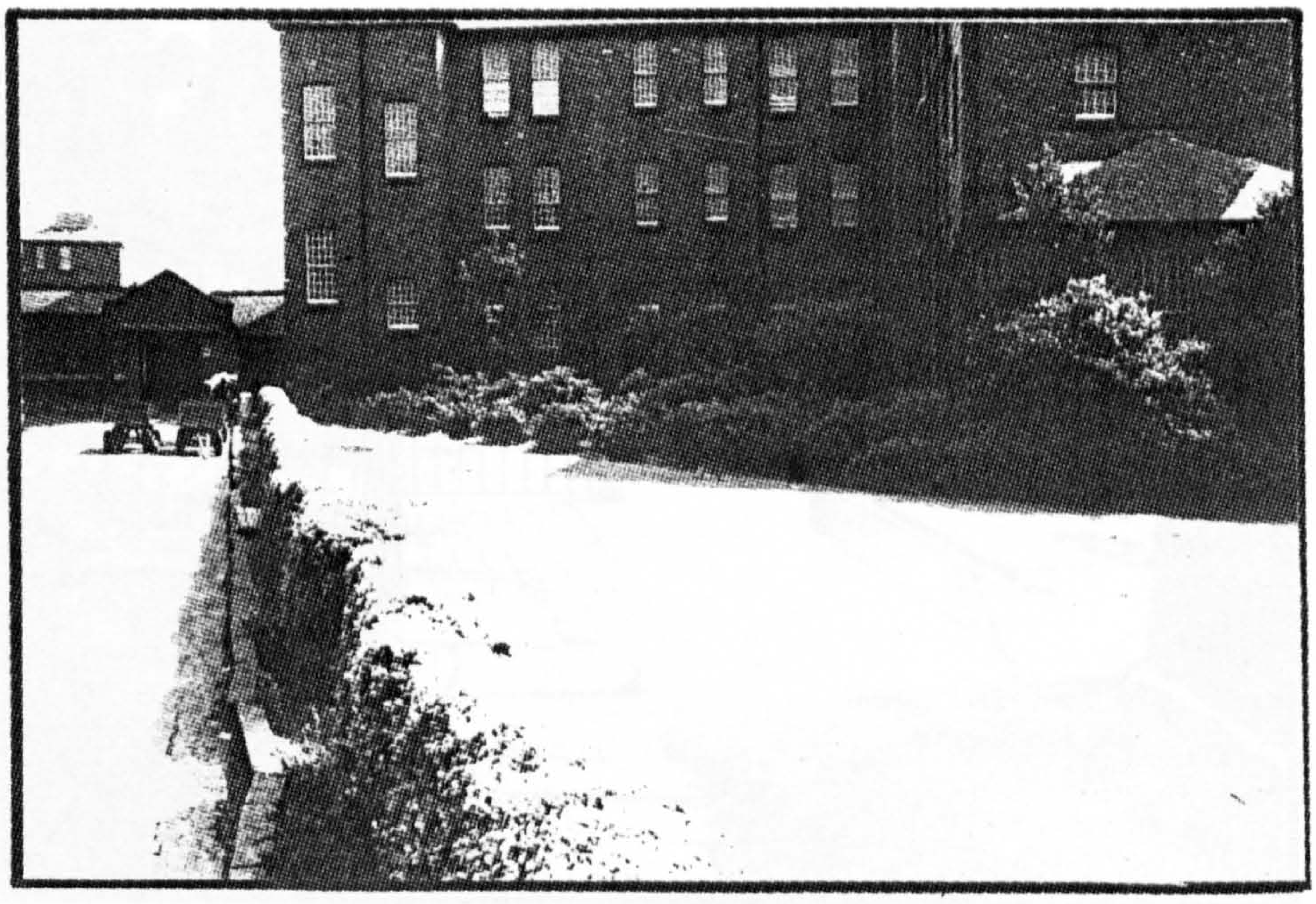


Plate 16. Zone D. The entrance to the main hospital corridor is at the end of the road on the left. Cats from group D were often observed here waiting for patients to come with food.

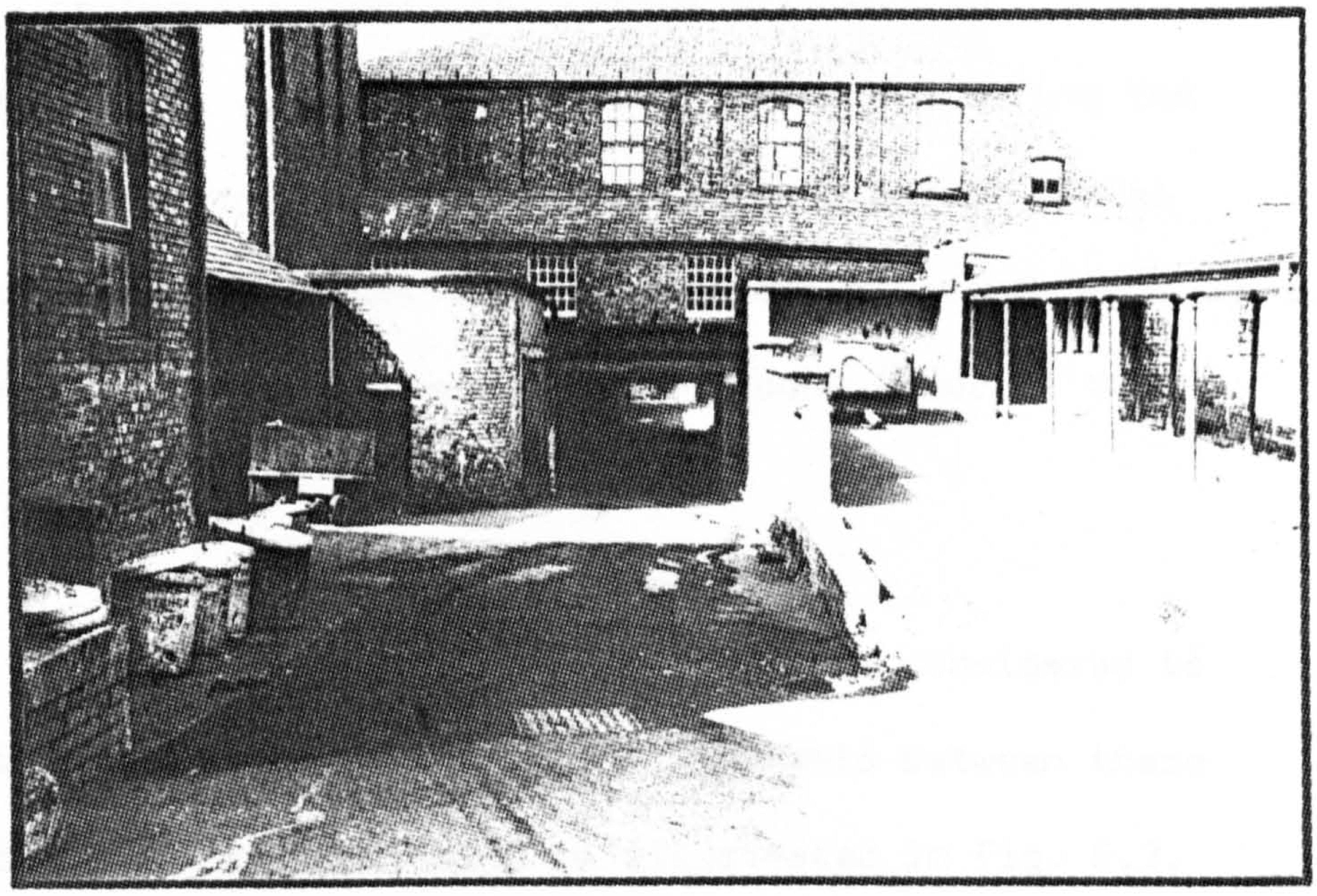


Plate 17. The main hospital kitchens (zone G). This is part of the area used by cats from group F. Food was obtained from the bins (left) and the skip (right). Cats usually congregated in this area in the late evening after the kitchen staff had left.

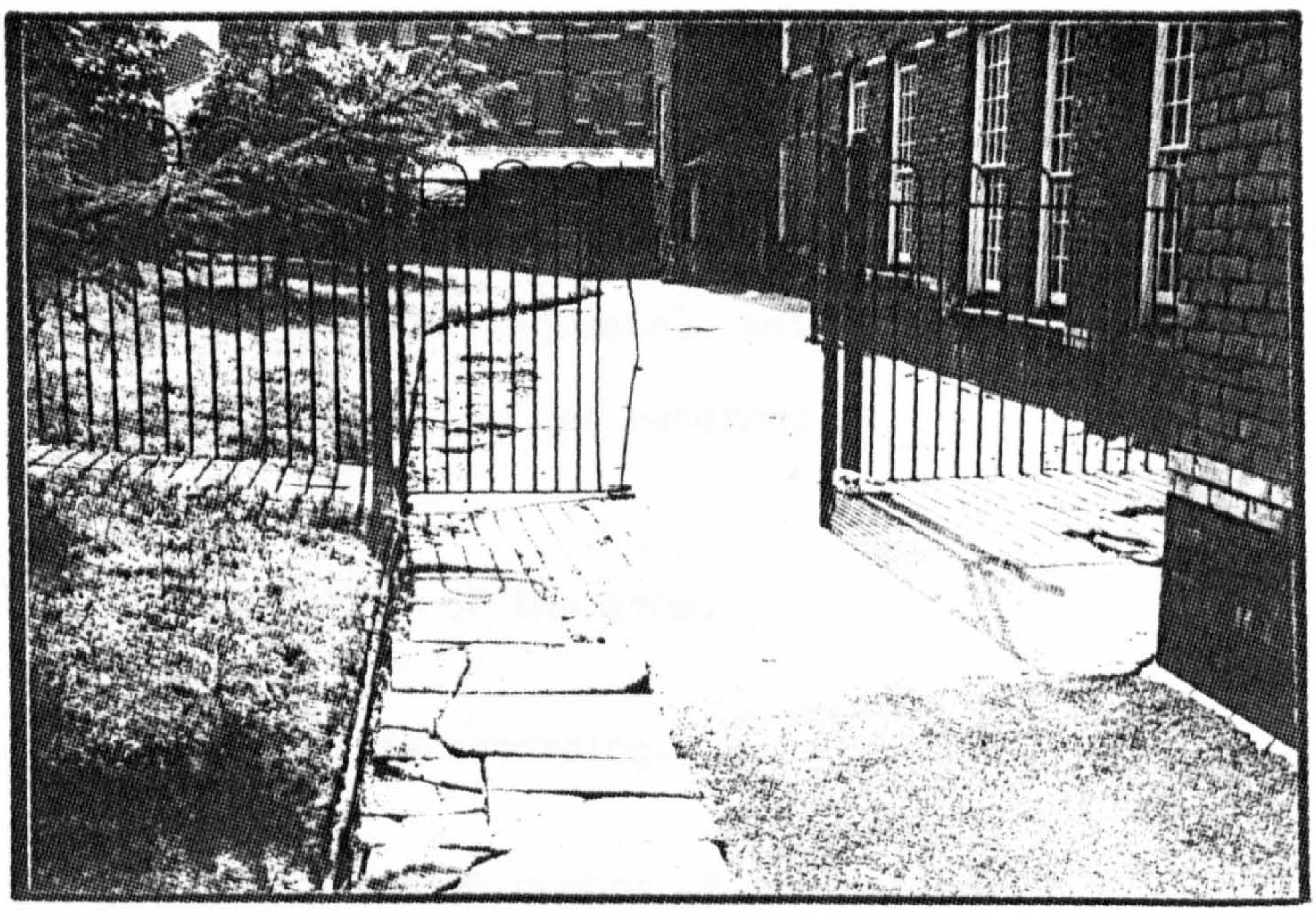


Plate 18. Zone R. This zone has a shape which is a mirror image of zone A (Plate 15), and contains a similar derelict shed which was used by the cats in group R. Cats from this group were sometimes observed sitting outside the windows of the ward waiting for food.

zones were included : zones AN (Plate 19) and AL were added because cats were discovered in these areas during the trapping operation; zone DJ was added as a result of the removal of the floor of the building between zones D and J, giving cats access to the basement and ground floor of this building.

For recording purposes each zone was considered to have rectilinear boundaries. The relationship between these zones and the hospital building is illustrated in Fig. 5.2. An accurate map of the hospital grounds was not available so the area of individual zones could not easily be determined. Most zones had an area of approximately 0.2 ha., but some were larger and some were smaller.

### 5.5.3. Field Recordings

During each visit to the colony the zones were examined in turn (always in the same sequence) and if any cats were seen the following information was recorded:

(i) Code letter of the zone.

(ii) Time of the recording.

(iii) Identification number of the cat(s).

(iv) Physical condition of the cat(s).

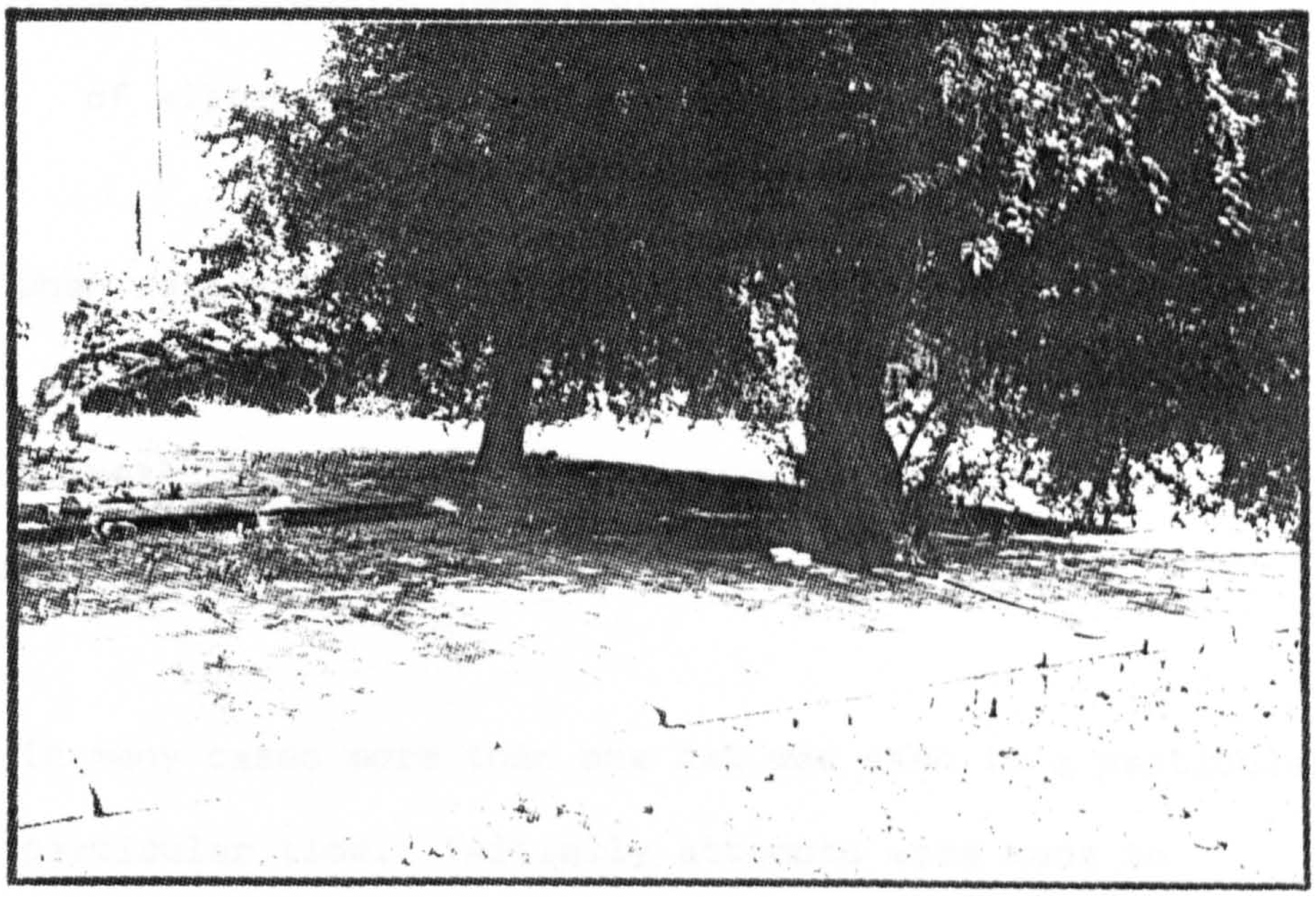


Plate 19. Zone AN. This is a heavily vegetated garden area located behind the Nurses' Home. A female (114f) and her kittens were discovered here during the trapping operation.

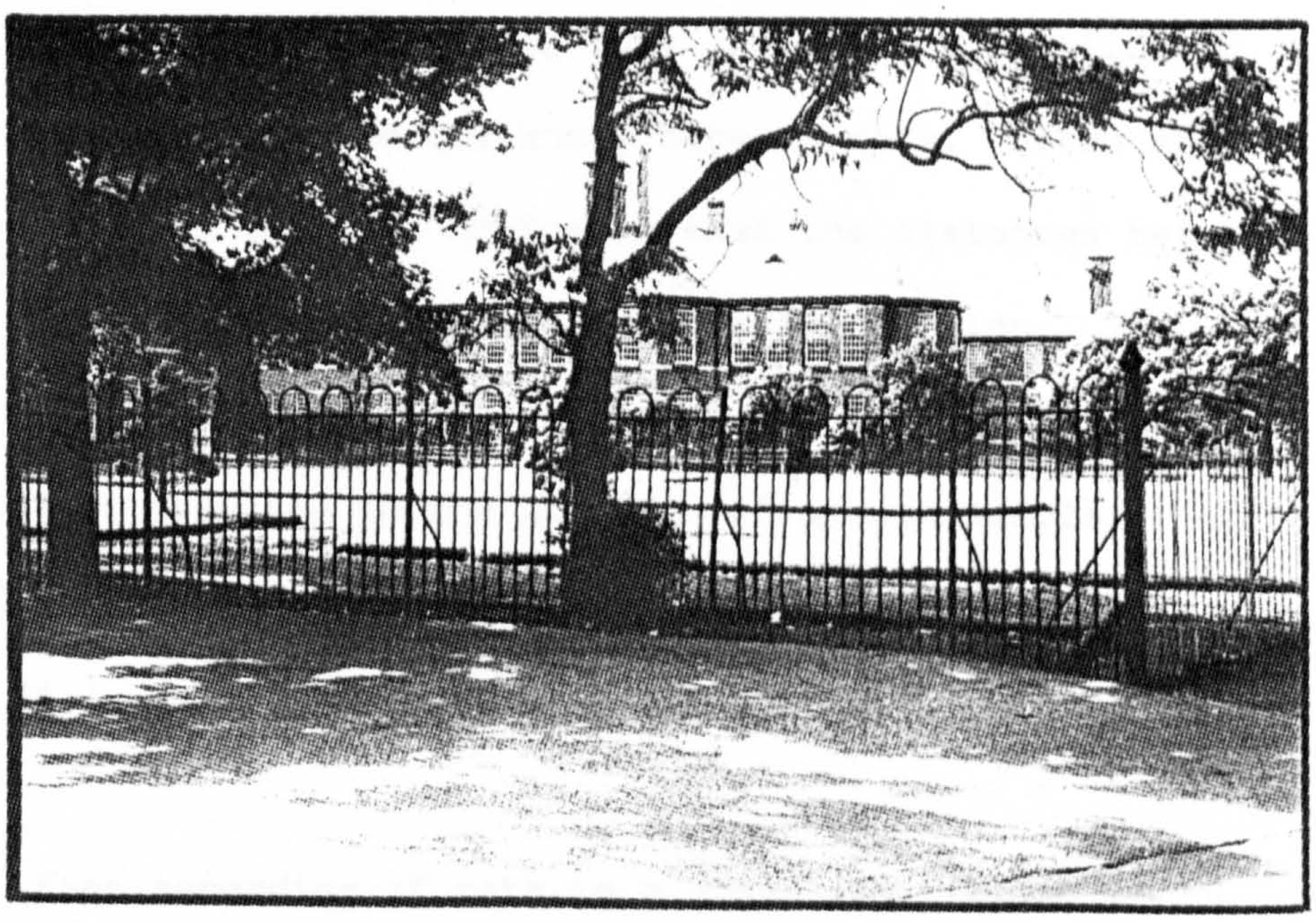


Plate 20. Zone AC. This is one of the fenced areas on the east side of the hospital. These areas were locked during the study so binoculars had to be used to search for cats.

(v) Any interesting behaviour observed e.g. suckling of kittens, aggression.

When cats could not be approached they were observed using 7 x 50 binoculars. This was necessary in zones S and AC because these were areas of garden surrounded by locked iron railing. (Plate 20.).

In many cases more than one cat was seen in a particular zone at a particular time. Initially attempts were made to distinguish degrees of association between cats seen together, on the basis of the distance between the cats when the recording was made. This proved impossible in large groups because of the large number of pairs of associations between cats which had to be recorded. Also in heavily vegetated zones many cats could remain hidden until disturbed and this disturbance invalidated any recordings made of the distances between cats. Often some members of a group would be moving so that the distances between them and other group members was continually changing. The problems caused by group size, movement and the complex nature of the habitat resulted in the adoption of a much simpler method of studying associations between cats in the colony (Chapter 11.).

Each recording of cats in a group was considered to be instantaneous. In a small, open zone (e.g. zone B) the cats present could easily be identified. However, in heavily vegetated zones (e.g. zone D) many cats could be present together but it might take several minutes to find and identify them all. This process often caused considerable disturbance of the group, and frequently the individuals would disperse so that although the cats were clearly present together in a small area they could not actually be seen as a group. So, while many of the recordings of groups of cats were made over a period of several minutes they were considered to be instantaneous for the purposes of recording associations. The instantaneous recording only of the cats visible in a heavily vegetated zone (e.g. zones C or E3) would have excluded concealed cats, and would have produced inaccurate recordings of associations (Plates 21 and 22). In general, cats were considered to form a group if they could reasonably have been expected to be aware of each others presence at the time the recording was made.

On each visit to the colony a cat was recorded twice only if it was seen at least five minutes after the first sighting and in a different zone, or if it was seen at least fifteen minutes after the first sighting in the same zone. If a cat was seen for a second time in the same zone less than fifteen minutes after the first sighting a recording was made only if the composition of the group in that zone had changed. This avoided overlooking important associations which in some cases may have been rare. When a cat moved into a zone other than that in which it was originally recorded as a result of

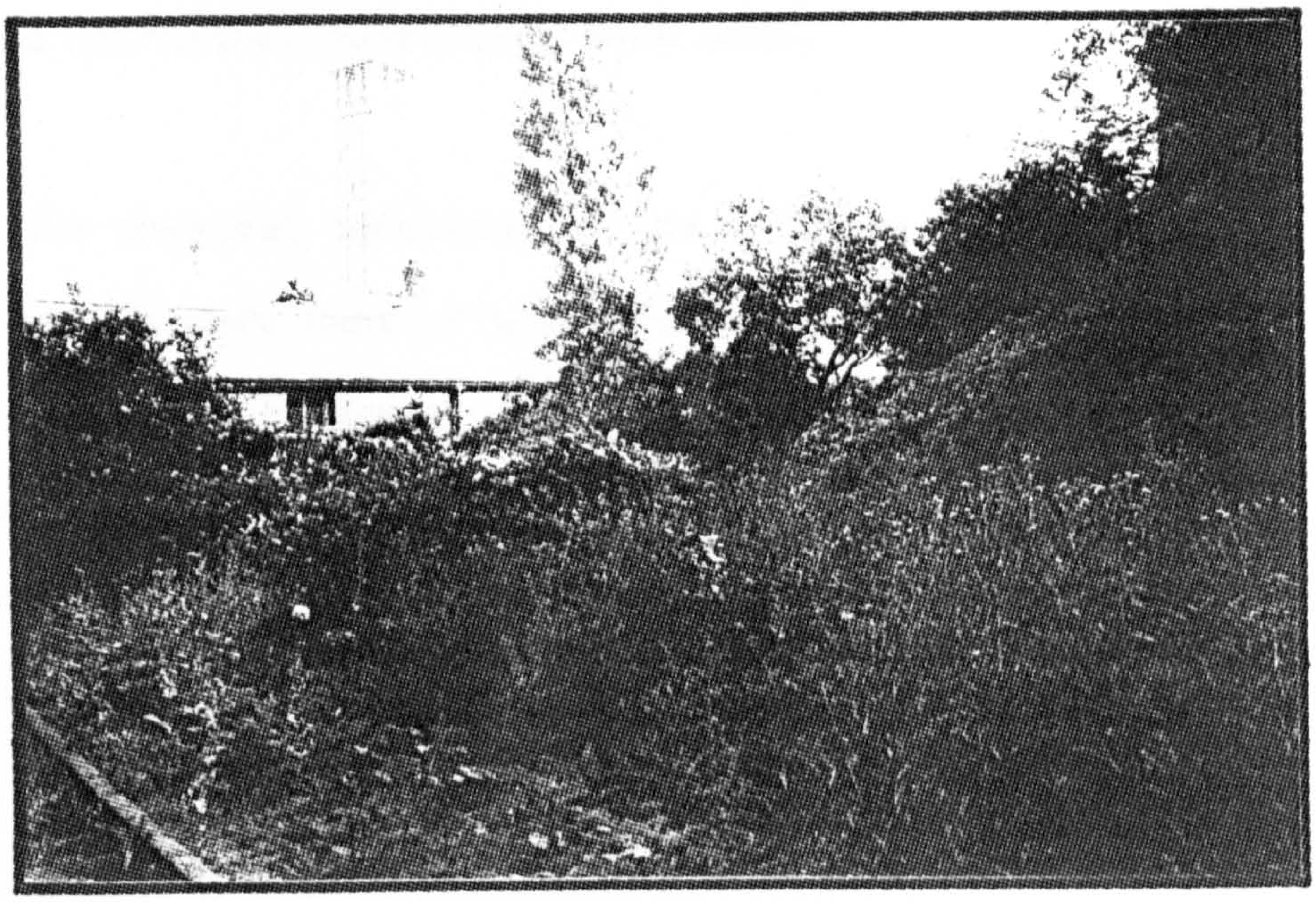


Plate 21. Zone C in summer. This was one of the most heavily vegetated zones and cats were difficult to locate here. Female 17f appeared to be the only cat which frequently utilised this zone.

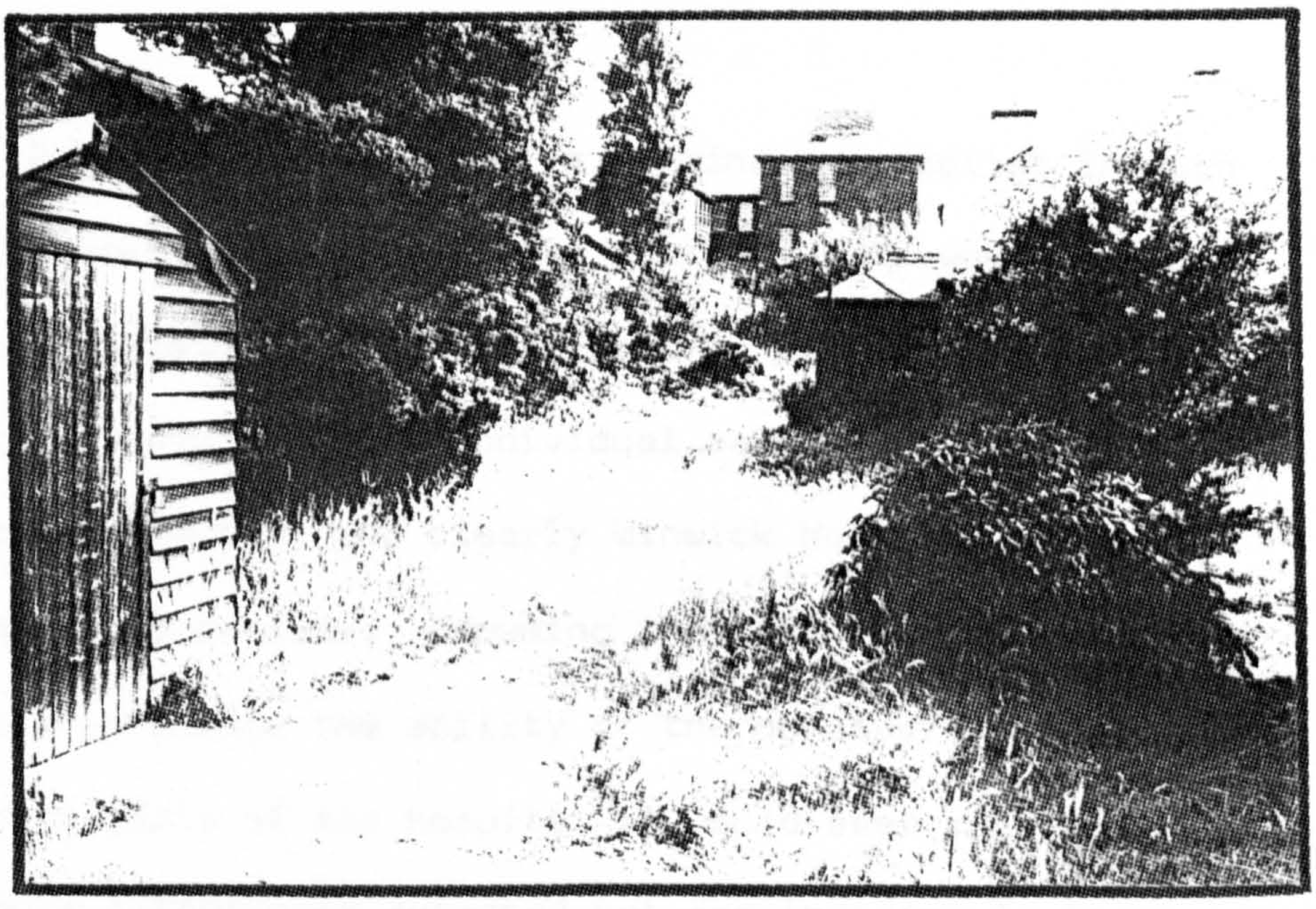


Plate 22. Zone E3 in summer. Access to this area was difficult during summer when vegetation blocked the paths. This zone was often used by cats from group D.

disturbance no further recordings were made.

The physical condition of the cats was difficult to assess. Records were kept of any obvious signs of damage or disease, such as bite marks, limps, or symptoms of feline influenza. Many of the conditions recorded were of a minor or temporary nature. Kittens were often diseased and records of their condition assisted in determining the cause and time of death.

The zones into which the habitat was divided were visited in the same order on each visit. Heavily vegetated zones and zones where cats were able to hide inside buildings were visited twice due to the possibility of overlooking concealed cats, for example in zones A and D.

Every effort was made to examine the habitat in such a way as to make it equally likely that all cats would be found on each visit assuming that there were no differences in the behaviour or ecology of the individual cats. This assumes a homogeneous environment and clearly Winwick Hospital is heterogeneous and complex. Assuming that the environment does not greatly influence the ability of the observer to find cats in different parts of the hospital it would seem reasonable to attribute differences detected between individuals in any year to differences in their behaviour and ecology. Differences in any individual before and after neutering may be attributed to neutering if no other explanation could be found.

The east side of the hospital was thought not to be utilised by any cats in the colony until October 1978 (year 1) when cats were first observed here. Unfortunately this led to an underestimate of the colony size before October 1978, as the animals found on the east side of the hospital were undoubtedly present from the beginning of the study.

Each visit to the colony was for a period of between one and two hours. This depended upon the amount of time taken to visit all of the zones, and varied with the weather conditions and the number of animals observed. For example, when the ground was covered with ice or snow, or when it was necessary to shelter from heavy rain, the visit took longer. If few animals were seen it was possible for the observer to walk almost continuously. However, if many animals were seen it was necessary to stop to identify the animals and record their activity. This was particularly time consuming when kittens were present.

It was important that each visit was of approximately the same duration so that recordings made on different days were comparable. Visits were made on any day of the week.

The number of visits which began in each hour of the day is shown in Fig. 5.8. Most visits were made between 08.00 hrs. and 18.00 hrs., with one visit beginning between 18.00 hrs. and

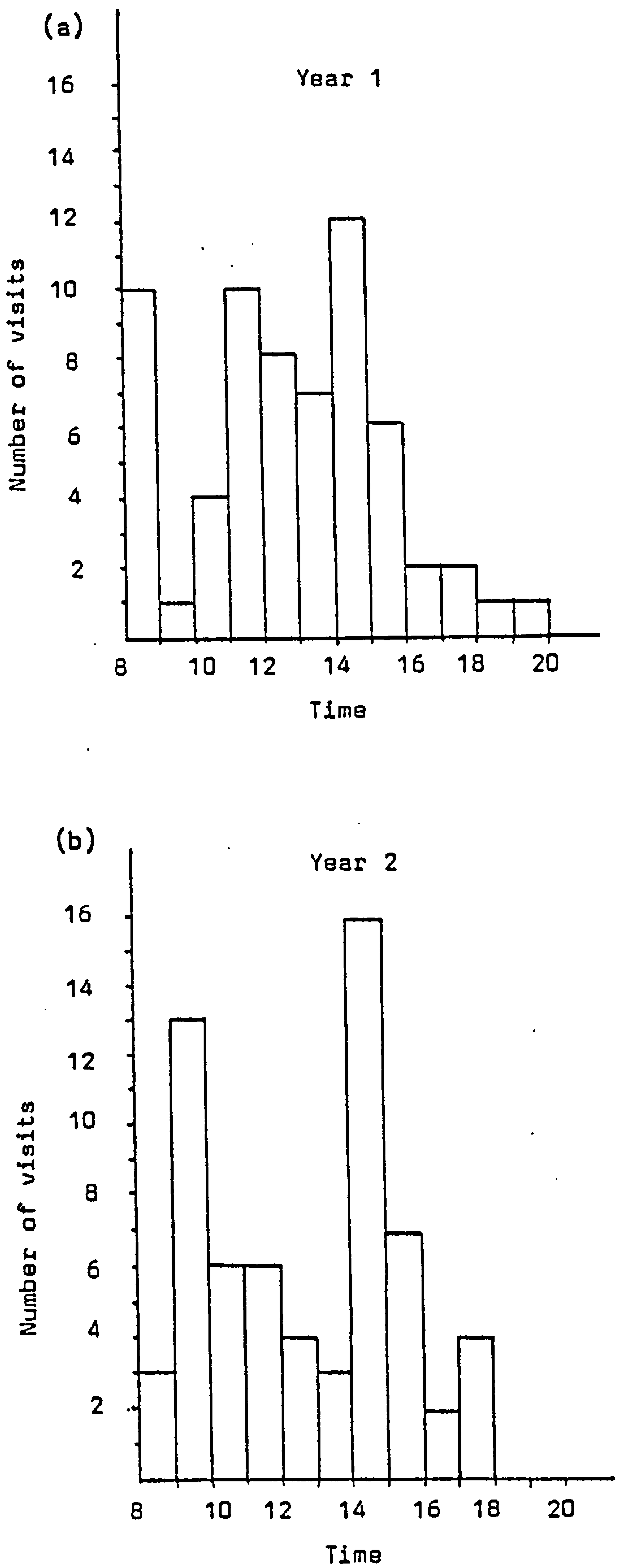



Fig.5.8. Times at which visits were made to Winwick Hospital in year 1 (a) and year 2 (b). Columns represent the number of visits which began in each hour.

19.00 hrs., and another between 19.00 hrs. and 20.00 hrs., in year 1. Visits were confined to the daylight hours because it was impossible to identify most of the cats in the dark due to the poor illumination of the hospital grounds.

Occasionally extended visits, of several hours, were made to the colony to record all the animals present. Searches were made for cats which had not been seen on earlier visits. Often these longer visits were extended into the late evening in order to find cats which were rarely seen during the day. The information collected at these times was not included in the analysis which follows.

It was not practicable to keep the number of visits at different times of the day equal for any year, or constant between years. At the beginning of this study of the Winwick Hospital colony many other colonies were also under study and a visit to Winwick may have been only one of four or five visits made in a single day. The geographical location of the colonies required the visits to be made in approximately the same order each time. Visits to Winwick at this time tended to be either at the beginning or the end of the day. Also, during year 1 the north - west of England experienced a particularly long and severe winter and the colony had to be visited whenever the weather permitted, regardless of the time of day.

The dates of the visits made to the colony are listed in Table 5.2. It was not possible to keep the number of visits

Table 5.2.

Dates of visits to Winwick Hospital.

| Preliminary visits | Visit | Year 1 | Year 2 | Post-study visits |
|---|---|---|---|---|
| 23.03.78 | 1 | 4.07.78 | 16.07.79 | 4.07.80 |
| 31. | 2 | 10. | 20. | 15. |
| 17.04. | 3 | 11. | 22. | 24. |
| 28. | 4 | 17. | 24. | 31. |
| 3.05. | 5 | 24. | 29. | 16.08. |
| 11. | 6 | 1.08. | 3.08. | 17. |
| 17. | 7 | 10. | 10. | 23. |
| 19. | 8 | 11. | 11. | 2.09. |
| 26. | 9 | 18. | 19. | 9. |
| 30. | 10 | 25. | 30. | 13. |
| 6.06. | 11 | 1.09. | 6.09. | 5.10. |
| 8. | 12 | 18. | 10. | 9. |
| 20. | 13 | 23. | 15. | 25. |
| 26. | 14 | 4.10. | 18. | 16.11. |
| 30. | 15 | 18. | 30. | 29.01.81 |
| | 16 | 21. | 8.10. | |
| | 17 | 27. | 11. | |
| | 18 | 31. | 15. | |
| | 19 | 7.11. | 19. | |
| | 20 | 16. | 23. | |
| | 21 | 21. | 24. | |
| | 22 | 28. | 2.11. | |
| | 23 | 12.12 | 9. | |
| | 24 | 22. | 13. | |
| | 25 | 29. | 16. | |
| | 26 | 13.01.79 | 20. | |
| | 27 | 18. | 22. | |
| | 28 | 23. | 25. | |
| | 29 | 25. | 6.12. | |
| | 30 | 30. | 14. | |
| | 31 | 6.02. | 21. | |
| | 32 | 13. | 31. | |
| | 33 | 21. | 1.01.80 | |
| | 34 | 23. | 7. | |
| | 35 | 24. | 12. | |
| | 36 | 25. | 25. | |
| | 37 | 27. | 5.02 | |
| | 38 | 1.03. | 15. | |
| | 39 | 4. | 23. | |
| | 40 | 6. | 27. | |
| | 41 | 10. | 7.03. | |
| | 42 | 13. | 14. | |
| | 43 | 19. | 15. | |
| | 44 | 20. | 29. | |
| | 45 | 21. | 2.04. | |
| | 46 | 23. | 13. | |
| | 47 | 25. | 18. | |
| | 48 | 29. | 24. | |
| | 49 | 1.04. | 30. | |
| | 50 | 4. | 10.05. | |
| | 51 | 7. | 12. | |
| | 52 | 13. | 15. | |
| | 53 | 18. | 18. | |
| | 54 | 20. | 28. | |
| | 55 | 25. | 29. | |
| | 56 | 2.05. | 30. | |
| | 57 | 24. | 4.06. | |
| | 58 | 1.06. | 6. | |
| | 59 | 4. | 7. | |
| | 60 | 8. | 19. | |
| | 61 | 10. | 20. | |
| | 62 | 14. | 23. | |
| | 63 | 19. | 25. | |
| | 64 | 22. | 27. | |

Trapping operation

1.07.79 to 13.07.79 inc.

equal for each month, initially due to other fieldwork commitments (as described above), and also because of seasonal variations in the weather. Cats were less likely to be seen during periods of very severe weather such as very low temperatures, snow, or heavy rain. Nevertheless sometimes visits had to be made in such conditions, especially during year 1, when they persisted for periods of many weeks, in order to avoid exceptionally long intervals between consecutive visits. The mean number of days between visits in year 1 was 5.29 ($\underline{s}$ = 3.54) and 5.51 ($\underline{s}$ = 3.54) in year 2. Some visits were made on consecutive days in both years of the study. The maximum number of days between consecutive visits was 17 in year 1 and 14 in year 2.

Information collected which was relevant to the biology of each individual cat was transcribed from field notes to the record files of the cats. Apart from details of distinguishing features and sex, these files were used to record place of birth, births of kittens (for females), genealogy and physical condition.

At the end of each visit the cats observed in the colony were recorded on a Calendar of Sightings similar to the Calendar of Catches first described by Petrusewicz & Andrzejewski (1962) as a means of summarising the results of a trapping survey of a small mammal population. A separate Calendar of Sightings was kept for each year of the study so that the dynamics of the colony could be compared. In addition Calendars of Sightings were kept of the cats recorded in zone A and in zone D. These zones contained most of the easily observed cats in the colony.

In the early stages of the study records of the zones in which a cat was seen and the cats with which it was associating on each occasion were kept within the individual cat's file.

This system was abandoned because it was error prone and time consuming due to the large amount of transcription necessary. For example if a group of five cats was seen this required four entries to be made in five record sheets, (20 in all). If ten cats were seen together, this required a total of 90 cat numbers to be transcribed. A simpler system was adopted recording all sightings in the following form:

| Visit Number | Time | Zone | Total No. of cats. | Individual Cat Numbers |
|---|---|---|---|---|
| 127, | 11.45, | A, | 3, | 14, 19, 53. |

These data were then analysed on the D.E.C., P.D.P. 8/1 computer in the Computer Unit of Stockport College of Technology. For the purposes of the computer analysis the visits to the colony in year 1 were numbered 1 to 64, and in year 2 from 65 to 128 consecutively. Elsewhere, visits in both years may be numbered 1 to 64, for convenience.

# 6. POPULATION DYNAMICS

## 6.1. INTRODUCTION

Few studies have been made of the dynamics of feral cat populations. Dards (1979) has recently examined the population ecology of feral cats living in Portsmouth dockyard. This is the only available detailed study of feral cats in an urban environment and it is particularly interesting as the population has been in existence for a very long period of time and appears to have stabilised at around 200 adults.

The other studies available are of island populations ( Derenne, 1976; Jones, 1977; van Aarde, 1978 ) which originated from small numbers of introduced cats and were still growing when examined.

This study is concerned particularly with the effect of neutering on the dynamics of a feral cat colony. In order to examine the effect of neutering it is first necessary to determine the nature of the dynamics of the colony before the animals were neutered.

## 6.2. METHODS

The methods used to collect the data presented here have been described in Chapter 5. Data on population numbers are based on a Calendar of Sightings kept for each year of the study and separately for zones A and D. The Calendars of Sightings kept for the whole population included adults and kittens, but those kept for zones A and D showed the presence of adults only.

For the purposes of determining the total number of cats present on each visit during the study a cat was considered to be present in the colony continuously from the date on which it was first sighted to the last occasion on which it was seen. A number of cats, mostly males, appeared to spend a considerable amount of time outside the colony. Temporary movements of animals out of the colony could have been taken into account by excluding these cats from the total considered to be present when they appeared to be absent for an extended period. However, this would not have taken into account the possibility of such cats being present in the colony on days when recordings were not made.

Kittens were treated in the same way as adults and only considered to be present from the date on which they were first seen. No attempt was made to include kittens in the population totals from the time when they were born (unless this was known with certainty ). This would have required the accurate determination of the age of the kittens and it was generally only possible to estimate the month of birth. Kittens were included in the adult classes from the beginning of the month after the month in which they became six months old. Kittens found dead were excluded from the total kitten population unless they had previously been seen alive.

The mean sizes of the adult male, adult female, kitten and total populations have not been calculated as these values would have been biased towards those times of the year when most visits were made to the colony. Instead a simple measure of average has been used, the mid-range value (M.R.V.), which is the mean of the upper and lower limits of the range calculated as

$$\text{M. R. V.} = \frac{U + L}{2} \qquad (6.1.)$$

where U and L are the upper and lower limits of the range respectively. The deviation of values from this mid-range value is expressed as the difference between the M.R.V. and the limits of the range calculated as a percentage of the M.R.V.

$$\text{Deviation} = \frac{U - \text{M. R. V.}}{\text{M. R. V.}} \times 100 \qquad (6.2.)$$

## 6.3. INITIAL IDENTIFICATION OF CATS

During the 15 preliminary visits made to the colony between March and June 1978, 24 adult cats were identified. Two of these cats disappeared before the beginning of year 1 and were not seen again. Most of the cats resident in the colony were discovered by the end of this period of preliminary visits (see Fig. 6.1.).

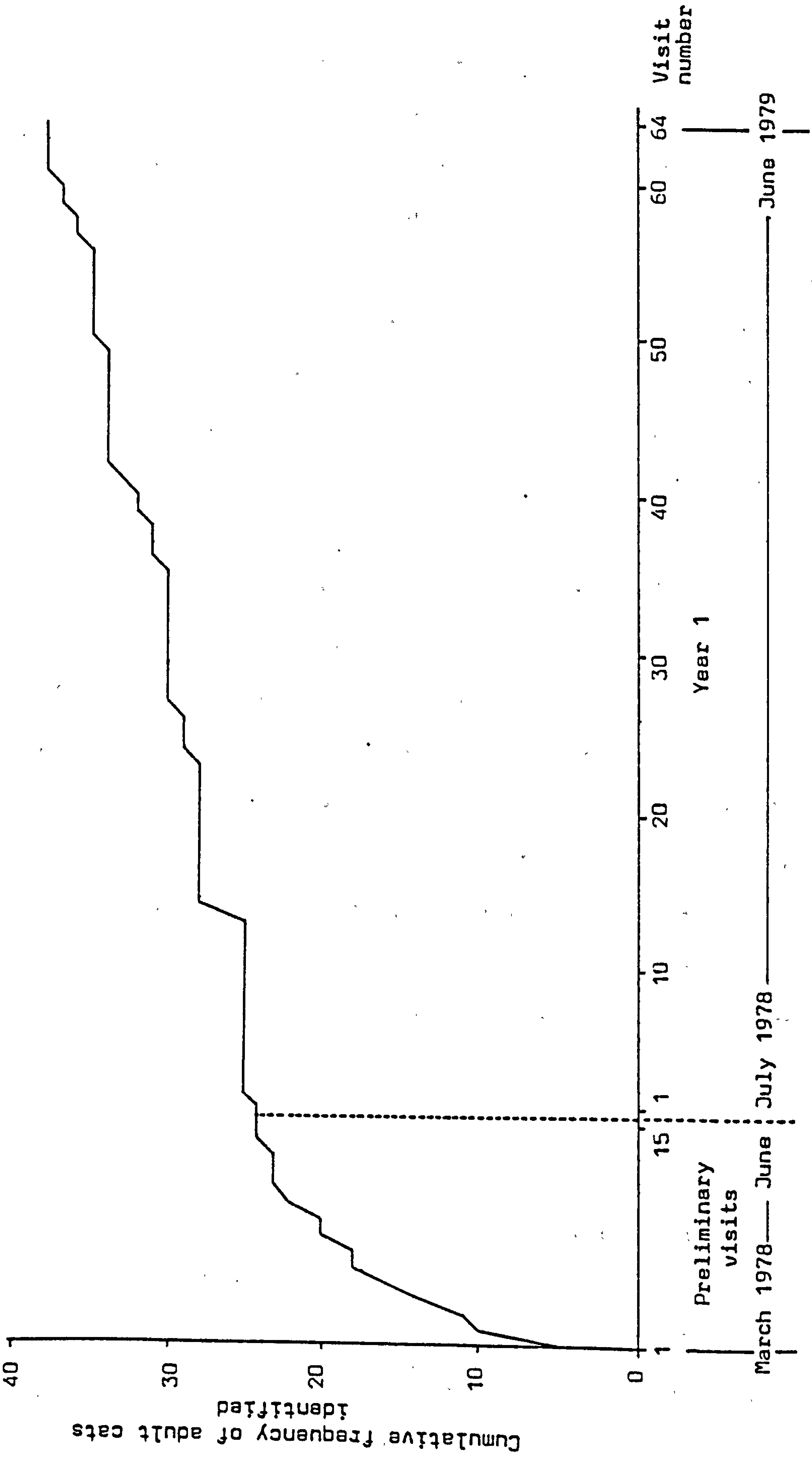



Fig.6.1. Cumulative frequency of cats identified during the preliminary visits and year 1.

However, three cats (50m, 51f and 54f) were first seen on visit 14 but were undoubtedly present from the beginning of the study. These cats were inhabiting the east side of the hospital which was previously thought not to be utilised by cats. The individuals identified thereafter were immigrants and possibly cats which lived in inaccessible areas of the hospital and were rarely seen. By the end of year 1, 38 adult cats had been identified in the colony (excluding individuals which were born during the study).

The rate of discovery of new cats was high at the beginning of the study with an average of 1.6 new cats discovered per visit during the preliminary visits. Ideally year 1 should have commenced when new cats were no longer being discovered. This was not possible because adult cats were still appearing in the colony after the end of year 2. The decision to begin year 1 in July 1978 was taken partly because of the decrease in the rate of discovery of new cats after the end of June 1978 but also because time constraints made it necessary to begin year 1 as early as possible.

## 6.4. SELECTION OF STUDY CATS

All of the adult cats seen within the study area at Winwick Hospital in either the first or the second year of the study are listed in Table 6.1. together with the number of sightings of each cat. Cats which were seen during the preliminary visits to the colony but disappeared before the beginning of year 1 have been

Table 6.1.

Adult cats recorded within the study area and the number of times each cat was observed in each year. Pet cats (except 29m*) and individuals which did not reach the age of six months before death or disappearance have been excluded.

| | | Cat | Number of sightings Year 1 | Year 2 | |
|---|---|---|---|---|---|
| Males | a | 1 | 23 + | - | |
| | | 11 | 23 + | - | |
| | | 23* | 34 | 40 | |
| | | 24 | 19 + | - | |
| | | 25 | 7 + | - | |
| | | 27 | 52 | 14 | x |
| | | 28 | 55 | 93 | x |
| | | 29* | 44 | 14 | |
| | | 34 | 30 | 23 | x |
| | | 39 | 10 | 6 | |
| | | 44 | 40 | 89 | x |
| | | 50 | 20 | 44 | x |
| | | 52 | 18 | 33 | x |
| | | 53 | 27 | 100 | x |
| | | 60 | 8 + | - | |
| | | 63 | 3 | 6 | |
| | | 64 | 11 | - + | |
| | | 67 | 1 + | - | |
| | | 69 | 8 | 2 + | |
| | | 68 | 3 | 2 | |
| | | 97 | 1 | - + | |
| | b | 49 | 68 | 88 | x |
| | | 65* | 4 | 5 | |
| | | 68 | 9 | 48 | x |
| | c | 100 | - | 2 | |
| | | 101 | - | 2 | |
| | | 105 | - | 1 + | |
| | | 107 | - | 1 | |
| | | 117 | - | 7 | |
| Females | a | 7 | 1 + | - | |
| | | 8 | 21 + | - | |
| | | 9 | 78 | 5 | x |
| | | 10 | 76 | 104 | x |
| | | 13 | 26 + | - | |
| | | 14 | 41 | 75 | x |
| | | 16 | 22 + | - | |
| | | 17 | 48 | 20 | x |
| | | 19 | 76 | 78 | x |
| | | 25 | 22 + | - | |
| | | 32 | 2 | 3 | |
| | | 33 | 4 | 0 | |
| | | 51 | 5 | 28 | x |
| | | 54 | 11 | 5 + | |
| | | 86 | 1 | 5 | |
| | b | 21 | 46 | 60 | x |
| | | 38 | 2 | 2 | |
| | | 43 | 21 | 30 | x |
| | | 47 | 10 + | - | |
| | | 62 | 26 | 33 | x |
| | | 66 | 17 | 43 | x |
| | c | 114 | - | 1 + | |
| | | 118 | - | 5 | |
| | | 121 | - | 39 | |
| | | Total | 1074 | 1156 | |

Key

+ = died/disappeared

* = not neutered during study

x = selected for detailed study

a = adult from the beginning of study

b = born during Year 1

c = seen in Year 2 only

- = not recorded

excluded. Pet cats have also been excluded, with the exception of 29m* who spent a considerable amount of time living with the feral animals. Two other pet cats (one male and one female ) were recorded in year 1 , but neither of these was ever seen associating with the feral cats.

In year 1, 21 adult males and 15 adult females were recorded. In addition three male kittens and six female kittens entered the adult classes in this year. Approximately 31% of the adult cats observed in the colony in year 1 were no longer present in year 2, while 21% of the adults observed in year 2 were not present in year 1 . Furthermore, some cats were recorded frequently while others were rarely seen. As a result it was not possible to study the effect of neutering on all of the cats in the colony.

In July 1979 the cats present were trapped and the adults were neutered and released. Nine males and ten females were selected for detailed study (see Table 6.1.). Two males avoided capture and were therefore entire throughout the study (23m* and 65m* ). Male 29m*, a pet cat, had already been neutered before the beginning of year 1. These three cats proved useful as controls: they were examined for changes in their biology in year 2 in the knowledge that they had not undergone a neutering operation between the two study years. An asterisk appears after their respective identification numbers to indicate that they were not included in comparative studies made of the experimental population.

Most of the 19 cats selected for detailed study were chosen because they were regularly seen before and after being neutered. Male 68m was not seen frequently in year 1 because he was still a kitten for part of this period. Female 51f lived in an inaccessible area of the hospital in year 1 and was only seen on five occasions. Both of these cats were included in the study because they were recorded frequently in year 2. Female 9f was seen infrequently in year 2 but she was included because she was the most frequently recorded cat in year 1.

## 6.5. THE FATE OF CATS DURING THE TRAPPING OPERATION

The trapping of the cats at Winwick Hospital is discussed in detail in Chapter 12. However, the fate of the cats present in the colony during the trapping operation is considered here because the constitution of the population altered between the end of year 1 and the beginning of year 2 and this affected its dynamics in the second year (see Fig. 6.2.).

At the end of year 1 , 18 adult males, 15 adult females and eight kittens were known to be present in the colony. Immediately prior to trapping, a new adult male (107m) and an additional nine kittens were discovered. The discovery of these kittens was to be expected since kittens were being born at this time in the previous year (see Sections 6.8.1. and 6.8.2.).

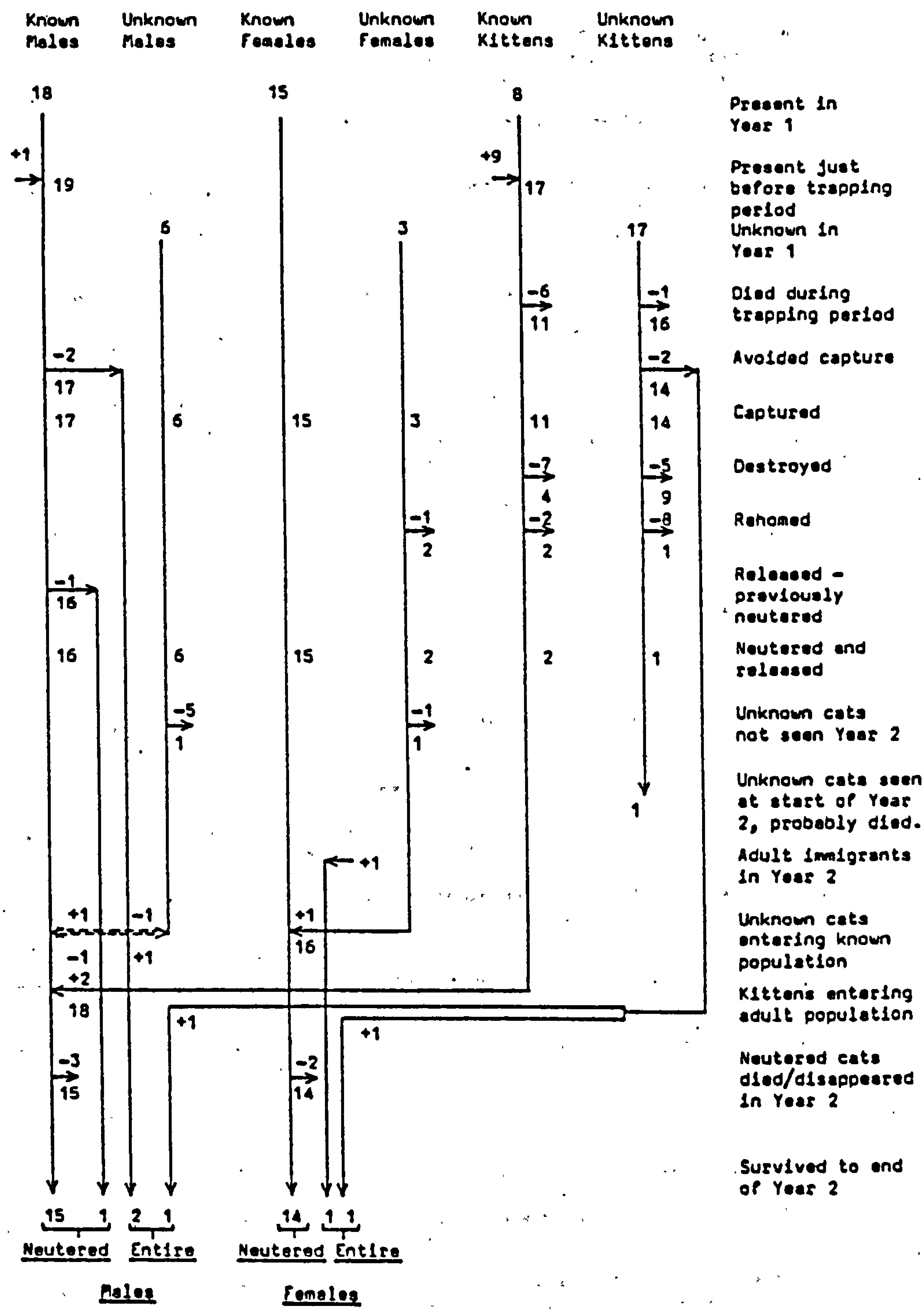



Fig. 6.2. Fate of cats during the trapping operation.

See notes on following page for explanation.

## Notes to Fig. 6.2.

The cats are divided into categories by sex and age (adult males, adult females, and kittens) and into 'known' and 'unknown' cats. Known cats are those which were identified in year 1. Unknown cats are those which were either absent in year 1 or present but not identified.

Gains and losses to each category of cats are indicated by an arrow accompanied by '+' or '-' respectively, and a number representing the number involved.

Solid horizontal lines indicate movements of cats between categories. One unknown male (105m) was recorded in the colony on only one occasion after being neutered. This temporary movement into the colony is indicated by a broken horizontal line.

<u>Present in year 1</u> Present and recorded in the colony at some time during year 1.

<u>Present just before trapping period</u> Not recorded in year 1 but recorded shortly before trapping commenced.

<u>Unknown in year 1</u> Not recorded in year 1. First seen during trapping operation.

<u>Died during trapping period</u> Kittens which probably died of natural causes during the trapping operation. No kittens died as a result of trapping. Includes kittens whose bodies were not found.

<u>Avoided capture</u> Cats which were present during the trapping operation but avoided capture and survived to the end of year 2.

<u>Captured</u> Cats captured alive. Excludes bodies of dead kittens.

<u>Destroyed</u> Sick kittens destroyed either at Winwick Hospital by Mr. Jackson or at the Liverpool Veterinary Hospital.

<u>Rehomed</u> Removed from Winwick Hospital during the trapping operation and rehomed.

<u>Released-previously neutered</u> Male 29* was found to be already neutered. He was released back into the colony.

<u>Neutered and released</u> Captured, neutered and released back into the colony.

<u>Unknown cats not seen in year 2</u> Cats which were captured, neutered and released but had not been recorded in the colony in year 1 and were not subsequently seen in year 2.

<u>Unknown cats seen at start of year 2, probably died</u> A single male kitten (117m) was returned to the colony neutered and was seen for only a short period in year 2. He had not been recorded in year 1.

<u>Adult immigrants in year 2</u> A female (121f) entered the colony in year 2. She had not been seen in year 1.

<u>Unknown cats entering the known population</u> One unknown female (114f) was recorded for the first time at the end of the trapping operation. She had probably been living in an area of the site which had not been examined in year 1 (zone AN). In year 2 this cat was recorded within the study area and was added to the population. An unknown male (105m) which had been captured and neutered was recorded in the colony on only one occasion in year 2. He was not a resident.

<u>Kittens entering adult population</u> Kittens which entered the adult class during year 2.

<u>Neutered cats died/ disappeared in year 2</u> Cats which were neutered and released and subsequently died or disappeared in year 2. This includes known adult cats only.

<u>Survived to end of year 2</u> All cats known to have survived to the end of year 2. This includes cats seen on the last day of the study (visit 143) or on any of the visits made in July 1980.

All of the adult males and females were captured and neutered with the exception of 23* and 65* which avoided capture, and 29* which was already neutered. Only two of the 17 kittens known to be present immediately before trapping commenced were healthy and old enough to be neutered and returned to the colony ( 100m and 101m ). Seventeen kittens which had not previously been seen were found in the colony. Only one (117m) was returned to the colony neutered. All of the other kittens were destroyed, re-homed or were found dead.

Six adult males and three adult females were captured which had not been seen in year 1. (All animals which had not been seen in year 1 or immediately before trapping commenced are referred to as 'unknown'.) One of the 'unknown' males (115m) was a pet from one of the hospital wards. He was neutered and returned, but not subsequently seen. The other five males ( 98m, 105m, 106m, 113m, and 119m ) were all captured either near the perimeter of the study area or just beyond (see Chapter 12 ). They were all considered to be temporary immigrants into the colony, possibly from the residential areas nearby. This hypothesis is supported by the fact that after neutering and release only one of these 'unknown' males (105m) was subsequently seen in the colony (see Section 6.7.2.).

One of the 'unknown' females (99f) was extremely tame. After neutering she was released in the zone where she had been captured but behaved as if she was unfamiliar with the area, sniffing, exploring and calling continuously. She was subsequently recaptured by hand and re-homed. Female 109f was found with a litter (included in the 'unknown' kittens referred to above ) outside the study area, but still within the hospital grounds. She was neutered and released but was not subsequently seen. It is likely that these two females were either abandoned in the hospital grounds because they had kittens (99f was lactating ) or they wandered into the colony to give birth. Staff at the hospital reported that in the past cats or kittens had been abandoned in the grounds. As the trapping operation was widely publicised within the hospital in advance people wishing to dispose of cats may have left them in the colony in the hope that they would be found. Some of the 'unknown' kittens captured were reported to have been dumped during the trapping operation.

Female 114f was first discovered during the trapping operation, living behind the Nurses' Home (zone AN ). This area had been visited only occasionally during year 1 because it was considered to be a private garden. The cat had clearly been living here throughout year 1, but had never been seen because she was extremely shy and the thick vegetation in zone AN provided a considerable amount of cover (see Plate 19 ). At this time 114f had two kittens (117m and 118f ). The mother was neutered and returned to zone AN, but the kittens could not be captured. During year 2 , 114f remained with her kittens in zone AN. Both kittens entered the adult classes in year 2 (entire). All three animals were only recorded as present in the colony when they appeared in zones other than AN for the purposes of examining their home ranges and associations. However, they were included in the total of animals present in the colony in year 2 for the purpose of calculating the population size.

At the beginning of year 2 the colony consisted of 46 cats: 22 neutered adult males (including five 'unknown' cats), 17 neutered adult females (including two 'unknown' cats), three neutered male kittens, two entire adult males, one entire male kitten and one entire female kitten.

## 6.6. DENSITY AND DISTRIBUTION

In year 1 the adult cat population of Winwick Hospital fluctuated around a mid-range value of 26.5 (20 - 33) and the total population around a mid-range value of 33.5 (26 - 41). In year 2 the adult population was more stable, at around 35 (33 - 37) with a total population of around 36.5 (35 - 38)(Table 6.2.).

The density of adult cats was high throughout the study (Table 6.3.). Density increased slightly from approximately 1.5 cats. $ha^{-1}$ (150 cats. $km^{-2}$) in year 1 to approximately 2 cats. $ha^{-1}$ (200 cats. $km^{-2}$) in year 2, and showed more variation in year 1 than in year 2. Similar changes were observed in the total number of cats recorded in the colony. These changes were a result of differences in the dynamics of the population in the two study years (see Section 6.7.)

Table 6.2.

Variation in the number of cats recorded in the colony.

| | Year 1 | | | Year 2 | | |
|---|---|---|---|---|---|---|
| | Mid-range value | Range | Deviation | Mid-range value | Range | Deviation |
| Males | 13.5 | 9 - 18 | ± 33.3% | 18.5 | 17 - 20 | ± 8.1% |
| Females | 12.5 | 10 - 15 | ± 20.0% | 17.0 | 16 - 18 | ± 5.9% |
| Kittens | 8.5 | 0 - 17 | ± 100.0% | 2.5 | 0 - 5 | ± 100.0% |
| Adults | 26.5 | 20 - 33 | ± 24.5% | 35.0 | 33 - 37 | ± 5.7% |
| Total | 33.5 | 26 - 41 | ± 22.4% | 36.5 | 35 - 38 | ± 4.1% |

Table 6.3.

Variation in the density of cats (cats. $ha^{-1}$).

| | Year 1 | | Year 2 | |
|---|---|---|---|---|
| | Mid-range value | Range | Mid-range value | Range |
| Adults | 1.56 | (1.18 - 1.94) | 2.06 | (1.94 - 2.18) |
| Total | 1.97 | (1.53 - 2.41) | 2.15 | (2.06 - 2.24) |

See equations 6.1 and 6.2 for the method of calculating mid-range value and deviation, respectively.

A total of 1074 sightings of adult cats were made in year 1 and 1156 in year 2 . The percentage of all sightings made in each zone during each three-month period of the study is shown in Table 6.4., together with similar figures for all of the sightings made in each year.

In the first three months of the study sightings were made in only 12 of the 57 zones in the study area. At this time the east side of the hospital was only rarely visited and the cats living here had not been identified. Subsequently between a third and a half of all sightings were made in zone D , while about a fifth of all sightings were made in zone A, in both years. Zones R and S were adjacent to each other and up to 15% of all sightings were made here. Most of the other zones were utilised little or not at all.

There was little difference in the distribution of sightings at different times of the year but some change was observed between years (Fig. 6.3.). Utilisation of zone A was lower in year 2 than year 1 because the number of cats living here decreased. There was an increase in the number of sightings made in zone R in year 2 because cats previously seen in the adjacent zones tended to congregate here when patients began providing food. Maintenance of the exterior of the buildings in year 1 on the east side of the hospital may have been responsible for the relatively few sightings made here at that time.

Table 6.4.

Percentage of all sightings made in each zone of the study area. Each three-month period of the study is shown separately and totals are shown for each year.

| | Period | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Zone | 7– 9.78 | 10–12.78 | 1– 3.79 | 4– 6.79 | 7– 9.79 | 10–12.79 | 1– 3.80 | 4– 6.80 | YEAR 1. | YEAR 2. |
| A | 47•84 | 18•48 | 25•24 | 21•51 | 19•93 | 23•83 | 24•59 | 25•36 | 29•43 | 23•55 |
| B | 10•30 | 0•54 | 1•92 | 3•23 | 1•07 | 0 | 1•09 | 1•20 | 4•36 | 0•86 |
| C | 9•63 | 23•91 | 0 | 0 | 0 | 0 | 0•55 | 3•59 | 6•78 | 1•38 |
| D | 20•60 | 37•50 | 52•08 | 47•67 | 49•11 | 49•82 | 39•89 | 38•76 | 39•65 | 44•09 |
| E1 | 1•00 | 1•09 | 0 | 0 | 1•07 | 0 | 0 | 0•48 | 0•46 | 0•43 |
| E2 | 1•66 | 1•09 | 0•64 | 0 | 0•36 | 0•36 | 0•55 | 0 | 0•84 | 0•26 |
| E3 | 0 | 1•09 | 2•24 | 1•43 | 1•07 | 3•61 | 1•64 | 3•83 | 1•21 | 2•76 |
| F | 1•00 | 0 | 0 | 1•79 | 1•78 | 0•36 | 0•55 | 0 | 0•74 | 0•60 |
| G | 0•66 | 0 | 0•64 | 2•51 | 0 | 0 | 0 | 1•20 | 1•02 | 0•43 |
| H2 | 1,00 | 2•17 | 0•96 | 1•79 | 1•07 | 1•44 | 1•64 | 1•20 | 1•39 | 1•29 |
| I | 0 | 0 | 0 | 0•36 | 0 | 0 | 0 | 0•48 | 0•09 | 0•17 |
| J | 1•33 | 0 | 0 | 0 | 0 | 0 | 0 | 0•72 | 0•37 | 0•26 |
| K | 3•99 | 2•72 | 0•32 | 0 | 0•36 | 0 | 0 | 1•44 | 1•67 | 0•60 |
| L | 0 | 2•72 | 0 | 0•36 | 0 | 0 | 0•55 | 0•24 | 0•56 | 0•17 |
| M | 0 | 0•54 | 0 | 0 | 0 | 0 | 1•09 | 0•24 | 0•09 | 0•26 |
| N | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0•24 | 0 | 0•09 |
| P | 0 | 0 | 0•32 | 0 | 0 | 0 | 0 | 0 | 0•09 | 0 |
| Q | 1•00 | 1•09 | 1•28 | 0•72 | 0•36 | 0•36 | 2•19 | 0•96 | 1•02 | 0•86 |
| R | 0 | 3•26 | 0•64 | 4•30 | 10•68 | 10•11 | 15•85 | 10•53 | 1•86 | 11•30 |
| S | 0 | 1•63 | 4•47 | 1•43 | 2•49 | 0•72 | 1•09 | 0 | 1•95 | 0•95 |
| T | 0 | 0•54 | 0 | 0 | 0 | 0 | 0 | 0 | 0•09 | 0 |
| U | 0 | 0•54 | 0•96 | 3•58 | 2•14 | 0 | 0 | 0•72 | 1•30 | 0•78 |
| V | 0 | 0 | 0•32 | 2•87 | 0•36 | 0 | 0 | 0 | 0•84 | 0•09 |
| W | 0 | 0 | 0•96 | 0•72 | 0•36 | 0•36 | 0 | 0 | 0•46 | 0•17 |
| X | 0 | 0 | 0 | 0•72 | 0 | 0 | 0 | 0 | 0•19 | 0 |
| Y | 0 | 0 | 0•64 | 1•43 | 1•42 | 0•72 | 0•55 | 0•48 | 0•56 | 0•78 |
| Z | 0 | 0 | 0•96 | 0•36 | 3•20 | 4•33 | 0 | 0•72 | 0•37 | 2•07 |
| AA | 0 | 0•54 | 0•32 | 0•72 | 0 | 0•36 | 0 | 0 | 0•37 | 0•09 |
| AB | 0 | 0 | 0•64 | 1•08 | 1•07 | 0 | 0 | 0•24 | 0•46 | 0•35 |
| AC | 0 | 0 | 0•96 | 0•36 | 0 | 0 | 0•55 | 0•24 | 0•37 | 0•17 |
| AD | 0 | 0•54 | 0•96 | 0•72 | 1•07 | 1•44 | 2•19 | 1•20 | 0•56 | 1•38 |
| AE | 0 | 0 | 0•64 | 0 | 0 | 0 | 0 | 0•48 | 0•19 | 0•17 |
| AF | 0 | 0 | 0 | 0•36 | 0 | 0•36 | 0 | 0 | 0•09 | 0•09 |
| AG1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| AG2 | 0 | 0 | 0 | 0 | 0•36 | 0 | 0 | 0 | 0 | 0•09 |
| AG3 | 0 | 0 | 0 | 0 | 0•36 | 0•72 | 0 | 0•24 | 0 | 0•35 |
| AH | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| AI | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| AJ | 0 | 0 | 0 | 0 | 0•36 | 0 | 2•19 | 2•39 | 0 | 1•29 |
| AK | 0 | 0 | 0•32 | 0 | 0 | 0 | 0 | 0 | 0•09 | 0 |
| AM | 0 | 0 | 0 | 0 | 0 | 1•08 | 1•09 | 2•63 | 0 | 1•38 |
| AP | 0 | 0 | 0•32 | 0 | 0 | 0 | 0 | 0•24 | 0•09 | 0•09 |
| AR | 0 | 0 | 0•32 | 0 | 0 | 0 | 0 | 0 | 0•09 | 0 |
| AS | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| AT | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| AU | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| AV | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| AW | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| AX | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| AY | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| AZ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| AQ | 0 | 0 | 0•32 | 0 | 0 | 0 | 0 | 0 | 0•09 | 0 |
| BA | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| BB | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| BC | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| BD | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| DJ | 0 | 0 | 0 | 0 | 0 | 0 | 0•55 | 0 | 0 | 0•09 |

Zone DJ has been added to the original 56 zones but AL and AN have not.

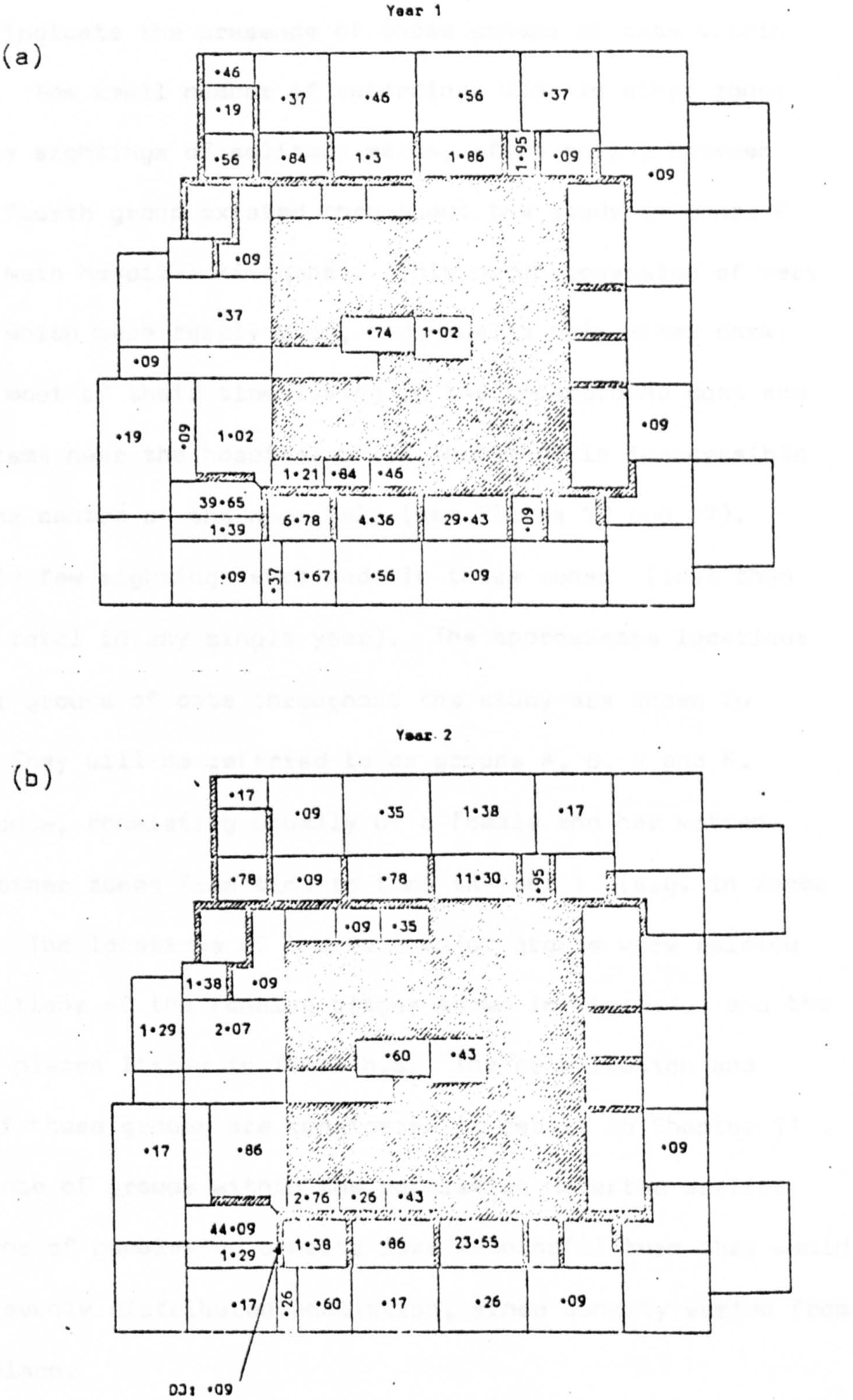



Fig. 6.3. Percentage of all sightings of all cats which was made in each zone in year 1 (a) and year 2 (b).

The concentration of sightings in zones A and D and R/S in both years indicate the presence of three groups of cats within the colony. The small number of recordings made in other zones were usually sightings of solitary males, often moving between groups. A fourth group existed throughout the study in zones F and G (the main hospital kitchens). This group consisted of very timid cats which were rarely seen, and usually only after dark. They spent most of their time living in the underground duct and subway systems near the hospital boiler house or in inaccessible areas in the centre of the hospital (see Plates 12 and 17). Consequently few sightings were made in these zones (less than 2% of the total in any single year). The approximate locations of the four groups of cats throughout the study are shown in Fig. 6.4. They will be referred to as groups A, D, R and F. Smaller groups, consisting usually of a female and her kittens formed in other zones from time to time in year 1 (e.g. in zones B and C ). The locations of the four major groups were related to the positions of the feeding places shown in Fig.5.4. and the sheltering places listed in Table 6.5. The constitution and dynamics of these groups are considered in detail in Chapter 11 . The existence of groups within the population makes the earlier calculations of population density less meaningful than they would be for an evenly distributed population, since density varied from place to place.

After being neutered each cat was released into the zone where it had been captured. The process of trapping and neutering

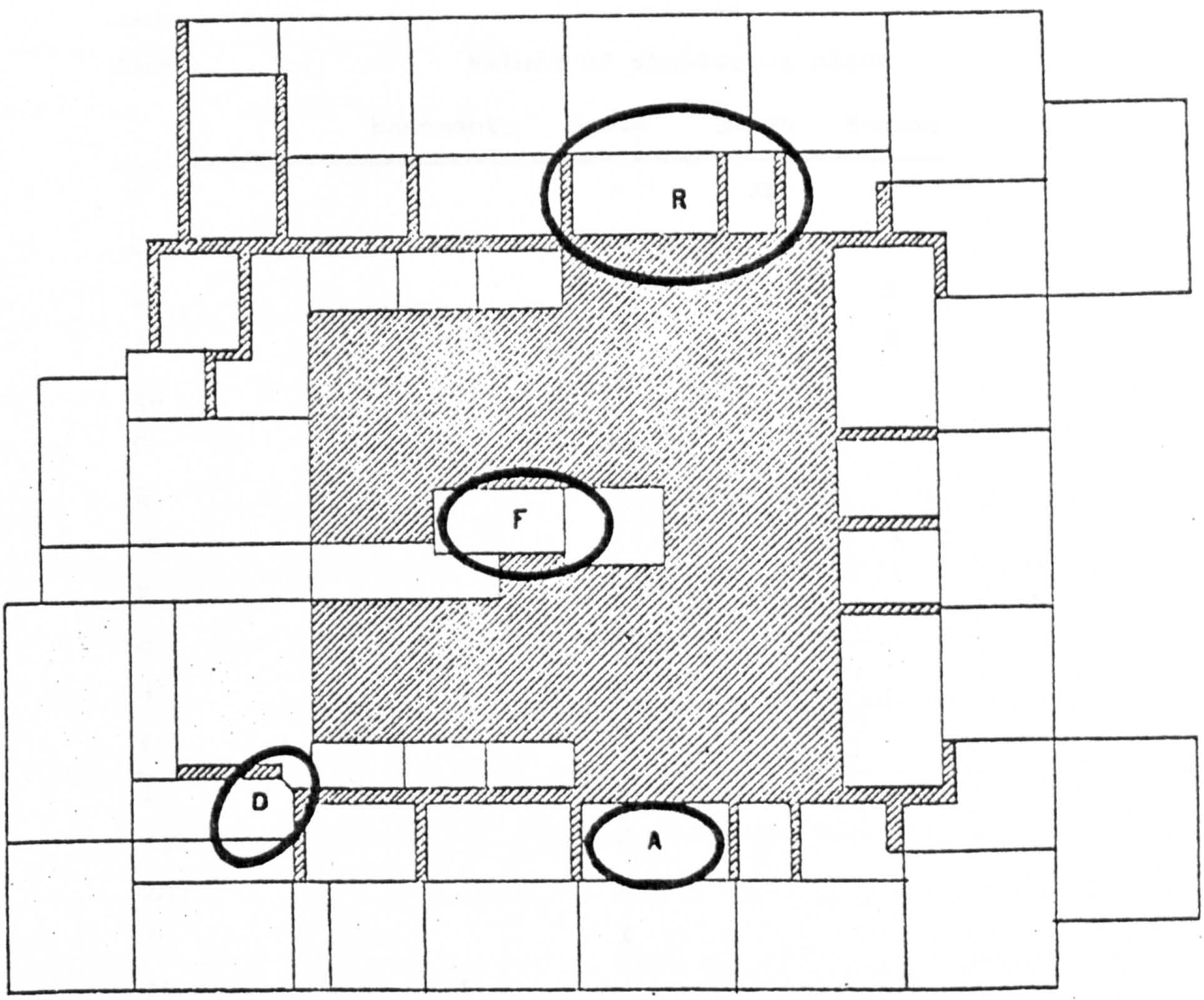



Fig.6.4. Diagrammatic representation of the location of the four major social groups of cats in the colony. The position of each ellipse indicates the main zones utilised by the cats. Details of these zones are presented in Fig.5.2.

Table 6.5.

The location and nature of major sheltering places used by cats in Winwick Hospital.

| Zone | Nature of sheltering place | | | |
|---|---|---|---|---|
| | Basements | Ducts | Sheds | Bushes |
| A | | | Xb | X |
| B | Xb | | | |
| C | | | | X |
| D | Xb | | | X |
| E3 | | X | | |
| F | X | Xb | | |
| G | X | | | |
| H2 | | | | X |
| R | | | X | |
| U | | X* | | |
| V | | X | | |
| Y | X | | | |
| Z | | X | | |
| AG1 | | X | | |
| AG3 | | X | | |
| AL | | X | | |
| AN | X | | | X |

X Indicates presence of a sheltering place.

b Indicates sheltering place used for breeding.

* Underground cavity covered by metal grid, probably no access to ducts or subways.

appears to have had no significant effect upon the distribution of sightings of cats within the study area. The small differences observed can be accounted for by changes in the number of animals and changes in the home range of individual cats (see Chapters 7 and 11 ). Periodic changes in the location of feeding sites and human disturbance may also have influenced the distribution of sightings within the study area.

## 6.7. CHANGES IN THE SIZE AND COMPOSITION OF THE POPULATION

### 6.7.1. Population changes in year 1

In the first year of the study the total number of cats in the colony varied between 26 and 41 individuals (see Fig. 6.5.). Kitten numbers were highest between July and September. Thereafter the kitten population declined due to mortality and also to maturation of animals, resulting in their removal from the kitten class and addition to the adult male or adult female class. Much of the variation in total and adult numbers in year 1 can be attributed to the dynamic nature of the kitten population. A number of adult cats disappeared in October 1978. (The possible reasons for these losses are discussed below). Throughout the year thereafter the number of males recorded in the colony gradually increased. This was probably due to some animals immigrating into the colony, especially in March 1979, and also the discovery of elusive animals which had previously been present in the colony but were difficult to find. Some males may have moved from inaccessible areas of the hospital to places where they were more likely to be

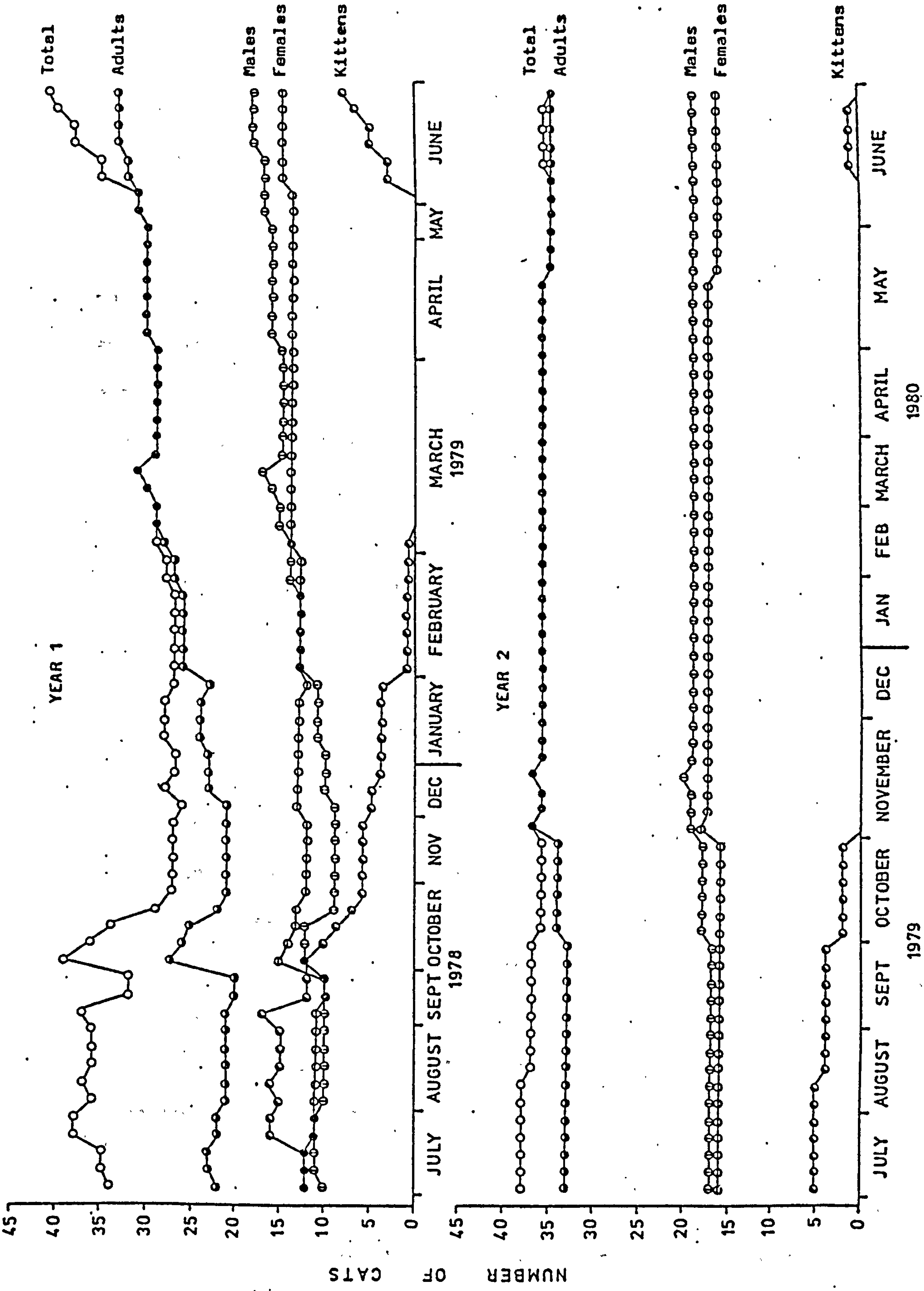



Fig. 6.5. The number of cats present at Winwick Hospital on each visit during the study.

seen. (The ranging behaviour of individual cats is discussed in Chapter 7 ). Changes which occurred in the adult population (with the exception of the maturation of kittens ) are indicated in Fig. 6.6.

The overall trend in the colony in year 1 was a tendency for the population to be relatively high between June and September and relatively low during the winter months. There appears to be a cyclic pattern in the total number of cats present, and a similar cycle of kitten numbers (Fig. 6.5.). Such cycles and the other population changes recorded may have occurred annually but since this study required that the cats be neutered it was not possible to study the unneutered colony for more than one complete year.

## 6.7.2. Population changes in year 2

In year 2, after most of the cats had been neutered, the total population remained remarkably stable in number. The kittens that were present at the beginning of this year moved into the adult classes by the end of July 1979, with the exception of one (117m) which disappeared in August 1979. (Two of the kittens included in this total were entire : 117m and 118f ). The number of adults remained very stable at about 35 animals.

In November 1979 one of the 'unknown' males captured during the trapping operation (105m ) was seen once on the edge of the

| Month | Visit Number | Year 1 Gains | Year 1 Losses | Year 2 Gains | Year 2 Losses | Month |
|---|---|---|---|---|---|---|
| July 1978 | 1 | | | | | July 1979 |
| | 2 | (44m) → | | | | |
| | 3 | | → 7f | | | |
| | 4 | | | | | |
| | 5 | | → 26m | | | |
| August | 6 | | | | | August |
| | 7 | | | | | |
| | 8 | | | | | |
| | 9 | | | | | |
| | 10 | | | | | |
| September | 11 | | → 25f | | | September |
| | 12 | | | | | |
| | 13 | | | | | |
| October | 14 | (51f 54f 50m) → | → 16f | | | |
| | 15 | | → 13f(d) | | → 69m(d) | |
| | 16 | | → 1m 11m 24m | | | October |
| | 17 | | → 8f | | | |
| | 18 | | | | | |
| November | 19 | | | | | |
| | 20 | | | | | |
| | 21 | | | | | |
| | 22 | | | 121f → | → 54f | November |
| December | 23 | | | | | |
| | 24 | (52m) → | | | | |
| | 25 | | | 105m(u) → | → 105m(u) | |
| | 26 | | | | | |
| January 1979 | 27 | 53m → | | | | |
| | 28 | | | | | |
| | 29 | | | | | December |
| | 30 | | | | | |
| | 31 | | | | | |
| February | 32 | | | | | |
| | 33 | | | | | January 1980 |
| | 34 | | | | | |
| | 35 | | | | | |
| | 36 | 60m → | | | | |
| | 37 | | | | | February |
| | 38 | | | | | |
| March | 39 | 63m → | | | | |
| | 40 | | | | | |
| | 41 | 64m → | | | | March |
| | 42 | 67m → | → 60m 67m | | | |
| | 43 | | | | | |
| | 44 | | | | | |
| | 45 | | | | | April |
| | 46 | | | | | |
| | 47 | | | | | |
| | 48 | | | | | |
| | 49 | | | | | |
| April | 50 | 69m → | | | | May |
| | 51 | | | | | |
| | 52 | | | | | |
| | 53 | | | | → 114f | |
| | 54 | | | | | |
| | 55 | | | | | |
| May | 56 | | | | | |
| | 57 | (88m) → | | | | June |
| June | 58 | | | | | |
| | 59 | (86f) → | | | | |
| | 60 | | | | | |
| | 61 | (97m) → | | | | |
| | 62 | | | | | |
| | 63 | | | | | |
| | 64 | | | | | |
| Between Year 1 and Year 2 | | (114f) → | → 64m 97m | | | |

( ) May have been present in the population earlier but was not identified.

(d) Found or reported dead.

(u) 'Unknown' cat, (ie captured during trapping operation but not seen previously).

Fig. 6.6. Changes which occurred in the adult population.

study area (zone W ) near where he had been captured, but was never seen again. In early November 1979 an entire female (121f) appeared in the colony. When she was first seen (visit 22, year 2 ) she was alone in zone Z and appeared to be less than six months old. Seven days later (visit 23) 121f was seen with the cats living in zone D and there she remained. She gave birth to at least one kitten (125 k ) in June 1980 (others were reported but not seen ). At the end of year 2, 121f was still present, but 125k could not be found. Female 121f may have been born in the colony before the colony females were neutered in July 1979 but this seems unlikely since she was quite tame when first seen and would probably have been recorded earlier if she had been present. It seems more probable that she either wandered into the hospital of her own volition or was abandoned.

A number of other cats were seen in year 2 that had not previously been recorded in the colony. In October 1979 a kitten ( 120k) was seen alone in zone G (the main hospital kitchens). It was probably four or five months old and was not subsequently seen. The kitten was being fed and was reported to be a pet. Two new adult cats were seen in the colony : one (122) in zone C in December 1979 and the other (124) in zone D in March 1980. Both were probably pet female cats (122 was seen outside a first floor ward window, and 124 wore a collar ). Each cat was only seen once.

A new adult male cat (123m) was seen near the hospital's incinerator (Plate 8) which is located away from the main buildings in the south-west of the grounds (and outside the study area). He was first seen in December 1979 and on a small number of subsequent occasions in the same place. A second adult male (126m) was also seen here on one occasion in July 1980, just after the end of year 2. Neither of these cats was ever recorded within the study area or associating with any of the colony cats. They may have been attracted by the presence of rats which were reported to inhabit the refuse dump adjacent to the incinerator. Cats may have been present here at other times during the study but the presence of thick vegetation in this area made it difficult to search and the area had not been examined in year 1.

In spite of the sightings of new cats made within the study area and at its periphery in year 2, at the end of the study period (July 1980) the only permanent addition to the population appeared to be 121f.

## 6.7.3. Cats recorded after the end of year 2

After the end of year 2 an adult male was seen in zone E2 (in August 1980) and in zone AG3 on another occasion. He was not seen associating with any other cats and did not appear to be living with any of the established groups. At the end of January 1981 a new adult cat was seen just outside the study area ( but within the hospital grounds ) to the north of zone AJ. The cat was too far away to sex, but it had distinctive coat markings and had definitely not previously been recorded.

In September 1980 the immigrant female 121f produced a second litter. None of the four kittens in this litter appeared to survive for more than a few weeks.

None of the cats observed within the study area after the end of year 2 were considered to be permanent residents. However, visits to the colony after July 1980 were infrequent and the status of these cats could not be determined with certainty.

### 6.7.4. Variation in the number of cats in the population

The variation in the numbers of cats in the colony in each year of the study is summarised in Table 6.2. Considerable variation was seen in all classes of cats in year 1 due to births, the maturation of kittens, mortality and migrations of cats. Less variation in numbers in all classes was apparent throughout year 2. This was undoubtedly due mostly to neutering, resulting in the absence of births (except 125k) and to a lesser extent reduced mortality and migration.

A comparison of the mid-range values of the number of males and females present in the colony indicates a sex ratio of adults of approximately 1 : 1 in both years (but slightly in favour of the males). The sex ratio was much more stable in year 2 than in year 1 (Fig. 6.5.).

Some of the adult cats identified late in year 1 may have been present from the beginning of the study (Section 6.3.). If this was the case then the changes in the variation in the numbers of adult cats and in the variation in the sex ratio discussed above would have been less marked.

## 6.8. PRODUCTIVITY IN YEAR 1

### 6.8.1. Kitten production in year 1

The visits on which new kittens were first observed in the colony between March 1978 and June 1979 are shown in Fig. 6.7. No new kittens were recorded between November 1978 and February 1979. It is possible to separate the breeding season from the reproductive season of the colony. By examining the appearance of new kittens in year 1 it should be possible to determine the time of conception if the age of the kittens is known, assuming a gestation period of 63 - 65 days (Kling *et al*, 1969). The exact age of kittens when first seen was not always known, but provided they were seen within the first few weeks of life the month of birth could usually be determined. The reproductive season appeared to be from April to September, and the breeding season from March to July or August. It is interesting that the predicted beginning of the breeding season corresponds with the time when five new males were identified in the colony (Fig. 6.6.)

One female, 13f, had a litter in May 1978 and another in September 1978. A total of at least seven kittens was produced in less than four months. The first litter survived for a few months and then disappeared. The three kittens in the second litter were


Fig.6.7. Times of appearance of kittens in the colony during the preliminary visits and year 1. Each dot represents a single kitten. Columns of dots indicate kittens in the same litter. The identification number of the mother is shown where known.

born on visit 11 in an exposed area and were not subsequently seen. The trapping operation interupted the reproductive season in June 1979 but it was nevertheless clear that at least four females ( 17f, 19f, 25f and 54f ) reproduced successfully in both calendar years and in addition two females (9f and 10f) which had kittens in 1978 were pregnant when captured (17f was captured with a kitten which had not been seen by the end of year 1 ). Females 8f, 13f, 14f and 16f were no longer present in the colony in 1979. Many other females were almost certainly reproducing regularly each year but time constraints and the fact that the mothers of some kittens could not be determined made it impossible to confirm this.

The litters observed contained between one and four kittens. The average size of litters has not been calculated because some kittens may have been missed. Many complete litters may have escaped detection especially if all the kittens died at a very early age. This problem was also encountered by Dards (1979). A number of litters were trapped underground in July 1979 and it is likely that many kittens which were born and died in the underground duct and basement systems of the hospital in year 1 were not detected.

The first litter of 54f (visit 14, October 1978) was of three kittens all of which survived to maturity and were present at the end of year 2. It is interesting that this litter was born on the east side of the hospital where no other litters were found during the study ( except 54f's second litter ) and where the density of adult cats was low. Most of the kittens discovered were on the west side where the adult density was much higher. Kitten mortality here was very high and no complete litter survived.

## 6.8.2. Reproductive status of captured adult females

Veterinary examination of the cats at Winwick Hospital during the trapping operation and observations of kittens revealed that approximately 87% of females had either given birth or were pregnant when captured (89% if the three 'unknown' females were included ). Females 43f and 86f did not appear to have reproduced and were not pregnant when captured. They might have become pregnant later in the year if they had not been neutered. However, 43f was born during the study and may not have reached breeding age. Female 86f was adult throughout the study but had never been observed to reproduce and may have been infertile.

Females 17f and 19f were both three weeks pregnant when captured and also had young kittens. They were not lactating and presumably their kittens were weaned. Female 19f's kittens had only been first seen in the previous month. The 'unknown' female 109f was not lactating when captured but was found with kittens and was four weeks pregnant. The reproductive status of each of the captured females is indicated in Fig. 6.8.

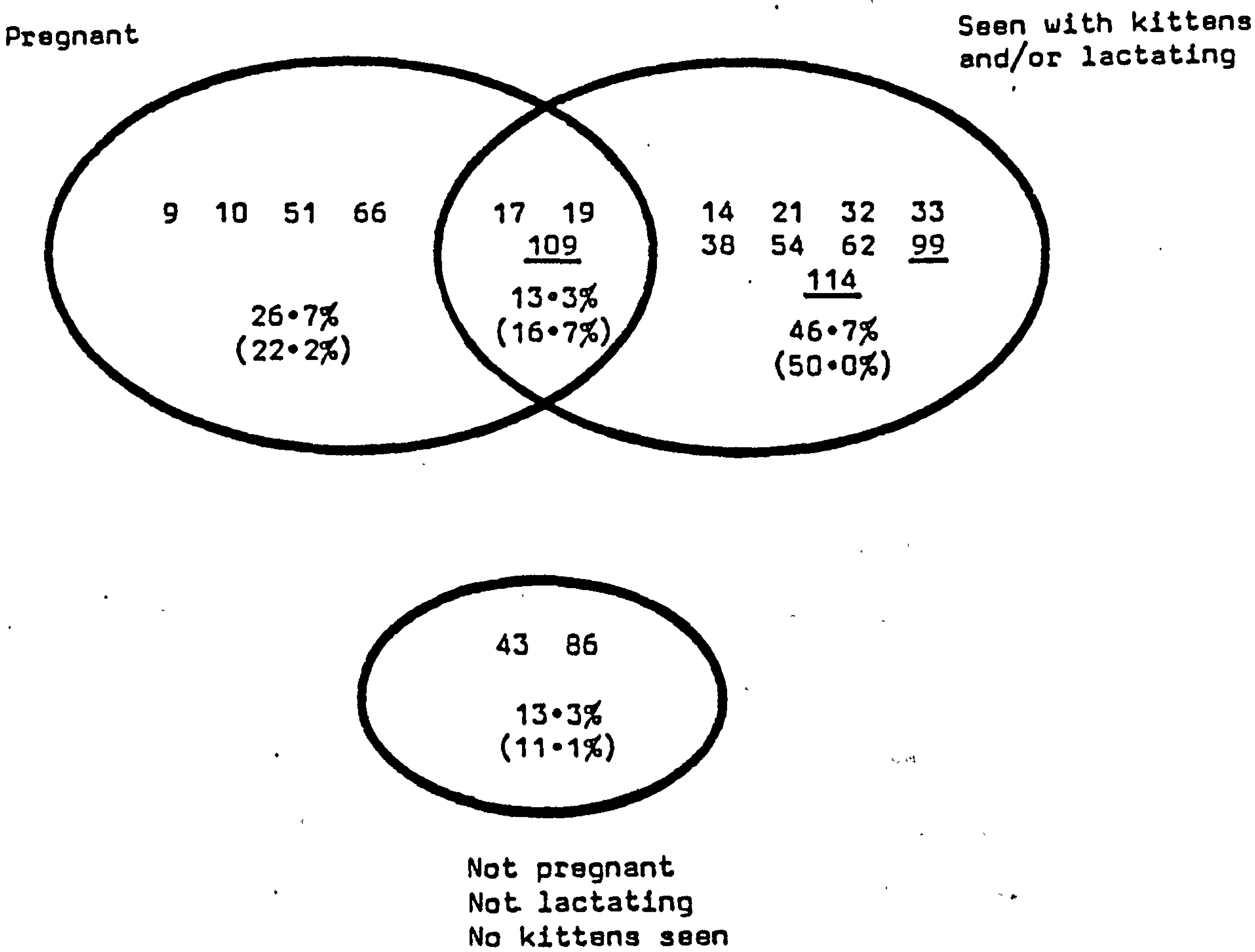



Fig.6.8. Reproductive status of adult female cats captured at Winwick Hospital. Identification numbers of unknown cats are underlined. Percentages of the total in each category are given excluding (without parentheses) and including (with parentheses) unknown cats.

The high proportion of females which had either given birth before or were pregnant during the trapping operation, and the short time between successive pregnancies in some females suggests that the observed productivity in year 1 was considerably below the actual productivity.

## 6.9. MORTALITY AND DISAPPEARANCE

### 6.9.1. Kitten mortality and disappearance in year 1

Forty-one kittens were seen in the colony between the beginning of the period of preliminary study in March 1978 and the end of year 1, in June 1979. The survival of kittens born late in year 1 could not be examined because most were removed during the trapping operation (see Chapter 12 and Fig. 6.2.). However, it was possible to consider the survival of the kittens seen in the first 12 months of the study, including the preliminary study period, since during this period no attempt was made to interfere with the population. Between March 1978 and February 1979, 31 kittens were seen. Only eight (25.8%) survived to the end of their first year, so the apparent mortality rate during this period was 74.2% . But many kittens must have been born which were not seen before they died because the mother kept them hidden.

There is considerable evidence available from the data collected during the trapping operation for a much higher productivity among females than was apparent from direct observation. It is likely that both the production of kittens and the mortality rate were considerably higher than suggested here. A total of 34 kittens were present in the colony during the trapping operation, but only eight (23.5%) of these had been definitely identified before the end of year 1, and only 17 (50%) kittens were known to be present immediately before trapping commenced in July 1979. Many of these kittens were diseased and would undoubtedly have died underground in the hospital heating ducts without being recorded if they had not been captured. Seven of the adult females captured were pregnant and clearly would have added to the kitten population had they been allowed to give birth within the colony.

### 6.9.2. Causes of death and disappearance of kittens

The cause of death of kittens which died in year 1 could not be determined since their bodies were rarely seen. Many must have died underground and those that were found were usually inaccessible. It is possible that some healthy kittens were removed by the hospital staff and taken as pets.

Thirty-four kittens were present during the trapping operation, of which seven died before they could be trapped, and two avoided capture. Of the remaining 25 kittens, 12 were destroyed due to the presence of disease, 10 were healthy and taken for re-homing because they were too young to be neutered, and three healthy older kittens were neutered and returned to the colony. Approximately 56% of the kittens originally present either died or were destroyed. One of the neutered kittens subsequently disappeared and there would undoubtedly have been further losses among the re-homed kittens if they had been returned to the colony since most of them were still no more than two or three months old.

The exact nature of the diseases present in the kittens was not determined. In year 1 symptoms of rhino-tracheal disease were observed (bilateral ocular and nasal discharges), probably indicating the presence of some form of virus. This was also observed in some of the kittens destroyed at the Liverpool Veterinary Hospital (see Chapter 13). Nystagmus (involuntary eye movements ) was observed in two kittens from the same litter which were destroyed in Liverpool, and this may have been a symptom of nervous disease.

At least one kitten was born to 121f in year 1 and she produced a further four kittens after the end of year 2. None of these kittens were observed in the colony for more than a few weeks but the reason for their disappearance could not be determined.

### 6.9.3. Adult mortality and disappearance

In year 1, 21 adult males and 15 adult females were recorded in the colony. By the end of this year six males (28.6%) and five females (33.3%) had disappeared, representing a loss of 30.6% of the adult population. If kittens which entered the adult classes during year 1 are included, 25% of males and 28.6% of females were lost, representing 26.7% of the adult population.

At the beginning of year 2, 15 of the adult males remaining from year 1 should have been present in the colony. However, 64m and 97m were not seen after being neutered and released, and were not present at the end of year 2. One male (69m) died, and these three cats together represent a loss of 20% of the adult males in year 2. Of the ten surviving adult female cats from year 1, only one (54f) disappeared in year 2. This represented 10% of the adult female population. The adult male and female losses considered together represent 16% of the adult population. Female 114f was not seen at the end of year 2 and was thought to have disappeared in May 1980. She was rediscovered after the end of the study (in March 1981) but has been excluded from the numbers of cats present from May 1980 onwards.

Female 33f was not seen during year 2 until the visits made at the end of the study. She was considered to have been present throughout the year.

If the three male kittens and five female kittens (47f died) which entered the adult classes in year 1 are included in the adult totals, the losses of adult males and females in year 2 are 16.7% and 6.7% respectively. These losses represent 12.1% of the adult population.

Of the nine kittens born in year 1 which survived to the age of six months, and therefore entered the adult classes, one (47f) subsequently died in year 1. The remaining eight were still living in the colony at the end of year 2.

The losses shown above indicate changes which occured in the original colony. Cats seen in year 2 only and the 'unknown' cats captured during the trapping operation have been excluded from the calculations.

### 6.9.4. Causes of death and disappearance of adults

Six adult cats were lost from the colony in October 1978 (year 1 ) three males and three females (Fig. 6.6.). One female (13f) was found dead but no explanation could be found for the disappearance of the others since they were all regularly seen in the colony. These cats lived in a relatively small area of the hospital grounds (between zones A and D) but were never all seen together. Cats 1m, 11m, 13f and 16f lived in zone A, 8f lived in zones C and D, and 24m moved between these zones.

Diseases or human interference seem most likely to have been responsible for the loss of these cats, but it is interesting that neither all of the cats in zone A nor all of those in zone D were affected. It was reported that poison was being used to remove cats from the colony, but this was never confirmed. A number of visits were made by an R.S.P.C.A. Inspector to remove sick cats during year 1. The times of these visits and the number of cats removed could not be determined because the Inspector kept no records of his activities and he was only contacted by chance during the trapping operation in July 1979. However, the number of animals involved appeared to be small and it was not possible to determine whether the cats concerned were members of the colony, strays or pets.

Only two of the adult cats which disappeared during the study were known to have died. A female, 13f, was found dead in a derelict shed in zone A in year 1. The body was inaccessible and the cause of death unknown. In year 2, 69m was reported killed by a motor vehicle in the hospital grounds, but its body was not recovered.

It seems likely that some of the males which appeared to immigrate into the colony in year 1 later left the colony, for example 60m, 64m and 67m. Other resident males may also have emigrated, but if they did not return and were never seen outside the colony there was no way of verifying this.

The loss of females from the colony was much more likely to be due to death than to emigration. Since females tended to have smaller home ranges than males (see Chapter 7), tended to be associated with particular sheltering places and were usually relatively easy to find, sudden disappearance was more likely to be due to death than to a significant change in home range. However, two adult females (9f and 17f) did show a marked change in home range in year 1 (while remaining within the hospital grounds) so the possibility of female emigration cannot be completely discounted.

It should have been possible to predict the death of any cats showing symptoms of disease or injury. This proved possible for some young kittens, but sick adult cats tend to remain hidden (Jackson, O.F. pers. comm.) so the number of disappearances due to death could not be determined.

During the study direct human interference with the adult cat population was not recorded. It is unlikely that any of the adults were taken as pets because most were unapproachable, although some hospital patients could stroke and feed by hand certain individual cats with which they were familiar. Periodically attempts were made by hospital staff to exclude cats from their sheltering places. For example, holes in the ducting system and broken air grids were covered with concrete blocks or metal plates. These measures were rarely permanent and often blocked holes were unblocked within a short time, presumably by cat-lovers on the hospital's staff. Wherever cats were prevented from entering or leaving their sheltering places by their usual route they were often able to find other means of access due to the poor state of repair of the buildings and the duct system. It is unlikely, therefore, that any cats perished inside sealed buildings or ducts.

## 6.10. DYNAMICS OF GROUPS A AND D

### 6.10.1. Dynamics of group A in year 1

At the beginning of year 1 there were five adult females (13f, 14f, 16f, 19f and 25f) and two adult males (1m and 11m) living permanently in zone A (Fig. 6.9.(a) ). Three other adult males (23m*, 24m and 26m) were also seen in this zone but were not considered to be resident here. Male 26m disappeared from the colony in July 1978 and was not seen again. By the following October a further three males and three females had disappeared, leaving only two females resident in zone A (14f and 19f) and one visiting male (23m*). The possible reasons for these disappearances have been discussed earlier (Section 6.9.3.).

In December 1978, after group A had been reduced in size from seven to only two resident adults, female 9f began visiting zone A regularly. She had never been seen here before but had previously lived in an adjacent zone (zone B). However, she normally wandered between a number of zones. Between December 1978 and the end of year 1 five adult males began visiting zone A. Male 52m was seen on three occasions in December 1978 and

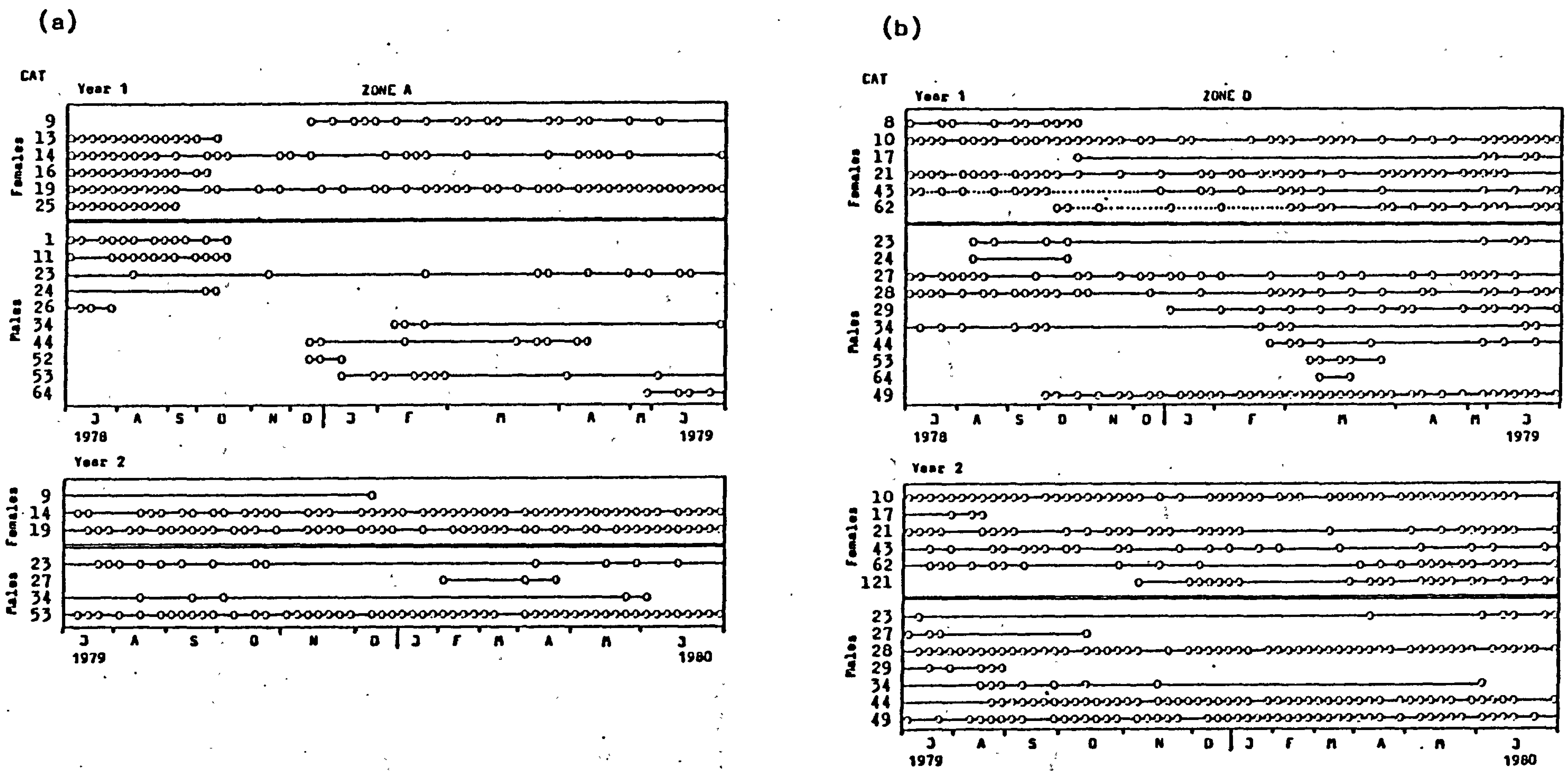



Fig.6.9. Dynamics of groups A (a) and D (b). Only sightings made in zones A and D respectively are indicated. A broken line is used to indicate that a cat was less than six months old.

January 1979. He had not previously been identified but had probably been living around zones AJ and AN as he was known to staff in the Nurses' Home. At about the same time 44m and 53m appeared in zone A. Both cats also visited zone D and eventually 44m settled in zone D while 53m settled in zone A in year 2. Male 44m had originally been identified in zone G in July 1978 but was only recorded here once. However, 53m had not been seen in the colony before he arrived in zone A. Male 34m began visiting zone A in February 1979 but had previously been seen in other zones, including zone D, from the beginning of year 1. In the following May 64m began visiting zone A after appearing in zone D in March 1979. He disappeared after the trapping operation and was not seen in year 2.

At the end of year 1 two of the original females (14f and 19f) remained in zone A and 23m* continued to visit them. Three other males (34m, 53m and 64m) and one other female (9f) were also occasionally seen in zone A. At least 19 kittens were born in zone A in year 1 but none survived to the age of six months and therefore they are not shown in Fig. 6.9.(a) since they did not contribute to the dynamics of the adult population.

It is interesting that after the disappearance of the two original resident males, three of the original resident females and the nomadic males 24m and 26m from zone A, five males and one female appeared in year 1 which had never been seen in this zone before. However, by the end of year 1, none of these cats had taken up permanent residence here.

### 6.10.2. Dynamics of group A in year 2

In year 2 (after neutering and return of the adult cats to the colony ) the two original females (14f and 19f) and the visiting (entire) male 23m* were still regularly seen in zone A. Of the cats that appeared here for the first time in year 1, 34m was seen occasionally, 9f was only seen once (she was discovered to be living elsewhere), and 53m settled permanently with the two original females. Males 44m and 52m were not seen in zone A at all in year 2 but remained in the colony. A new male, 27m, was seen in zone A on three occasions between February and April 1980. He had originally lived in zone D in year 1. At the end of year 2 the group of cats in zone A consisted of two resident females (14f and 19f) one resident male (53m), and the group was visited by the same two males as in year 1 (23m* and 34m).

### 6.10.3. Dynamics of group D in year 1

Two adult females (8f and 10f) and two adult males (27m and 28m) were living permanently in zone D at the beginning of year 1 (Fig. 6.9.(b)). In addition 34m visited the group occasionally during the year and 23m* visited the group between August and December 1978 and during May and June 1979. In August 1978 another male, 24m was seen in zone D. He disappeared in October 1978 along with 8f at the same time as several adult cats in zone A.

Three female kittens (21f, 43f and 62f) grew up in zone D in year 1 and entered the adult female class. All three kittens became permanent members of the group. Kittens 43f and 62f were two of at least nine kittens which were born in the group in year 1. Their mother(s) were not known. None of the others survived to the age of six months. Kitten 21f was probably not born in zone D but appeared to have moved here with 10f (her mother) from zone C during the preliminary study period. In October 1978 49m appeared in zone D. He was thought to have been born to 9f, in zone B.

In October 1978 female 17f visited zone D from zone C where she normally lived. She was not seen in zone D again until May 1979. By March 1979 there were four adult female cats permanently living in zone D, (due to births) and from the following May up to five were recorded on some visits.

In January 1979 the neutered pet male 29m* moved into group D more or less permanently. He had previously lived in nearby zones (especially B and C) and appeared to spend some time inside the hospital wards. In the following February male 44m was recorded in zone D after first having been seen in zone A in December 1978. He eventually settled in zone D permanently in year 2. In March 1979 male 53m was seen briefly in zone D after first appearing in zone A in January 1979. He settled in zone A as described above. Also in March 1979 male 64m was seen briefly in zone D before visiting zone A. After March 1979 up to seven adult males may have been present in zone D at any time.

At the end of year 1 four females (10f, 21f, 43f and 62f) and five males (27m, 28m, 29m*, 44m and 49m) were living in zone D, and two males (23m* and 34m) and one female (17f) were visiting the group.

## 6.10.4. Dynamics of group D in year 2

During the second year of the study the group of cats in zone D consisted essentially of the four adult females present at the end of year 1 (three of which had been born during year 1), and three adult males (28m, 44m and 49m), two of which had moved into the group during year 1. Males 23m* and 34m continued to visit zone D in year 2. Male 34m was not recorded here after the beginning of June 1980 but was recorded elsewhere in the colony. After August 1979 17f and the pet male 29m* did not appear in zone D but both were recorded in other parts of the hospital. Male 27m, one of the original resident males, left the group in year 2 and was not seen in zone D after October 1979. He visited a number of other groups including group A.

In November 1979 female 121f moved into zone D permanently, probably from outside the colony (see Section 6.7.). She subsequently produced at least one kitten, which did not appear to survive for more than a few weeks. At the end of year 2 group D consisted of five adult females and three adult males, and was visited by two other adult males.

## 6.10.5. A comparison of the dynamics of the two groups

Groups A and D had in common the disappearance of adult cats in October 1978 followed by the appearance and eventual permanent addition of immigrants. The adult cats lost from zone D were in part replaced by kittens so that by the end of year 1 group D had shown a net increase in size. However, in zone A, where the loss of adult cats had been greater, no kittens survived so group A showed a net loss of animals by the end of the year.

The appearance of immigrant adult males in groups A and D in year 1 is difficult to explain. Four adult males disappeared from the west side of the hospital (where zones A and D are located) only a few months before the new males appeared. However, it has already been shown that there were oestrus females in zones A and D at this time (see Section 6.8.1.) and their presence may have attracted outside males even if the original males had been present. It is interesting to note that no immigrant males were recorded in year 2 when all of the adult females in zones A and D (except 121f) were neutered. Unfortunately, little can be deduced from this because the adult male population of the colony was higher and more stable than it was in year 1 and this may have deterred immigrants.

Groups A and D both had different visiting females (9f and 17f respectively) during the study but were visited by the same males (23m* and 34m). Although these two males visited both groups 23m* was recorded more frequently in zone A than in zone D while the opposite was true of 34m. Male 34m was neutered but 23m* was not. Nevertheless, this situation remained the same in year 2, and these cats were rarely recorded together (twice in year 1 and once in year 2 ). It is interesting that neither the two males nor the two females which were visiting groups A and D in year 1 showed any sign of settling in either group permanently even after the group sizes were reduced in October 1978.

After neutering these four cats still remained separate from the two groups. In year 2 it is perhaps surprising that the entire male 23m* did not take advantage of the absence of other entire males and move into one of the groups. However, since all of the females except 121f were neutered there would have been little reproductive advantage to be gained by settling, especially if he was visiting other entire females outside the colony.

Individual associations between all of the adult cats in the colony are discussed in Chapter 11. These associations have been used to define the composition of the social groups separately for each three-month period of the study. Changes in the home range of individual cats which influenced the dynamics of groups A and D are discussed in Chapter 7.

## 6.11. DISCUSSION

Two questions need to be answered about the dynamics of this population of feral cats. First, how did the population numbers change with time when the cats were entire ? Second, what effect did neutering have ? It is important to bear in mind that the answers to these questions may not be the same for all feral cat populations.

Although the effect of neutering on a feral cat colony has not been previously studied in detail, studies have been made of entire populations and the dynamics of these populations have been found to be considerably different. Some feral cat populations show a rapid rate of increase while others are relatively stable in number. Van Aarde (1978) estimated the mean increase in the number of feral cats on Marion Island to be 23.3% per year and and an increase of 43% per year has been calculated for Kerguelen (Derenne, 1976). These island populations arose from a small number of original cats. On Marion Island (an area of some 290 $km^2$) the feral cat population has grown from five in 1949 to approximately 2,137 in 1975 (van Aarde, 1978). A plentiful supply of food (sea-birds), the absence of other terrestrial predators and a large amount of available space all undoubtedly contributed to this rapid population increase. Presumably such populations eventually stabilise. In the more restricted environment of Portsmouth dockyard Dards (1979) found the adult feral cat population to be remarkebly stable, over a period of two years, at around 200.

Before neutering, the Winwick Hospital colony showed a gradual increase in the number of adult males present, apparently due to immigration (but possibly in part due to the late identification of some individuals) while the number of adult females remained fairly constant. The colony as a whole appeared to exhibit a cyclic pattern of abundance caused largely by the seasonal addition of kittens and subsequent kitten mortality.

It is possible that the population of cats in Winwick Hospital was stable before neutering. A stable population need not necessarily remain at a constant size. Populations may exhibit cycles in abundance yet still be stable. Krebs (1972) has defined stability as 'a dynamic concept that refers to the ability of a system to bounce back from disturbances'. When applied to animal populations the term 'stability' must be qualified since it may refer to the absence of fluctuations in number with time, or alternatively seasonal variations may be present which, in the long-term, are ignored since they have no permanent effect on abundance.

The factors which may regulate the size of feral cat colonies are discussed in Chapter 15. However, most colonies are probably affected by the removal of cats by man (see Chapter 3) and because of this it is unlikely that factors which might otherwise regulate these populations have any significant long-term effect. The reported persistence of these colonies is evidence of their ability to withstand disturbance and to this extent they may be considered relatively stable. Cats had been removed from the Winwick Hospital colony before this study began and there may even have been a small number of removals during the study itself. This could have contributed to some of the fluctuations in numbers in year 1.

Dards (1979) has recently compared the densities of cats in different environments. Densities in rural populations range from one cat.km $^{-2}$ in New Zealand (Fitzgerald & Karl, 1979) to 14 cats. km $^{-2}$ in the coastal regions of Marion Island (van Aarde 1978). The only figures available for an urban population are those of Dards (1979) for Portsmouth dockyard. She found an average density of over 200 adult cats. km $^{-2}$ which is similar to the densities calculated for Winwick Hospital (150 cats. km $^{-2}$ in year 1 ; 200 cats . km $^{-2}$ in year 2 ).

It must be remembered that the accurate calculation of density relies upon the careful delimitation of the area used by the animals. If, in this study, densities are calculated for the entire area of the grounds of Winwick Hospital the figures obtained would be much lower than those presented as they are based on the study area (17 ha.) and very few sightings of cats were made outside this area. The boundaries of the study area were for convenience , based on roads encircling the hospital, and it is unlikely that these roads had any particular significance for the cats. Some areas within these boundaries were apparently not used by cats and if these areas had been excluded from the calculations the density of the animals would have appeared higher. The problem of defining the study area must affect all calculations of density except where the boundaries are naturally determined by some physical feature, for example the sea around an island or where walls surround the population as in Portsmouth dockyard.

After neutering the population of feral cats in Winwick Hospital remained almost constant in both size and composition. Small changes occured in the adult population due to mortality (which was much lower in year 2 than in year 1 ) and the maturation of neutered kittens, the overall effect being a slight decrease in the total population size at the end of year 2. As might be expected the most important effect of neutering on the population dynamics of the colony was the cessation of reproduction and consequent lack of recruitment of kittens into the adult population (except 117m, 118f and those kittens that were neutered). This caused a change in the age structure of the colony such that four months after the cats had been neutered only adult males and adult females were present.

It has been suggested that neutering 'stabilizes' feral cat colonies (Hammond, 1981). If this is taken to mean 'stabilises the population size' then this is not true. Clearly if all the cats are neutered there will be a decrease in their number with time due to mortality, leading to eventual extinction if immigrants do not enter the colony. Neutering certainly removes the fluctuations in total number of cats caused by births, which give the appearance of instability, but since most kittens die at an early age the high birth rate does not greatly affect the size of the adult population. The situation is undoubtedly different in 'unlimited' environments such as those inhabited by some island populations (Derenne, 1976; van Aarde, 1978), but even here eventual stabilisation can be expected.

If neutered feral cat colonies do eventually become extinct, and where no immigration occurs they must, then there is little practical difference between removing all of the cats for destruction or re-homing and neutering them. In either case all the cats must be captured. Often when colonies are neutered the authorities at the site concerned will only accept the return of a small proportion of the original population (Jackson, M., 1981). The remaining cats are often destroyed along with any kittens present. It is therefore, difficult to see the moral distinction between removing colonies completely and neutering them since both approaches involve killing cats and the difference is a matter of degree.

It has been argued that the presence of a neutered colony will prevent other cats from moving into the area (Remfry, 1981). However, a site which has had all its cats removed and a site which has a dwindling neutered colony both, in the long-term, represent areas suitable for re-colonisation. Immigrants in either situation would have to be captured for neutering or removal and this requires a continual input of effort.

Theoretically removal of cats followed by the proofing of buildings and removal of food sources ought to be a more effective means of solving the problem. Remfry (1981) has suggested that total eradication is difficult to achieve, but this is probably due to a lack of determination on the part of the trappers and the authorities responsible for maintaining the buildings concerned. During the course of this study a number of sites were visited where apparently effective proofing of buildings had been achieved and it is clear from information received during the survey of feral cat colonies (see Chapter 3) that some of the colonies reported had been completely removed. However, the long-term effectiveness of the measures taken could not be determined.

This study has provided little information on the long-term usefulness of neutering as a means of managing feral cat colonies because of its short duration. It is likely to be many years before the population of cats at Winwick Hospital decreases appreciably in size due to mortality. It would, of course, be most useful to continue this study indefinitely in order to examine the mortality rate and the possible future immigration of other cats. The situation at Winwick Hospital was, however, complicated by the presence of two entire adult males (23m* and 65m*), one entire adult female (121f) which appeared to immigrate into the colony in year 2, and the entire male 117m and female 118f which, although they were rarely seen, became sexually mature in year 2. The presence of entire females may result in the eventual recruitment of kittens into the population.

It is clearly important that all of the cats in a colony are captured and neutered if a neutering operation is to be successful. It is also necessary that the colony should be carefully monitored so that immigrants may be identified and neutered. This type of monitoring has been reported from a number of established neutered colonies (Hammond, 1981; Remfry, 1981). It is often difficult to capture all of the cats in a colony (Remfry, 1981) but it has been suggested that this is advantageous if an input of new animals is required to replace cats lost due to mortality.

The possibility that cats may immigrate into a neutered colony is interesting because it could obviously affect the success of a neutering operation in controlling the population size. No male immigrants were detected in the Winwick Hospital colony in year 2 and it is tempting to suggest that this was a result of neutering the cats. Since the 'unknown' males captured during the trapping operation (which were released neutered) were perhaps the animals most likely to have entered the colony in year 2, it could be argued that these potential immigrants were now unlikely to enter the colony in search of females. However, two other males, (presumably entire) were known to occasionally visit the periphery of the hospital grounds in year 2 but they made no attempt to enter groups A or D which were nearby. It is interesting that one neutered 'unknown' male (105m) did reappear once within the study area in year 2 . The immigration of a female (121f) into the colony after the cats were neutered, and the subsequent production of kittens indicates the potential of immigrants to contribute to the growth of a neutered colony.

Dards (1979) considered that most immigration and emigration of the Portsmouth dockyard cats was between areas within the dockyard itself. The dockyard is surrounded by the sea and high walls which prevent the movements of animals, except through the gates, in marked contrast to the relatively open grounds of Winwick Hospital. A small number of young males may have permanently left the population and at least one older male was known to periodically spend time outside the dockyard. Dards (1979) recorded at least five adult male and two adult female immigrants, and kittens were also apparently abandoned within the dockyard. Two of the male immigrants entered the dockyard in January when most of the females were starting to come into oestrus. The immigrants observed in Winwick Hospital in year 1 entered the colony between January and early March. Dards (1979) considered that while males must have been attracted by the ample supply of food and females in the dockyard, the relatively high density of adult males here must have acted as a deterrant. She noted that most of the immigrants were large males. The density of males in year 2 was higher than in year 1 in the Winwick Hospital colony and this may have been important in preventing male immigration. The lack of oestrus females (except 118f and 121f) was probably also important in this respect.

The movement of the adult males 44m and 53m into groups D and A respectively in year 2 was interesting. Both cats wandered between these groups in year 1 before settling. Unfortunately they were neutered before they were seen frequently enough in any group for them to be considered to be resident. There is, therefore, no way of knowing whether they settled in a particular social group in a particular zone as a result of neutering or whether this would have happened anyway. It is interesting to compare the behaviour of 34m. He wandered between groups A and D in year 1 but did not settle in either group permanently after neutering. The home ranges of these cats and the possible effects of neutering are discussed in detail in Chapter 7.

Unfortunately it was only possible to study the population dynamics of this colony for a single year before the animals were neutered. Thus, time limitation and the relatively small size of the population (c.f. the population in Portsmouth dockyard) did not allow the collection of large quantities of data on natality and mortality, or the examination of the stability of the population from year to year. Nevertheless, some useful information has been obtained. Before neutering the colony appeared to have a relatively stable adult population subjected to periodic male immigration, while fluctuations in the total number of cats present were observed due to reproduction. After neutering there appeared to be no male immigration and the population began to decline slowly due to mortality.

# 7. HOME RANGE

## 7.1. INTRODUCTION

The extent to which individual cats utilise different parts of their habitat is of interest as it provides an insight into their specific ecological requirements and because it may in part be the result of interactions between individuals. The area utilised by a cat may be called its home range. This has been defined as 'the area over which an animal normally travels in pursuit of its routine activities' (Burt, 1943). Any change in the home range of cats after neutering is of interest in the context of this particular study because it could be indicative of a change in their ecological requirements or of an alteration of their social relationships. This could have implications for the future stability of the colony and the effectiveness of neutering as a control measure.

A distinction must be made between home range and territory. Territory is generally accepted to be 'any defended area' (Noble, 1939; Burt, 1943 and 1949; Jewell, 1966; Manning, 1972; Delany, 1974) and the holding of a territory may involve elaborate behavioural displays (Wilson, 1980). This distinction is important because although some workers have referred to territories in studies of cats (Leyhausen, 1979; Tabor, 1981) their existence in feral cat colonies has never been shown. Leyhausen (1979) has reported territorial behaviour and considerable aggression amongst captive domestic cats in confined conditions. However, only low levels of aggression have been observed in feral cat colonies (Dards, 1979; Macdonald, 1981).

The home range of feral cats inhabiting Portsmouth dockyard has recently been examined by Dards (1979). She used three methods of calculating home range from points (representing the positions of sightings ) plotted on an Ordnance Survey map. Macdonald & Apps (1978) used radio-tracking and direct observation in similar studies of a small group of cats in a rural area in north Devon. Macdonald et al (1979) have discussed the use of radio-tracking in home range studies. The use of trapping and the recording of tracks in studies of the ranges of small mammals have been discussed by Delany (1974).

From location records various methods of measuring home range have been proposed: minimum area, inclusive boundary strip, exclusive boundary strip, range length and centre of activity (Delany, 1974). Some of these methods have been modified to suit the purposes of particular studies (for example, Dards, 1979).

The method of studying home range used in this study is based on recordings made within zones in the habitat. A similar method was used by Gates (1979) to record the ranges of ponies (Equus caballus L.) in part of the Exmoor National Park. Methods which use zones are less precise than those which use accurate point location records. However, they allow a clear description and comparison of the ranges of individuals, and changes which occur over a period of time. Furthermore, as the individual zones used in this study are small (most had an area of less than 0.2 ha ) it is possible that a cat seen within a zone will make use of all of it.

## 7.2. METHODS

Home range was examined by dividing the study area into zones and recording the zones utilised by each cat. The methods used to collect these data and the location of each zone have been described in Chapter 5. The relative sizes of the zones are indicated in Fig. 5.2.

In order to analyse changes of home range with time the two year study period was divided into eight three-month periods:

| | Period | Months | Year | Number of visits |
|---|---|---|---|---|
| Year 1 | 1 | July - Sept. | 1978 | 13 |
| | 2 | Oct. - Dec. | 1978 | 12 |
| | 3 | Jan. - Mar. | 1979 | 23 |
| | 4 | Apr. - June | 1979 | 16 |
| Year 2 | 5 | July - Sept. | 1979 | 15 |
| | 6 | Oct. - Dec. | 1979 | 17 |
| | 7 | Jan. - Mar. | 1980 | 12 |
| | 8 | Apr. - June | 1980 | 20 |

For each cat the total number of sightings made in each zone was calculated separately for the eight periods shown above and also for years 1 and 2. These figures have been converted to percentages so that changes in home range can be easily seen, independent of the number of sightings made at different times. Sorting of the original home range data was performed by computer. Kittens were excluded from the analysis until the three-month period after that in which they became six months old.

The size of the home range was considered to be the total number of zones utilised in any period. An index of similarity ($I_s$) has been used to compare the home range of each cat and its utilisation in year 1 with that in year 2. For example if a cat was recorded in zones A, B, C and D the number of sightings made in each zone may have been:

Number of sightings

| A | B | C | D | Zone |
|---|---|---|---|---|
| 10 | 17 | 26 | 7 | year 1. |
| 9 | 8 | 42 | 10 | year 2. |

In order to remove apparent changes in range due to differences in the number of sightings made in each year these figures must be converted to percentages:

Percentage of sightings

| A | B | C | D | Zone |
|---|---|---|---|---|
| 17% | 28% | 43%* | 12%* | year 1. |
| 13%* | 12%* | 61% | 14% | year 2. |

The index of similarity is simply the sum of the smaller values for each zone (i.e. those marked '*' ), in this case, 80%. Values of $I_s$ may range from zero (no similarity) to 100% (identical), so this figure suggests a high degree of similarity between the home range utilisation of the cat in the two study years.

The index of similarity is not a statistical test since it does not have a probabilistic basis. However, it is a useful method of quantifying changes in home range and its utilisation. The original method was devised to examine the similarity between species in different habitats, where the zones would be replaced by the species, and the years by the habitats (Southwood, 1978).

## 7.3. HOME RANGE SIZE

In year 1 males and females showed considerable variation in the size of their home ranges (Fig. 7.1.). The largest ranges were those of males, but half of the males studied had ranges which were similar in size to the home ranges of the females in year 1. The smallest ranges were those of females. Three of the four females born in year 1 (21f, 43f and 62f ) had home ranges covering only two zones. The males with the smallest ranges were also cats which had been born in year 1 (49m, 68m and 65m*).

In year 2 the home range of some female cats remained the same as in year 1, some showed an increase in the size of their range while others showed a decrease. Many males appeared to show a decrease in home range in year 2 , especially those with

| Females Year 1 | Females Year 2 | Home range | Males Year 1 | Males Year 2 |
|---|---|---|---|---|
| | | 12 | • 44 | |
| | | 11 | | |
| | | 10 | | |
| | | 9 | • 23* | |
| | | 8 | • 28, 34, 50, 52 | |
| • 9 | | 7 | | • 27, 49 |
| • 66 | • 66 | 6 | • 53 | • 34, 23* |
| • 51 | • 21, 62 | 5 | • 27 | • 50 |
| • 17 | • 9, 10, 17, 19, 51, 43 | 4 | • 29* | • 44, 52, 68, 29*, 65* |
| • 10 | | 3 | • 49, 68, 65* | • 28 |
| • 19, 21, 43, 62 | | 2 | | |
| • 14 | • 14 | 1 | | • 53 |
| | | Number of zones | | |

Fig. 7.1. Home range size (number of zones utilised) of males and females in year 1 and year 2.

previously large ranges. Some males did however, increase their ranges in year 2 and it is therefore difficult to make generalised statements about the effect of neutering on home range size.

No consistent changes were observed in the home ranges of the cats after neutering. However, a statistical analysis of the differences in home range size before and after neutering is presented in Chapter 10. The size of the home range of any cat, measured as the number of zones utilised, gives little information about the ranging behaviour of the animal. When the location of the zones comprising each individual cat's range are examined it is clear that some cats occupied a small number of contiguous zones whereas others were recorded in widely separated zones. In order to assess the possible effects of neutering on ranging behaviour each animal must be considered individually (see Section 7.5.).

## 7.4. OVERLAP IN HOME RANGES

There was considerable overlap in the home ranges utilised by the cats in both years of the study (Fig. 7.2.). This was indicative of the social structure of the colony, since although overlap of home range does not necessarily mean that the individuals concerned used identical areas at the same time, this was generally the case, especially in the females.

In year 1 the colony consisted of four main groups of cats

**Year 1**

| Zone | Females | | | | | | | | | | Males | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 9 | 10 | 14 | 17 | 19 | 51 | 21 | 43 | 62 | 66 | 27 | 28 | 34 | 44 | 50 | 52 | 53 | 49 | 68 | 23* | 29* | 65* |
| A | x | | x | | x | | | | | | | | x | x | | x | x | | | x | | |
| B | x | | | | | | | | | | | | x | x | | | x | | | x | | |
| C | x | | | x | | | | | | | x | x | x | x | | | | | | x | x | |
| D | | x | | x | | | x | x | x | | x | x | x | x | | | x | x | | x | x | |
| E1 | | | | | | | | | | | | | | | | | | | | x | | |
| E2 | x | | | | | | | | | | | x | | | | | | | | x | | |
| E3 | x | | | | | | x | | | | | x | | x | | | x | | | | | |
| F | | | | | | | | | | | | | | | | | | | | | | |
| G | | | | | | | | | | | | | | x | | | | | | | | |
| H2 | | x | | x | | | | x | | | | x | | x | | | x | x | | | x | |
| I | | | | | | | | | | | | | | x | | | | | | | | |
| J | | | | | | | | | | | | x | | | | | | | | | | |
| K | x | | | x | | | | | | | | x | | x | | | | | | x | x | |
| L | x | | | | | | | | | | | | | | | | | | | | | |
| M | | | | | | | | | | | | | | | | | | | | x | | |
| N | | | | | | | | | | | | | | | | | | | | | | |
| P | | | | | x | | | | | | | | | | | | | | | | | |
| Q | | x | | | | | | | | | x | x | x | x | | | | x | | | | |
| R | | | | | | x | | | | x | | | | | x | | | | x | | | x |
| S | | | | | | x | | | | x | | | | | x | x | x | | x | | | x |
| T | | | | | | x | | | | | | | | | | | | | | | | |
| U | | | | | | | | | | x | | | | | x | | | | x | | | x |
| V | | | | | | | | | | | | | | | | x | | | | | | |
| W | | | | | | | | | | | | | | | x | x | | | | | | |
| X | | | | | | | | | | | | | | | | | | | | | | |
| Y | | | | | | x | | | | | | | | | | x | | | | | | |
| Z | | | | | | | | | x | | x | | | x | | | | | | | | |
| AA | | | | | | | | | | | | | | | x | x | | | | | | |
| AB | | | | | | | | | | x | | | | | x | x | | | | | | |
| AC | | | | | | | | | | x | | | | | x | | | | | | | |
| AD | | | | | | x | | | | x | | | | | x | | | | | | | |
| AE | | | | | | | | | | | x | | | x | | | | | | | | |
| AF | | | | | | | | | | | | | x | | | | | | | | | |
| AG1 | | | | | | | | | | | | | | | | | | | | | | |
| AG2 | | | | | | | | | | | | | | | | | | | | | | |
| AG3 | | | | | | | | | | | | | | | | | | | | | | |
| AH | | | | | | | | | | | | | | | | | | | | | | |
| AI | | | | | | | | | | | | | | | | | | | | | | |
| AJ | | | | | | | | | | | | | | | | | | | | | | |
| AK | | | | | | | | | | | | | | | | | | | | x | | |
| AM | | | | | | | | | | | | | | | | | | | | | | |
| AP | | | | | | | | | | | | | | | | x | | | | | | |
| AR | | | | | | | | | | | | | x | | | | | | | | | |
| AS | | | | | | | | | | | | | | | | | | | | | | |
| AT | | | | | | | | | | | | | | | | | | | | | | |
| AU | | | | | | | | | | | | | | | | | | | | | | |
| AV | | | | | | | | | | | | | | | | | | | | | | |
| AW | | | | | | | | | | | | | | | | | | | | | | |
| AX | | | | | | | | | | | | | | | | | | | | | | |
| AY | | | | | | | | | | | | | | | | | | | | | | |
| AZ | | | | | | | | | | | | | | | | | | | | | | |
| AQ | | | | | | | | | | | | | x | | | | | | | | | |
| BA | | | | | | | | | | | | | | | | | | | | | | |
| BB | | | | | | | | | | | | | | | | | | | | | | |
| BC | | | | | | | | | | | | | | | | | | | | | | |
| BD | | | | | | | | | | | | | | | | | | | | | | |
| DJ | | | | | | | | | | | | | | | | | | | | | | |

**Year 2**

| Zone | Females | | | | | | | | | | Males | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 9 | 10 | 14 | 17 | 19 | 51 | 21 | 43 | 62 | 66 | 27 | 28 | 34 | 44 | 50 | 52 | 53 | 49 | 68 | 23* | 29* | 65* |
| A | x | | x | | x | | | | | | x | | x | | | | x | | | x | | |
| B | x | | | x | | | | | | | | | x | | | | | x | | x | x | |
| C | | | | x | | | | | | | | | | | | | | | | | | |
| D | | x | | x | | | x | x | x | | x | x | x | x | | | | x | | x | x | |
| E1 | | | | | | | | | | | | | | x | | | | | | x | x | |
| E2 | | x | | | | | | | | | | | | | | | | | | x | | |
| E3 | | x | | | | | x | | x | | | | | | | | | x | | x | | |
| F | | | | | | | | | | | x | | | | | | | | | | | |
| G | | | | | | | | | | | x | | | | | | | | | | | |
| H2 | | | | | | | x | x | x | | | x | | x | | | | x | | | | |
| I | | | | | | | x | | | | | | | | | | | | | | | |
| J | | | | | | | | x | x | | | x | | | | | | | | | | |
| K | x | | | x | | | | | | | | | x | | | | | x | | | x | |
| L | | | | | x | | | | | | | | x | | | | | | | | | |
| M | | | | | x | | | | | | | | | | | | | | | | | |
| N | | | | | x | | | | | | | | | | | | | | | | | |
| P | | | | | | | | | | | | | | | | | | | | | | |
| Q | | x | | | | | x | | | | | | x | | | | | x | | | | |
| R | | | | | | x | | | | x | | | | | x | | | | x | | | x |
| S | | | | | | x | | | | x | | | | | x | | | | | | | |
| T | | | | | | | | | | | | | | | | | | | | | | |
| U | | | | | | | | | | x | | | | | x | | | | x | | | x |
| V | | | | | | | | | | | | | | | | | | | | | | |
| W | | | | | | | | | | | | | | | | | | | | | | |
| X | | | | | | | | | | | | | | | | | | | | | | |
| Y | | | | | | | | | | | | | | | | x | | | x | | | x |
| Z | | | | | | | | | | | x | | | x | | x | | | | | | |
| AA | | | | | | | | | | | | | | | | | | | | | | |
| AB | | | | | | | | | | x | | | | | x | | | | | | | x |
| AC | | | | | | x | | | | x | | | | | | | | | | | | |
| AD | | | | | | x | | | | x | | | | | x | | | | x | | | |
| AE | | | | | | | | | x | | | | | | | | | x | | | | |
| AF | x | | | | | | | | | | | | | | | | | | | | | |
| AG1 | | | | | | | | | | | | | | | | | | | | | | |
| AG2 | | | | | | | | | | | | | | | | | | | | | | |
| AG3 | | | | | | | | | | | | | | | | | | | | | | |
| AH | | | | | | | | | | | | | | | | | | | | | | |
| AI | | | | | | | | | | | | | | | | | | | | | | |
| AJ | | | | | | | | | | | | | | | | x | | | | | | |
| AK | | | | | | | | | | | | | | | | | | | | | | |
| AM | | | | | | | | | | | x | | | | | x | | | | | | |
| AP | | | | | | | | | | | x | | | | | | | | | | | |
| AR | | | | | | | | | | | | | | | | | | | | | | |
| AS | | | | | | | | | | | | | | | | | | | | | | |
| AT | | | | | | | | | | | | | | | | | | | | | | |
| AU | | | | | | | | | | | | | | | | | | | | | | |
| AV | | | | | | | | | | | | | | | | | | | | | | |
| AW | | | | | | | | | | | | | | | | | | | | | | |
| AX | | | | | | | | | | | | | | | | | | | | | | |
| AY | | | | | | | | | | | | | | | | | | | | | | |
| AZ | | | | | | | | | | | | | | | | | | | | | | |
| AQ | | | | | | | | | | | | | | | | | | | | | | |
| BA | | | | | | | | | | | | | | | | | | | | | | |
| BB | | | | | | | | | | | | | | | | | | | | | | |
| BC | | | | | | | | | | | | | | | | | | | | | | |
| BD | | | | | | | | | | | | | | | | | | | | | | |
| DJ | | | | | | | | | x | | | | | | | | | | | | | |

Fig. 7.2. Zones utilised by each cat during the study. The presence of 'x' indicates that at least one sighting was made in the zone during the year. The number of sightings made of each cat in each zone is indicated in Table 7.2.

which included resident males, resident females and their young. In addition the groups were visited by other males and females which were sometimes recorded alone, and at other times seen within a group. The ranges of the permanent members of any group overlapped significantly; group A : 14f and 19f; group D: 10f, 21f, 43f, 62f, 27m, 28m, and 49m; and group R: 51f, 66f, 50m, 65m* and 68m. (Group F has not been examined in this respect due to lack of information on the home ranges of the cats concerned). In year 2 the members of the groups altered slightly but similar overlapping of the ranges of group members was observed. In both years the ranges of the individual groups remained discrete.

It is important to remember that Fig. 7.2. shows only the ranges of the cats selected for detailed study. If all of the cats recorded in the colony had been included the situation would have been more complex, although not all of the cats were present for the entire duration of the study. If the ranges of these additional cats were added to Fig. 7.2. zones F and G would include more animals (because of the presence of group F) but the many zones not utilised would remain largely unchanged.

The male cats which wandered between several of the social groups within the colony (nomadic males) showed a remarkable degree of overlap in their home ranges. Males 23m* and 34m had similar ranges in year 1 in that they both utilised zones A, B, C, and D. However in addition they were each seen in zones which were apparently not utilised by the other. From analysis of the association data presented in Chapter 11 it is clear that although 23m* and 34m used some of the same zones, they generally used them at different times, thereby avoiding each other. In year 2 their ranges appeared to change slightly but their ranging behaviour followed the same broad pattern as in year 1 , with the two cats rarely meeting (even though 34m was neutered in year 2 while 23m* was not). It is interesting that although 23m* and 34m appeared to be avoiding each other throughout the study, both were regularly seen within the home ranges of resident males in group D while these males were present.

In year 1 three other nomadic males, 44m, 52m and 53m, had home ranges which overlapped considerably with each other and also with the ranges of 23m* and 34m and in some cases with those of resident males in zone D. This situation did not exist for the entire year, and in year 2 the ranges of 44m, 52m and 53m changed considerably so that they did not appear to overlap with each other at all. Overlapping of the ranges of 23m* and 34m with those of 44m and 53m continued because 44m joined group D and 53m joined group A, and these groups were visited by the other two cats. The extent to which these and other males were actually seen together is discussed in Chapter 11.

## 7.5. CHANGES IN THE HOME RANGES OF INDIVIDUAL CATS

### 7.5.1. Resident females

The ranges of all of the study cats are indicated in Fig. 7.3.

expressed as the percentage of sightings made in each zone in each three-month period. It should be noted that the zones do not appear in the same sequence in all sections of Fig. 7.3.

The home range of 14f was remarkably stable throughout the study as she was only ever seen in zone A. The range of 19f was almost as stable. She normally lived in zone A, but after neutering appeared to make slightly more use of a small number of adjacent zones. It seems likely that she had also used these areas in year 1.

Female 10f showed little change in home range in year 2. She was normally seen in zone D but also used adjacent zones. The greater use of zone E3 (which was connected to zone D by a duct) in year 2 was probably due to human disturbance in zone D caused by workers repairing the buildings here. Shortly after the neutering operation patients were moved away from the area of zone D due to this repair work and consequently less food appeared to be available for the cats.

Females 14f, 19f and 10f were the only adult females which showed little or no change in home range in year 2, and were present as adults throughout the study. Female 51f was not identified until period 2 and thereafter was only rarely seen in year 1. Before she was neutered she was seen in five different zones. However, in year 2 she tended to use zones R and S in particular until period 8, when the was only ever seen in zone R.

| Cat | Period | A | B | C | D | E2 | E3 | H2 | K | L | M | N | P | Q | AF | Sightings |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 9f | 1 | | 86 | 10 | | | | | 5 | | | | | | | 21 |
| | 2 | 5 | 5 | 30 | | 5 | 5 | | 25 | 25 | | | | | | 20 |
| | 3 | 92 | 8 | | | | | | | | | | | | | 24 |
| | 4 | 54 | 38 | | | | | | | 8 | | | | | | 13 |
| | 5 | | 67 | | | | | | 33 | | | | | | | 3 |
| | 6 | 50 | | | | | | | | | | | | | 50 | 2 |
| | 7 | | | | | | | | | | | | | | | 0 |
| | 8 | | | | | | | | | | | | | | | 0 |
| 10f | 1 | | | | 95 | | | 5 | | | | | | | | 19 |
| | 2 | | | | 76 | | | 12 | | | | | | 12 | | 17 |
| | 3 | | | | 100 | | | | | | | | | | | 19 |
| | 4 | | | | 95 | | | | | | | | | 5 | | 21 |
| | 5 | | | | 100 | | | | | | | | | | | 27 |
| | 6 | | | | 81 | 4 | 15 | | | | | | | | | 26 |
| | 7 | | | | 80 | | 7 | | | | | | | 13 | | 15 |
| | 8 | | | | 78 | | 17 | | | | | | | 6 | | 36 |
| 14f | 1 | 100 | | | | | | | | | | | | | | 16 |
| | 2 | 100 | | | | | | | | | | | | | | 7 |
| | 3 | 100 | | | | | | | | | | | | | | 8 |
| | 4 | 100 | | | | | | | | | | | | | | 10 |
| | 5 | 100 | | | | | | | | | | | | | | 12 |
| | 6 | 100 | | | | | | | | | | | | | | 17 |
| | 7 | 100 | | | | | | | | | | | | | | 15 |
| | 8 | 100 | | | | | | | | | | | | | | 31 |
| 17f | 1 | | | 86 | | | | | 14 | | | | | | | 22 |
| | 2 | | | 95 | 5 | | | | | | | | | | | 19 |
| | 3 | | | | | | | | | | | | | | | 0 |
| | 4 | | | | 86 | | | 14 | | | | | | | | 7 |
| | 5 | | | | 100 | | | | | | | | | | | 3 |
| | 6 | | | | | | | | | | | | | | | 0 |
| | 7 | | 50 | 50 | | | | | | | | | | | | 2 |
| | 8 | | | 93 | | | | | 7 | | | | | | | 15 |
| 19f | 1 | 100 | | | | | | | | | | | | | | 21 |
| | 2 | 100 | | | | | | | | | | | | | | 7 |
| | 3 | 96 | | | | | | | | | | | 4 | | | 25 |
| | 4 | 100 | | | | | | | | | | | | | | 23 |
| | 5 | 100 | | | | | | | | | | | | | | 17 |
| | 6 | 100 | | | | | | | | | | | | | | 18 |
| | 7 | 79 | | | | | | | | 7 | 14 | | | | | 14 |
| | 8 | 93 | | | | | | | | | 3 | 3 | | | | 29 |

Fig. 7.3. Percentage of sightings of each cat made in each zone. Individual three-month periods are shown separately.

| Cat | Period | D | E3 | H2 | I | J | Q | R | S | T | U | Y | Z | AB | AC | AD | AE | DJ | Sightings |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 21f | 1 | | | | | | | | | | | | | | | | | | 0 |
| | 2 | 100 | | | | | | | | | | | | | | | | | 7 |
| | 3 | 95 | 5 | | | | | | | | | | | | | | | | 21 |
| | 4 | 94 | 6 | | | | | | | | | | | | | | | | 18 |
| | 5 | 81 | 6 | 6 | | | 6 | | | | | | | | | | | | 16 |
| | 6 | 90 | 10 | | | | | | | | | | | | | | | | 21 |
| | 7 | 43 | 29 | 29 | | | | | | | | | | | | | | | 7 |
| | 8 | 88 | | | 13 | | | | | | | | | | | | | | 16 |
| 43f | 1 | | | | | | | | | | | | | | | | | | 0 |
| | 2 | 100 | | | | | | | | | | | | | | | | | 2 |
| | 3 | 100 | | | | | | | | | | | | | | | | | 13 |
| | 4 | 83 | | 17 | | | | | | | | | | | | | | | 6 |
| | 5 | 91 | | 9 | | | | | | | | | | | | | | | 11 |
| | 6 | 100 | | | | | | | | | | | | | | | | | 9 |
| | 7 | 75 | | | | | | | | | | | | | | | | 25 | 4 |
| | 8 | 83 | | | | 17 | | | | | | | | | | | | | 6 |
| 51f | 1 | | | | | | | | | | | | | | | | | | 0 |
| | 2 | | | | | | | 50 | | 50 | | | | | | | | | 2 |
| | 3 | | | | | | | | | | | 100 | | | | | | | 1 |
| | 4 | | | | | | | | 50 | | | | | | | 50 | | | 2 |
| | 5 | | | | | | | 17 | 67 | | | | | | | 17 | | | 6 |
| | 6 | | | | | | | 50 | 33 | | | | | | | 17 | | | 6 |
| | 7 | | | | | | | 67 | | | | | | | 33 | | | | 3 |
| | 8 | | | | | | | 100 | | | | | | | | | | | 13 |
| 62f | 1 | | | | | | | | | | | | | | | | | | 0 |
| | 2 | | | | | | | | | | | | | | | | | | 0 |
| | 3 | 92 | | | | | | | | | | | 8 | | | | | | 12 |
| | 4 | 100 | | | | | | | | | | | | | | | | | 14 |
| | 5 | 100 | | | | | | | | | | | | | | | | | 10 |
| | 6 | 80 | | 20 | | | | | | | | | | | | | | | 5 |
| | 7 | | | | | | | | | | | | | | | | | | 0 |
| | 8 | 77 | 6 | 6 | | 6 | | | | | | | | | | | 6 | | 18 |
| 66f | 1 | | | | | | | | | | | | | | | | | | 0 |
| | 2 | | | | | | | | | | | | | | | | | | 0 |
| | 3 | | | | | | | 11 | 44 | | 11 | | | | 11 | 22 | | | 9 |
| | 4 | | | | | | | 25 | | | 38 | | | 13 | 13 | 13 | | | 8 |
| | 5 | | | | | | | 91 | | | 9 | | | | | | | | 11 |
| | 6 | | | | | | | 88 | | | | | | | | 13 | | | 8 |
| | 7 | | | | | | | 77 | 8 | | | | | | | 15 | | | 13 |
| | 8 | | | | | | | 64 | | | 9 | | | 9 | 9 | 9 | | | 11 |

Fig. 7.3. (Continued).

| Cat | Period | A | B | C | D | E2 | E3 | F | G | H2 | I | J | K | L | Q | Z | AE | AF | AM | AP | AQ | AR | Sightings |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 27m | 1 | | | | 93 | | | | | | | | | | 7 | | | | | | | | 14 |
| | 2 | | | 30 | 70 | | | | | | | | | | | | | | | | | | 10 |
| | 3 | | | | 81 | | | | | | | | | | 6 | 6 | 6 | | | | | | 16 |
| | 4 | | | | 100 | | | | | | | | | | | | | | | | | | 12 |
| | 5 | | | | 80 | | | | | | | | | | | 20 | | | | | | | 5 |
| | 6 | | | | 100 | | | | | | | | | | | | | | | | | | 1 |
| | 7 | 50 | | | | | | 50 | | | | | | | | | | | | | | | 2 |
| | 8 | 33 | | | | | | | 17 | | | | | | | 17 | | | 17 | 17 | | | 6 |
| 28m | 1 | | | | 75 | | | | | | | 13 | 6 | | 6 | | | | | | | | 16 |
| | 2 | | | 9 | 73 | 9 | | | | 9 | | | | | | | | | | | | | 11 |
| | 3 | | | | 91 | | 9 | | | | | | | | | | | | | | | | 11 |
| | 4 | | | | 82 | | 12 | | | 6 | | | | | | | | | | | | | 17 |
| | 5 | | | | 100 | | | | | | | | | | | | | | | | | | 25 |
| | 6 | | | | 96 | | | | | 4 | | | | | | | | | | | | | 23 |
| | 7 | | | | 94 | | | | | 6 | | | | | | | | | | | | | 17 |
| | 8 | | | | 86 | | | | | 11 | | 4 | | | | | | | | | | | 28 |
| 34m | 1 | | | | 88 | | | | | | | | | | 13 | | | | | | | | 8 |
| | 2 | | | 50 | 50 | | | | | | | | | | | | | | | | | | 2 |
| | 3 | 29 | 21 | | 29 | | | | | | | | | | 7 | | | | | | 7 | 7 | 14 |
| | 4 | 33 | | | 50 | | | | | | | | | | | | | 17 | | | | | 6 |
| | 5 | 20 | | | 80 | | | | | | | | | | | | | | | | | | 10 |
| | 6 | 50 | | | 50 | | | | | | | | | | | | | | | | | | 4 |
| | 7 | | | | | | | | | | | | | | | | | | | | | | 0 |
| | 8 | 22 | 22 | | 11 | | | | | | | | 22 | 11 | 11 | | | | | | | | 9 |
| 44m | 1 | | | | | | | | 100 | | | | | | | | | | | | | | 1 |
| | 2 | 60 | | 40 | | | | | | | | | | | | | | | | | | | 5 |
| | 3 | 27 | | | 43 | | 6 | | | | | | 6 | | 6 | 6 | 6 | | | | | | 18 |
| | 4 | 25 | 13 | | 31 | | 6 | | | 13 | 6 | | | | | 6 | | | | | | | 16 |
| | 5 | | | | 93 | | | | | | | | | | | 7 | | | | | | | 15 |
| | 6 | | | | 90 | | 3 | | | 7 | | | | | | | | | | | | | 29 |
| | 7 | | | | 100 | | | | | | | | | | | | | | | | | | 19 |
| | 8 | | | | 100 | | | | | | | | | | | | | | | | | | 26 |
| 49m | 1 | | | | | | | | | | | | | | | | | | | | | | 0 |
| | 2 | | | | 100 | | | | | | | | | | | | | | | | | | 11 |
| | 3 | | | | 94 | | | | | 3 | | | | | 3 | | | | | | | | 35 |
| | 4 | | | | 95 | | | | | | | | | | 5 | | | | | | | | 22 |
| | 5 | | | | 83 | | 6 | | | 6 | | | | | 6 | | | | | | | | 17 |
| | 6 | | | | 92 | | | | | | | | | | 8 | | | | | | | | 24 |
| | 7 | | | | 100 | | | | | | | | | | | | | | | | | | 19 |
| | 8 | | 4 | | 74 | | 7 | | | 4 | | | 4 | | 4 | | 4 | | | | | | 28 |

Fig. 7.3. (Continued).

| Cat | Period | A | B | D | E3 | H2 | R | S | U | V | W | Y | Z | AA | AB | AC | AD | AJ | AM | AP | Sightings |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 50m | 1 | | | | | | | | | | | | | | | | | | | | 0 |
| | 2 | | | | | | 56 | 11 | 11 | | | | | 11 | | | 11 | | | | 9 |
| | 3 | | | | | | 14 | 14 | | | 14 | | | | 14 | 29 | 14 | | | | 7 |
| | 4 | | | | | | 75 | | 25 | | | | | | | | | | | | 4 |
| | 5 | | | | | | 73 | | 9 | | | | | | 9 | | 9 | | | | 11 |
| | 6 | | | | | | 89 | | | | | | | | | | 11 | | | | 9 |
| | 7 | | | | | | 80 | 10 | | | | | | | | | 10 | | | | 10 |
| | 8 | | | | | | 86 | | 7 | | | | | | | | 7 | | | | 14 |
| 52m | 1 | | | | | | | | | | | | | | | | | | | | 0 |
| | 2 | 100 | | | | | | | | | | | | | | | | | | | 3 |
| | 3 | 29 | | | | | | 43 | | | 14 | | | | | | | | | 14 | 7 |
| | 4 | | | | | | | 13 | | 24 | 13 | 24 | | 13 | 13 | | | | | | 8 |
| | 5 | | | | | | | | | | | 17 | 83 | | | | | | | | 6 |
| | 6 | | | | | | | | | | | | 90 | | | | | | 10 | | 10 |
| | 7 | | | | | | | | | | | | | | | | | 80 | 20 | | 5 |
| | 8 | | | | | | | | | | | | | | | | | 75 | 25 | | 12 |
| 53m | 1 | | | | | | | | | | | | | | | | | | | | 0 |
| | 2 | | | | | | | | | | | | | | | | | | | | 0 |
| | 3 | 45 | 5 | 40 | 5 | 5 | | | | | | | | | | | | | | | 20 |
| | 4 | 43 | 29 | | | | | 29 | | | | | | | | | | | | | 7 |
| | 5 | 100 | | | | | | | | | | | | | | | | | | | 17 |
| | 6 | 100 | | | | | | | | | | | | | | | | | | | 25 |
| | 7 | 100 | | | | | | | | | | | | | | | | | | | 18 |
| | 8 | 100 | | | | | | | | | | | | | | | | | | | 40 |
| 68m | 1 | | | | | | | | | | | | | | | | | | | | 0 |
| | 2 | | | | | | | | | | | | | | | | | | | | 0 |
| | 3 | | | | | | | 100 | | | | | | | | | | | | | 2 |
| | 4 | | | | | | 29 | | 71 | | | | | | | | | | | | 7 |
| | 5 | | | | | | 67 | | 17 | | | 8 | | | | | 8 | | | | 12 |
| | 6 | | | | | | 91 | | | | | | | | | | 9 | | | | 11 |
| | 7 | | | | | | 90 | | | | | | | | | | 10 | | | | 10 |
| | 8 | | | | | | 73 | | 7 | | | | | | | | 20 | | | | 15 |

| Cat | Period | A | B | C | D | E1 | E2 | E3 | H2 | K | M | R | S | U | Y | AB | AK | Sightings |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 23m* | 1 | 7 | 14 | 14 | 14 | 7 | 29 | | | 14 | | | | | | | | 14 |
| | 2 | 25 | | | 50 | | | | | | 25 | | | | | | | 4 |
| | 3 | 71 | | | | | 14 | | | | | | | | | | 14 | 7 |
| | 4 | 67 | | | 33 | | | | | | | | | | | | | 9 |
| | 5 | 57 | 7 | | 7 | 14 | 7 | 7 | | | | | | | | | | 14 |
| | 6 | 50 | | | | | | 50 | | | | | | | | | | 6 |
| | 7 | | | | | | 100 | | | | | | | | | | | 1 |
| | 8 | 21 | | | 47 | 11 | | 21 | | | | | | | | | | 19 |
| 29m* | 1 | | | 40 | | | | | | 60 | | | | | | | | 5 |
| | 2 | | | 93 | | | | | 7 | | | | | | | | | 14 |
| | 3 | | | | 92 | | | | 8 | | | | | | | | | 12 |
| | 4 | | | | 100 | | | | | | | | | | | | | 13 |
| | 5 | | | | 89 | 11 | | | | | | | | | | | | 9 |
| | 6 | | | | | | | | | | | | | | | | | 0 |
| | 7 | | 100 | | | | | | | | | | | | | | | 1 |
| | 8 | | 50 | | | | | | | 50 | | | | | | | | 4 |
| 65m* | 1 | | | | | | | | | | | | | | | | | 0 |
| | 2 | | | | | | | | | | | | | | | | | 0 |
| | 3 | | | | | | | | | | | | 50 | 50 | | | | 2 |
| | 4 | | | | | | | | | | | 100 | | | | | | 2 |
| | 5 | | | | | | | | | | | 25 | | 25 | | 50 | | 4 |
| | 6 | | | | | | | | | | | | | | | | | 0 |
| | 7 | | | | | | | | | | | | | | 100 | | | 1 |
| | 8 | | | | | | | | | | | | | | | | | 0 |

Fig. 7.3. (Continued).

In year 2 patients began feeding cats from a hospital window in zone R. This feeding did not appear to take place in year 1 and it may have been responsible for the change in 51f's range.

Four females were included in this study which were born at the beginning of year 1 or during the preliminary study period: 21f, 43f, 62f and 66f. Consequently data on home range is not available for these animals for the early parts of year 1. Females 21f, 43f and 62f all lived in group D. The comments already made about the possible reasons for the change in home range seen in 10f in year 2 also apply to these animals. In addition 43f and 62f were, because of their small size, able to gain access to the basement of one of the hospital buildings (zone DJ) and from there into the ground floor of the building in year 2. This probably accounted for their appearance in zones J and DJ. Female 66f had quite a large range in both years of the study. As a kitten she was seen following her mother (54f) over this area. In year 2 66f spent most of her time in zone R, probably due to the appearance of the feeding place referred to above.

### 7.5.2. Nomadic females

The home ranges of the female cats described so far were relatively stable throughout the study and the approximate location of each cat could be predicted with a reasonable degree of accuracy from one visit to the next. Two adult female cats, 9f and 17f, were much less predictable in their ranging behaviour. Female 9f was seen throughout year 1. She gave birth to at least three kittens in zone B in the preliminary study period and remained here during period 1 in spite of the fact that her underground sheltering place was boarded up. At this time food was being provided by patients in zone B and by staff in zone C so occasionally 9f was also recorded in zone C. In period 2, after her kittens had either died or moved away from zone B, 9f began wandering extensively, to group A and to zone E3 (near to group D). In period 3 she was seen frequently in zone A, after the loss of adult cats from group A (described in Chapter 6). Removal of food from zone C and the closure of the ward in zone B may have contributed to 9f's change in home range in year 1. Late in year 1 she was found to be using zone AL (outside the study area) where food was being provided by a member of the hospital staff. In year 2 9f was rarely seen. She began appearing in zone B , where feeding recommenced once the ward became occupied but was clearly also using zone AL (not shown in Fig. 7.3.) and probably areas of the hospital which were inaccessible.

Female 17f lived in zone C for the first six months of year 1. She was fed here regularly and gave birth to a litter of kittens. She was observed on one occasion in period 2 to follow one of these kittens into zone D when members of group D were present. She had not been seen in this group previously and had never appeared to make any attempt to join the group. While present in zone D no aggressive interactions between 17f and members of group D were observed. In period 3, 17f disappeared after her kittens had all presumably died. She had been seen so regularly in zone C that she was thought to have died. However, in period 4 she reappeared in zones D and H2. During the trapping operation 17f was captured outside the study area with a kitten from a second litter. After neutering both cats were returned to the place where they were captured. Nevertheless, in period 5 both reappeared in zone D briefly before disappearing again. Later in year 2 (period 7) 17f returned alone to the area where she had originally lived and remained here until the end of the study. Clearly she had been utilising a small number of zones within the study area and also spent considerable periods outside the study area. The removal of food from zone C in year 1 may have had some effect on her ranging behaviour, but this seems unlikely since when she returned in year 2 there still appeared to be no food available in zone C. She was however occasionally observed feeding at a window in zone B.

### 7.5.3. Resident males

Four male cats were permanent residents in relatively small areas of the habitat throughout the study and exhibited ranging behaviours which showed little change after the cats were neutered. Male 28m was resident in group D during year 1 and showed little change in his home range in year 2 in spite of the environmental changes which occured in zone D. Male 50m was not identified until period 2 in year 1 but appeared to spend most of his time in zone R. In year 2 he spent almost all of his time in this zone, and was seen more frequently, possibly because of an increase in the food available here, as described earlier (Section 7.5.1.)

Male 49m was still a kitten in period 1. He was born to female 9f in zone B and moved into group D early in year 1, where he remained for the duration of the study. This cat showed slightly more movement in year 2, possibly due to the disturbance in zone D but his range remained essentially the same as in year 1. He was occasionally seen walking along the hospital corridors and he probably travelled to zone B (period 8) in this way. Male 68m was also born during the study and did not enter the adult male class until period 3. During year 1 he was only seen infrequently. Once again, this cat probably settled in zone R in year 2 because of the increased food availability.

### 7.5.4. Nomadic males

The remaining males showed ranging behaviour which was more difficult to interpret. In year 1 , male 34m was seen mainly in, around and between zones A and D. He was never permanently resident in any zone. Male 34m was not seen in zone A in year 1 until the original resident males in group A (1m and 11m) and several of the resident females had disappeared (see Section 6.10.). However, during year 2 he continued to visit zone A in spite of the presence of a new (neutered) resident male (53m). It is interesting that throughout the entire study period 34m visited zone D and for most of this time this area contained a large number of cats including several resident males.

Four males which were adult throughout the study showed interesting changes in ranging behaviour in year 2. In period 1 male 44m was seen once in zone F. Later he reappeared covering an extensive range and spent most of his time wandering between groups A and D, but in the last six months of year 1 he appeared to spend slightly more time in zone D than in zone A. After being neutered and returned to the colony 44m was seen almost exclusively in zone D in year 2. Male 53m showed a remarkably similar pattern of behaviour. He first appeared in period 3 of year 1 and wandered between zones A and D, but had a smaller range than 44m. Male 53m was an old cat and he was assumed to have originated from outside the colony. In year 1 he visited groups A and D but spent considerably more time with group A (which at this time consisted of only two adult females: 14f and 19f ). After neutering and return to the colony 53m was seen exclusively and frequently in zone A.

Male 27m was resident in zone D throughout year 1 and was only rarely seen in the adjacent zones. In year 2 he was seen infrequently and began wandering extensively. After the end of period 6 he was not seen in group D , and he began visiting groups A and F but did not appear to permanently join either of these groups. The behaviour of 27m is difficult to interpret. It may be that he left group D because of the permanent presence of 44m in year 2, or because of the disturbance in zone D described earlier. Unfortunately interpretation of 27m's behaviour is further complicated by the fact that after the end of year 2 it was discovered that he had an undescended testicle which was not detected at the time of neutering so that only one testicle had been removed.

Male 52m was not identified until period 2. He wandered extensively , visiting group A and group R (in zone S). In year 2, 52m's range appeared to completely change. He was often seen in zone AJ, around one of the hospital churches and the vicarage, where he was probably being fed. It seems likely that 52m may have lived here in year 1 hiding in the gardens, since the staff of the nearby Nurses' Home reported feeding a cat answering his description for several years.

### 7.5.5. Control males

Finally the ranging behaviour of the three control males must be considered. Male 23m* was not neutered during the study. His home range was similar to that of 34m, as described above, but he was recorded in more zones. He regularly visited groups A and D before and after the colony had been neutered. The absence of entire females in these groups (except 121f who appeared in year 2) did not appear to affect his ranging behaviour. He was seen in zone A at the begining of year 1, when a large number of resident cats, including two males, were present, but 34m was not observed visiting this zone until many of these resident cats disappeared.

Male 29m* was neutered throughout the study. At the beginning of the study he was recorded with 17f in zone C, but later moved to group D. In year 2 he left zone D and disappeared during period 6 , to later reappear in zone B. These changes in range appeared to be partly related to changes in the location of feeding places in zones B and C, and also movements of the cat into and out of the colony since he was treated as a pet by one particular ward and was frequently seen entering buildings via open windows.

Male 65m* was a kitten early in year 1 and entered the adult male class in period 3. He was entire throughout the study, but rarely seen in either year. This cat appeared to leave the colony in year 2 for considerable periods and it was clear that his actual range was much larger than indicated here. However, when present in year 2 he utilised zones in which he had been recorded in year 1, and other adjacent zones.

## 7.6. PERCENTAGE OF SIMILARITY OF HOME RANGES IN YEAR 1 AND 2

A comparison of the mean percentage of similarity of the home ranges of the cats studied in years 1 and 2 suggests that greater changes occurred in the ranges of males than in those of females (Table 7.1.). However, the changes observed in the control males were similar to those observed in the experimental males.

Clearly, some animals of both sexes showed considerable

Table 7.1.

Index (pecentage) of similarity for home ranges in year 1 and year 2. The higher the value of the index the greater the degree of similarity between the ranges in the two years. A value of 100 indicates that no change occurred in year 2.

| | Cat Number | Index (percentage) of similarity | Number of sightings Year 1 | Number of sightings Year 2 |
|---|---|---|---|---|
| Females | 9 | 61•0 | 78 | 5 |
| | 10 | 88•5 | 76 | 104 |
| | 14 | 100•0 | 41 | 75 |
| | 17 | 94•6 | 48 | 20 |
| | 19 | 93•6 | 76 | 78 |
| | 51 | 47•1 | 5 | 28 |
| | 21 | 86•0 | 46 | 60 |
| | 43 | 93•3 | 21 | 30 |
| | 62 | 84•8 | 26 | 33 |
| | 66 | 38•6 | 17 | 43 |
| | | $\bar{x}$ = 78•8 | s = 21•7 | |
| Males | 27 | 35•7 | 52 | 14 |
| | 28 | 84•7 | 55 | 93 |
| | 34 | 80•9 | 30 | 23 |
| | 44 | 35•9 | 40 | 89 |
| | 50 | 63•2 | 20 | 44 |
| | 52 | 3•0 | 18 | 33 |
| | 53 | 44•4 | 27 | 100 |
| | 49 | 90•8 | 68 | 88 |
| | 68 | 28•5 | 9 | 48 |
| | | $\bar{x}$ = 51•9 | s = 29•7 | |
| Control Males | 23 | 68•5 | 34 | 40 |
| | 29 | 54•5 | 44 | 14 |
| | 65 | 40•0 | 4 | 5 |
| | | $\bar{x}$ = 54•3 | s = 14•3 | |

Table 7.2.

Number of sightings of each cat made in each zone.

| | Cat | Number of sightings | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Females | | A | B | C | E2 | E3 | K | L | AF | | | | | | Zone |
| | 9 | 30 | 26 | 8 | 1 | 1 | 6 | 6 | 0 | | | | | | Year 1 |
| | | 1 | 2 | 0 | 0 | 0 | 1 | 0 | 1 | | | | | | Year 2 |
| | | D | H2 | Q | E2 | E3 | | | | | | | | | |
| | 10 | 70 | 3 | 3 | 0 | 0 | | | | | | | | | |
| | | 88 | 0 | 4 | 1 | 11 | | | | | | | | | |
| | | A | | | | | | | | | | | | | |
| | 14 | 41 | | | | | | | | | | | | | |
| | | 75 | | | | | | | | | | | | | |
| | | C | D | H2 | K | B | | | | | | | | | |
| | 17 | 37 | 7 | 1 | 3 | 0 | | | | | | | | | |
| | | 15 | 3 | 0 | 1 | 1 | | | | | | | | | |
| | | A | P | L | M | N | | | | | | | | | |
| | 19 | 75 | 1 | 0 | 0 | 0 | | | | | | | | | |
| | | 73 | 0 | 1 | 3 | 1 | | | | | | | | | |
| | | R | S | T | Y | AO | AC | | | | | | | | |
| | 51 | 1 | 1 | 1 | 1 | 1 | 0 | | | | | | | | |
| | | 19 | 6 | 0 | 0 | 2 | 1 | | | | | | | | |
| | | D | E3 | H2 | I | Q | | | | | | | | | |
| | 21 | 44 | 2 | 0 | 0 | 0 | | | | | | | | | |
| | | 49 | 5 | 3 | 2 | 1 | | | | | | | | | |
| | | D | H2 | J | DJ | | | | | | | | | | |
| | 43 | 20 | 1 | 0 | 0 | | | | | | | | | | |
| | | 27 | 1 | 1 | 1 | | | | | | | | | | |
| | | D | Z | E3 | H2 | J | AE | | | | | | | | |
| | 62 | 25 | 1 | 0 | 0 | 0 | 0 | | | | | | | | |
| | | 28 | 0 | 1 | 2 | 1 | 1 | | | | | | | | |
| | | R | S | U | AB | AC | AD | | | | | | | | |
| | 66 | 3 | 4 | 4 | 1 | 2 | 3 | | | | | | | | |
| | | 34 | 1 | 2 | 1 | 1 | 4 | | | | | | | | |
| Males | | C | D | Q | Z | AE | A | F | G | Z | AM | AP | | | |
| | 27 | 3 | 45 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | | | |
| | | 0 | 5 | 0 | 0 | 0 | 3 | 1 | 1 | 2 | 1 | 1 | | | |
| | | C | D | E2 | E3 | H2 | J | K | Q | | | | | | |
| | 28 | 1 | 44 | 1 | 3 | 2 | 2 | 1 | 1 | | | | | | |
| | | 0 | 87 | 0 | 0 | 5 | 1 | 0 | 0 | | | | | | |
| | | A | B | C | D | Q | AF | AR | AQ | K | L | | | | |
| | 34 | 6 | 3 | 1 | 15 | 2 | 1 | 1 | 1 | 0 | 0 | | | | |
| | | 6 | 2 | 0 | 11 | 1 | 0 | 0 | 0 | 2 | 1 | | | | |
| | | A | B | C | D | E3 | G | H2 | I | K | Q | Z | AE | E1 | |
| | 44 | 12 | 2 | 2 | 13 | 2 | 1 | 2 | 1 | 1 | 1 | 2 | 1 | 0 | |
| | | 0 | 0 | 0 | 85 | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 0 | 1 | |
| | | R | S | U | W | AA | AB | AC | AD | | | | | | |
| | 50 | 9 | 2 | 2 | 1 | 1 | 1 | 2 | 2 | | | | | | |
| | | 36 | 1 | 2 | 0 | 0 | 1 | 0 | 4 | | | | | | |
| | | A | S | V | W | Y | AA | AB | AP | Z | AJ | AM | | | |
| | 52 | 5 | 4 | 2 | 2 | 2 | 1 | 1 | 1 | 0 | 0 | 0 | | | |
| | | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 14 | 13 | 5 | | | |
| | | A | B | D | E3 | H2 | S | | | | | | | | |
| | 53 | 12 | 3 | 8 | 1 | 1 | 2 | | | | | | | | |
| | | 100 | 0 | 0 | 0 | 0 | 0 | | | | | | | | |
| | | D | H2 | Q | B | E3 | K | AE | | | | | | | |
| | 49 | 65 | 1 | 2 | 0 | 0 | 0 | 0 | | | | | | | |
| | | 76 | 2 | 4 | 1 | 3 | 1 | 1 | | | | | | | |
| | | R | S | U | Y | AO | | | | | | | | | |
| | 68 | 2 | 2 | 5 | 0 | 0 | | | | | | | | | |
| | | 38 | 0 | 3 | 1 | 6 | | | | | | | | | |
| Control males | | A | B | C | D | E1 | E2 | K | M | AK | E3 | | | | |
| | 23* | 13 | 2 | 2 | 7 | 1 | 5 | 2 | 1 | 1 | 0 | | | | |
| | | 15 | 1 | 0 | 10 | 4 | 2 | 0 | 0 | 0 | 8 | | | | |
| | | C | D | H2 | K | B | E1 | K | | | | | | | |
| | 29* | 15 | 24 | 2 | 3 | 0 | 0 | 0 | | | | | | | |
| | | 0 | 8 | 0 | 0 | 3 | 1 | 2 | | | | | | | |
| | | R | S | U | Y | AO | | | | | | | | | |
| | 66* | 2 | 1 | 1 | 0 | 0 | | | | | | | | | |
| | | 1 | 0 | 1 | 1 | 2 | | | | | | | | | |

changes in their range while others showed very little change. The low value calculated for the percentage of similarity is in some cases undoubtedly in part due to the small number of sightings made (e.g. 51f and 68m). Nevertheless the changes which were observed in the commonly recorded cats were real (Table 7.2.)

## 7.7. DISCUSSION

Any change in the home range of feral cats after neutering could have implications which would affect the acceptability and usefulness of neutering as a method of managing cat colonies. For example, if home range is reduced then the colony would be more stable in position since its members would be confined to smaller areas than before. This could be desirable in many colonies, such as those in hospitals, where the authorities may wish to completely exclude cats from certain areas. A reduction in the movements of cats may also reduce the transmission of disease. If home range is increased after neutering then there could be an increase in the total area utilised by the colony, which is likely to be undesirable. This could result in the dispersal of some individuals and a consequent reduction in colony stability.

From the human point of view a reduction in home range would appear to be the most desirable effect of neutering that could be expected. However, from the cats' point of view this could have undesirable effects. The local densities of cats could be changes in their range while others showed very little change. The low value calculated for the percentage of similarity is in some cases undoubtedly in part due to the small number of sightings made (e.g. 51f and 68m). Nevertheless the changes which were observed in the commonly recorded cats were real (Table 7.2.)

## 7.7. DISCUSSION

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From the human point of view a reduction in home range would appear to be the most desirable effect of neutering that could be expected. However, from the cats' point of view this could have undesirable effects. The local densities of cats could be increased thereby intensifying competition for food and space, and the social organisation of the colony could be altered if nomadic animals became resident in a particular group with cats they would otherwise rarely have met. (The effect of neutering on the associations between cats in the colony is examined in Chapter 11). Before the effect of neutering can be considered the home range of entire cats must be studied.

A number of recent studies have examined the home range of cats. Macdonald & Apps (1978) used radio-tracking and direct observation to determine the range of a group of farm cats (three adult females and one adult male). The male utilised a home range of approximately 60 ha while the female ranges were between only 2 - 7 ha. All four cats spent most of the daylight hours around one particular farm within an area of 0.8 ha but the male also visited other farms in the vicinity. The female ranges were widely overlapping although each cat had exclusive areas. Laundré (1977) observed individual preferences for certain areas as resting or sleeping sites in a similar study of farm cats.

Tabor (1981) has estimated the home range of female feral cats to be approximately 0.04ha and 0.2ha in two urban areas of London. Using data from various studies he appears to have shown an inverse relationship between the home range of females and the density of cats.

The most detailed study of the home range of feral cats is that of Dards (1979) in Portsmouth dockyard. Using the minimum area method (Mohr, 1947) Dards calculated the mean and standard errors of the ranges of adult females and males to be 0.84ha $\pm$ 0.101 and 8.43ha $\pm$ 1.106 respectively. This ten-fold difference in the size of the male and female ranges is similar to that found by Macdonald & Apps (1978). The sightings of adult females in the dockyard were strongly clumped, showing the use of a 'core area', while those of adult males tended to be more evenly distributed. Most of the females lived in small groups with their young. The group ranges appeared to be relatively stable and did not appear to overlap. Young males remained with their natal group but most emigrated at between one and two years old. Food sites occurred in localised concentrations in the dockyard. Dards (1979) considered that small shared family ranges of females and young were probably the most efficient means of exploiting the food sources. Wandering males utilised transient food supplies in areas seldom or never used by females. The large overlapping range of males and the emigration of young males into new areas probably prevented excessive inbreeding. In general Dards (1979) found that the more favourable the environment, the greater the density of cats and the smaller the home range.

Dards (1979) used precise map co-ordinates in order to accurately determine the size of the home range of individual cats, but she experienced difficulty in examining changes of range with time. In this study home range has been defined in terms of zones. While this approach is less precise than that used by Dards (1979) these zones refer to easily identified specific areas and allow a relatively straightforward analysis of temporal changes in range.

The observations made on the home ranges of feral cats in Winwick Hospital were generally similar to those made by Dards (1979) on the cats in Portsmouth dockyard. Unfortunately the sizes of the ranges observed in these two studies could not be compared because of the differences in the methods used.

Leyhausen (1979) has reported the use of a territory by cats, which he also calls a 'first-order home', and a home range which consists of a number of more or less regularly visited localities connected by an elaborate network of pathways. The areas between these pathways are rarely used. Leyhausen (1979) appears to have experienced difficulty in defining the limits of a territory as he does not interpret the various marking behaviours exhibited by cats (such as spraying urine or depositing faeces) as territorial, and he reports little fighting. (Signs of fighting in the Winwick Hospital colony are discussed in Chapter 13). However, he has suggested that territory should be considered in terms of time as well as space, since animals may use the same areas but at different times. Eaton (1970) has reported that in cheetahs (*Acinonyx jubatus* (Schreber)) the temporal component of territory is more important than the spatial component.

While the use of territories has not been identified in the cats in Winwick Hospital, there is evidence that some males utilise the same areas but at different times, thus reducing the possibility of their meeting. Also, some zones were used intensively while the zones connecting them were used less frequently. This is similar to the concept of regularly visited localities connected by pathways described by Leyhausen (1979). Such pathways were undoubtedly present in this colony but no detailed study of their use was made.

In many species, when territory owners die or are experimentally removed they are rapidly replaced by newcomers. In Great tit (Parus major L. ) populations vacated woodland territories are reoccupied by birds from hedgerow territories where reproductive success is suboptimal (Krebs, 1971). In this species overall fecundity and population size are limited by territorial behaviour, and similar phenomena have been reported in mammals (Healey, 1967; Carl, 1971; Macdonald, 1977).

Although territoriality was not observed in the Winwick Hospital cat colony the movement of 53m into group A in year 1 (i.e. before neutering) after all the original group males had disappeared was interesting. It is not possible to determine how permanent this movement would have been if he had been left entire. Nevertheless, 53m was assumed to have immigrated from outside the colony and for a short time, at least, this movement probably increased his chances of reproducing since at the time of his immigration group A consisted of two adult females.

It is difficult to assess the effect of neutering on the home range of the cats in this study because some individuals of both sexes showed no change after neutering while others showed considerable change. This could be explained in several ways. There may have been different individual behavioural responses to neutering. It is possible that neutering had no effect on range and all of the observed changes were the result of individual responses to local environmental changes. The observed changes in range may have been due to social interactions between the cats, or some combination of several of these factors may have been responsible.

Changes were observed in the home ranges of the control males in year 2 and it therefore appears unlikely that neutering alone was responsible for the changes recorded in the neutered cats. However, the control cats were living in an almost entirely neutered colony in year 2 and the movements of these males may have been affected by the changes which occurred in the remainder of the colony, for example changes in group composition.

Cats born during the study may have changed their home range as they matured. Such changes have been reported by Dards (1979). Maturation may have been responsible for the disappearance of 65m* in year 2 and some of the movements of young cats in year 1.

The location of feeding places clearly affects home range. The ranges of the cats were generally centred around important food sources, particularly in the case of females. The increased availability of food in zone R in year 2 almost certainly led to changes in the ranges of the cats in group R.

The relationship between food sources and home range is unclear. It is difficult to determine whether cats appear where food is provided or food is provided where cats appear. This problem has been discussed by Dards (1979) and Tabor (1981). Similarly, when cats disappear it is difficult to determine whether the cats moved because food was withdrawn, or food was withdrawn after the cats had moved elsewhere. It would be interesting to investigate the relationship between the location and abundance of food sources and the home range and group sizes of cats by experimentally altering the distribution and availability of food in the habitat.

The nomadic males 23m* and 34m both visited groups A and D before and after the colony was neutered. This was interesting because in year 2 there were no entire females present in these groups (except 121f in group D). It may be that the movements of these males should be considered as movements between feeding places, rather than between social groups. If this is the case no change in the movements of the neutered male 34m and the entire male 23m* would be expected after the females in the groups had been neutered. Rosenblatt & Aronson (1958) have shown in laboratory conditions that the degree to which a male cat's sexual behaviour persists after castration depends to a great extent on its prior sexual experience. More experienced cats continued to copulate for a longer period after castration than less experienced cats. In one group of cats sexual behaviour persisted for between 8 months and 3.5 years after castration. This study was conducted using oestrus females. The effect of the presence of neutered females on the sexual behaviour of castrated males does not appear to have been studied. The possibility that neutered males in the Winwick Hospital colony moved between groups of neutered females for sexual reasons connot be entirely discounted, but it is unlikely that neutered females would participate in sexual behaviour in the absence of an oestrus cycle.

During this study the home ranges of the cats may have altered in year 2 due to environmental disturbance, changes in the location of feeding places, social interactions between cats, maturation of young cats or as a result of neutering. Without a carefully controlled study of the factors that affect ranging behaviour in entire and neutered cats it is not possible to say which was the most important. Indeed, it is likely that some of the factors which affected the home range of individual cats were not detected. If neutering does have an effect on range it is undoubtedly not consistent enough to be easily defined.

# 8. DISTRIBUTION OF SIGHTINGS IN TIME

## 8.1. INTRODUCTION

In field studies of mammals it is quite common to find that some individuals are observed frequently whereas others are only rarely seen. Of 161 lions (Panthera leo (L.)) tagged by Schaller (1972) in the Serengeti 86% were resighted and identified at least once while 14% were not seen again. In her study of the home ranges of feral cats in Portsmouth dockyard Dards (1979) did not calculate the size of the ranges of some animals because they were rarely seen.

If any animal is known to have been alive throughout a particular period it should be possible to calculate the probability of sighting that animal during this period. Such a measure of the frequency of appearance in the study population is useful in distinguishing resident animals from nomadic visitors which move into and out of the population, especially if this is used in conjunction with data on home range. Clearly animals which are rarely seen may be spending time outside the study population or they may be hidden within the study area. Information on the extent to which the animal wanders within the study area may help to determine which of these alternatives is true for any individual.

In addition sightings of an animal at different times of the year may be examined to determine whether it appears in the population at regular intervals, at random or at particular times of the year. The method used here calculates an index of dispersion for the sightings of any animal in time, identical to that widely used to study the spatial distribution of organisms, particularly plants (Southwood, 1978).

Using these methods it is possible to describe the frequency and pattern of appearance of individual cats in the colony, to examine the similarities and differences within and between the sexes, and to investigate the possible effects of neutering on these aspects of their behaviour.

## 8.2. METHODS

The presence or absence of each cat on every visit during the study was recorded on the 'Calender of Sightings' referred to in Chapter 5. For each cat the record of its appearances in the

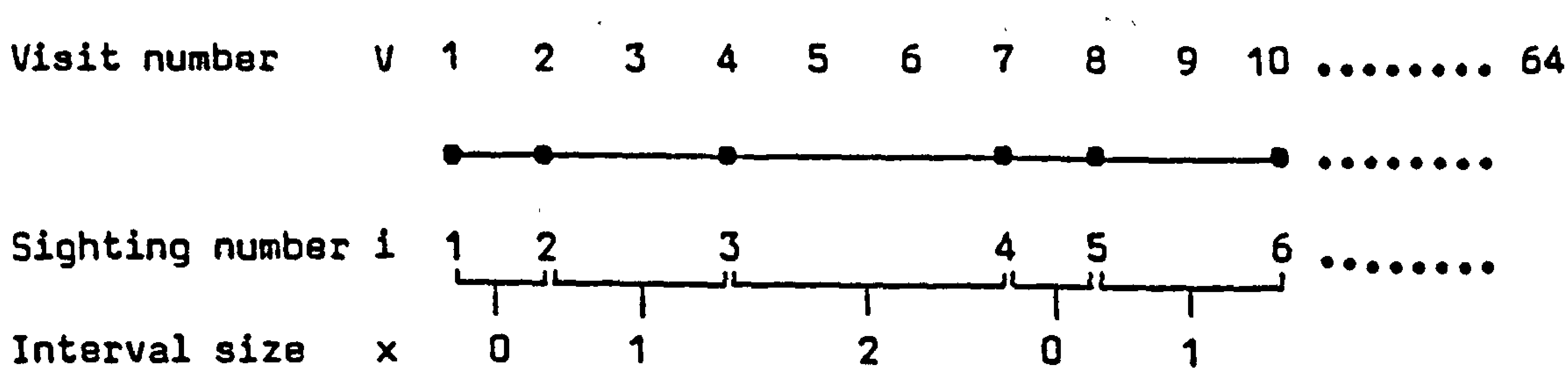



Fig. 8.1. Hypothetical one-dimensional lattice of sightings in time.

colony in each year took the form of a one - dimensional lattice which could contain a maximum of 64 sightings (Fig. 8.1.).

The probability of sighting any cat ($P_s$) was calculated as the number of visits on which the cat was seen as a proportion of the total number of visits on which it could have been present:

$$P_s = N / ( V_n - V_1 + 1 ) \qquad (8.1.)$$

where, N is the total number of sightings of the cat, $V_n$ is the visit number of the last sighting of the cat, and $V_1$ is the visit number of the first sighting of the cat.

For each year $P_s$ was calculated from the first and last sightings, even if the cat was known to have been present before the first or after the last sighting (e.g. neutered cats released between the end of year 1 and the beginning of year 2 were not recorded as present in year 2 until they were actually seen). Possible values of $P_s$ range from 0.016 to 1.0 since 64 visits were made to the colony in each year and the lowest possible number of sightings was one. However, cats which were only seen rarely were excluded from the study and the lowest calculated value of $P_s$ was 0.11. The presence of kittens which eventually entered the adult classes was recorded from the first day they were seen, not from the time they became adults (c.f. treatment of kittens in Chapters 7 and 11.)

The index of dispersion (I) is calculated as:

$$I = \frac{s^2}{\bar{x}} \qquad (8.2.)$$

where $\bar{x}$ is the mean interval between consecutive visits on which a cat was sighted and $s^2$ is the variance of the intervals. The interval between two consecutive sightings, $x$, was calculated as:

$$x = V_{i+1} - V_i - 1 \qquad (8.3.)$$

where $V$ = the visit number on which sighting $_i$ was made. Sightings made on consecutive visits were considered to have an interval of zero (see Fig. 8.1.). The value of I may indicate one of three basic types of distribution for $x$ : random, regular (uniform) or clumped (contagious). These distributions are illustrated in three hypothetical lattices for cats with an identical $P_s$ of 0.52 (Fig. 8.2.).

It is possible to use theoretical distributions as models for these patterns : Poisson (random), Positive Binomial (regular) and Negative Binomial (clumped) (Southwood, 1978). Attempts were made to fit these models to the observed distributions of $x$ but were abandoned due to insufficient data. For a random distribution the variance is equal to the mean (I = 1); for a regular distribution the variance is less than the mean (I < 1); and for a clumped distribution the variance is greater

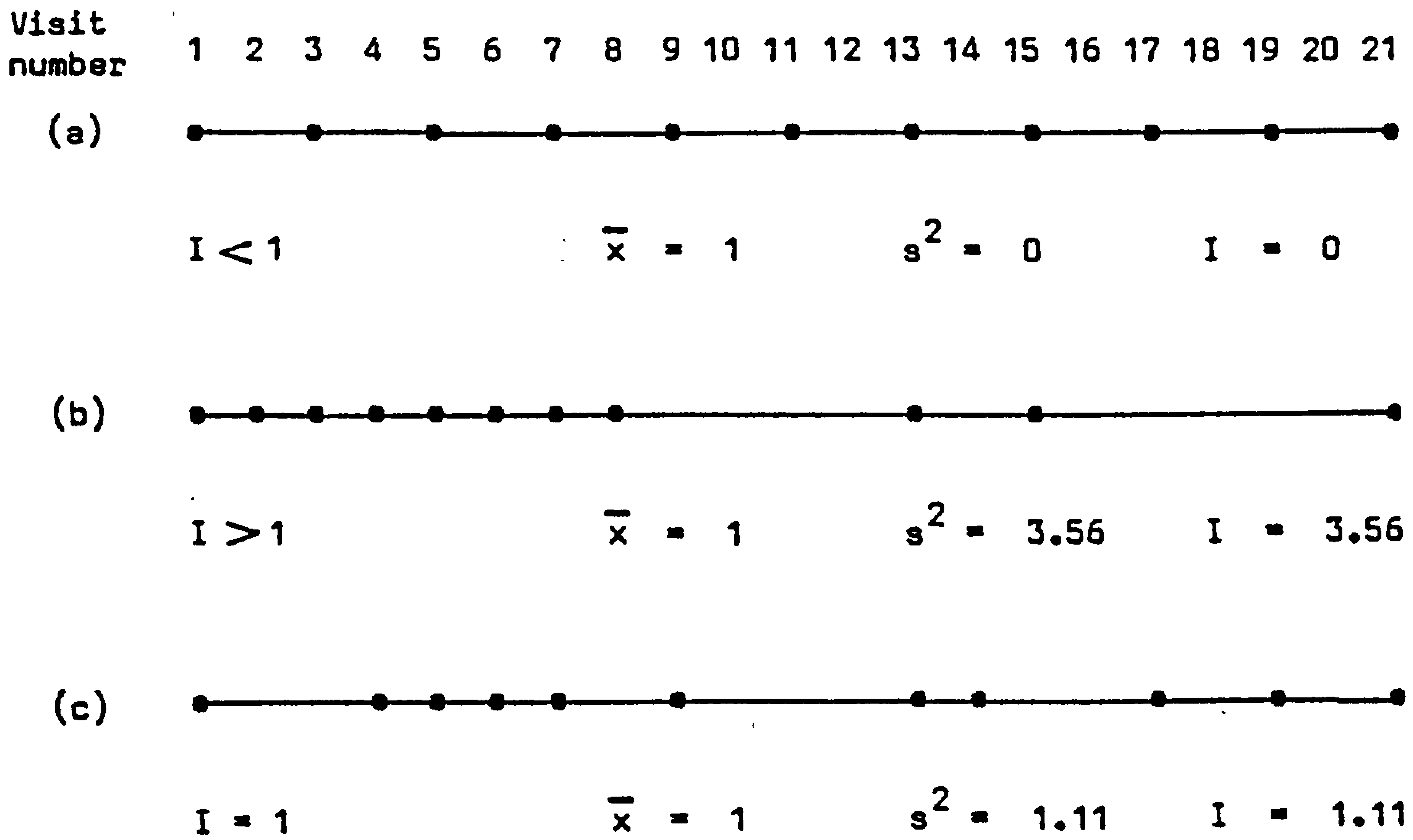



Fig. 8.2 Hypothetical examples of regular (a), clumped (b), and random (c) distributions of sightings in time. In each distribution the total number of sightings is the same (11) giving a probability of sighting of 0.52.

than the mean ($I > 1$). The index of dispersion will often depart from unity even if there is a reasonably good approximation to the Poisson distribution. The significance of any departure can be assessed by calculating a chi - square value with $n - 1$ degrees of freedom:

$$\chi^2 = I\ (n - 1) \qquad (8.4.)$$

where $n$ is the number of observations (intervals between consecutive sightings).

The index of dispersion is useful for distinguishing between different patterns of appearance of animals, but it cannot provide any information about these patterns in relation to any time scale. For example, two distributions may have the same value for $I$ (and $P_s$ ) indicating the same degree of clumping, but with the clumped sightings at opposite ends of the time scale (Fig. 8.3.).

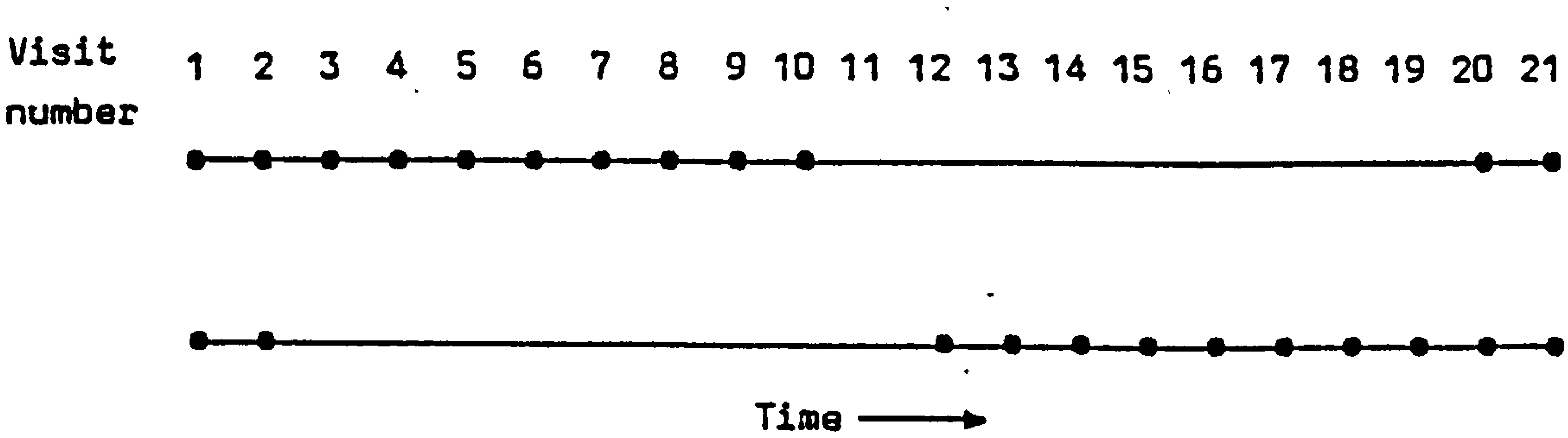



Fig. 8.3. Two hypothetical distributions of sighting in time which have the same values for $P_s$ (0.57) and I (8.98). These distributions only appear different if examined in relation to time.

In order to examine the precise times at which a cat was present or absent during the study the Calender of Sightings must be studied.

## 8.3. PROBABILITY OF SIGHTING

A Calender of Sightings is presented for each year of the study (Fig.8.4.). All visits on which each cat was seen are indicated between and including the first and last sighting in each year. For the purposes of studying the distribution of sightings in time cats were only considered to be present between the first and last sightings made in any year. The last occasion on which a cat was seen in any year does not necessarily indicate the time of its disappearance from the colony. Cats which died or disappeared during the study are indicated in Table 6.1.

Considerable variation was observed in the value of $P_s$ for cats in the population in both years of the study, values ranging from around 0.1 to over 0.9 (i.e. seen on approximately 10% and 90% of all possible visits, respectively) (Fig. 8.5.) None of the cats was seen on every visit between its first and last sighting in any year. Clearly some cats of both sexes were seen very frequently while others were rarely seen. It must be remembered that cats which were seen on only a very small number of occasions, and which would therefore have a very low $P_s$, have been excluded from the study and as a result many cats which would have a $P_s$ between zero

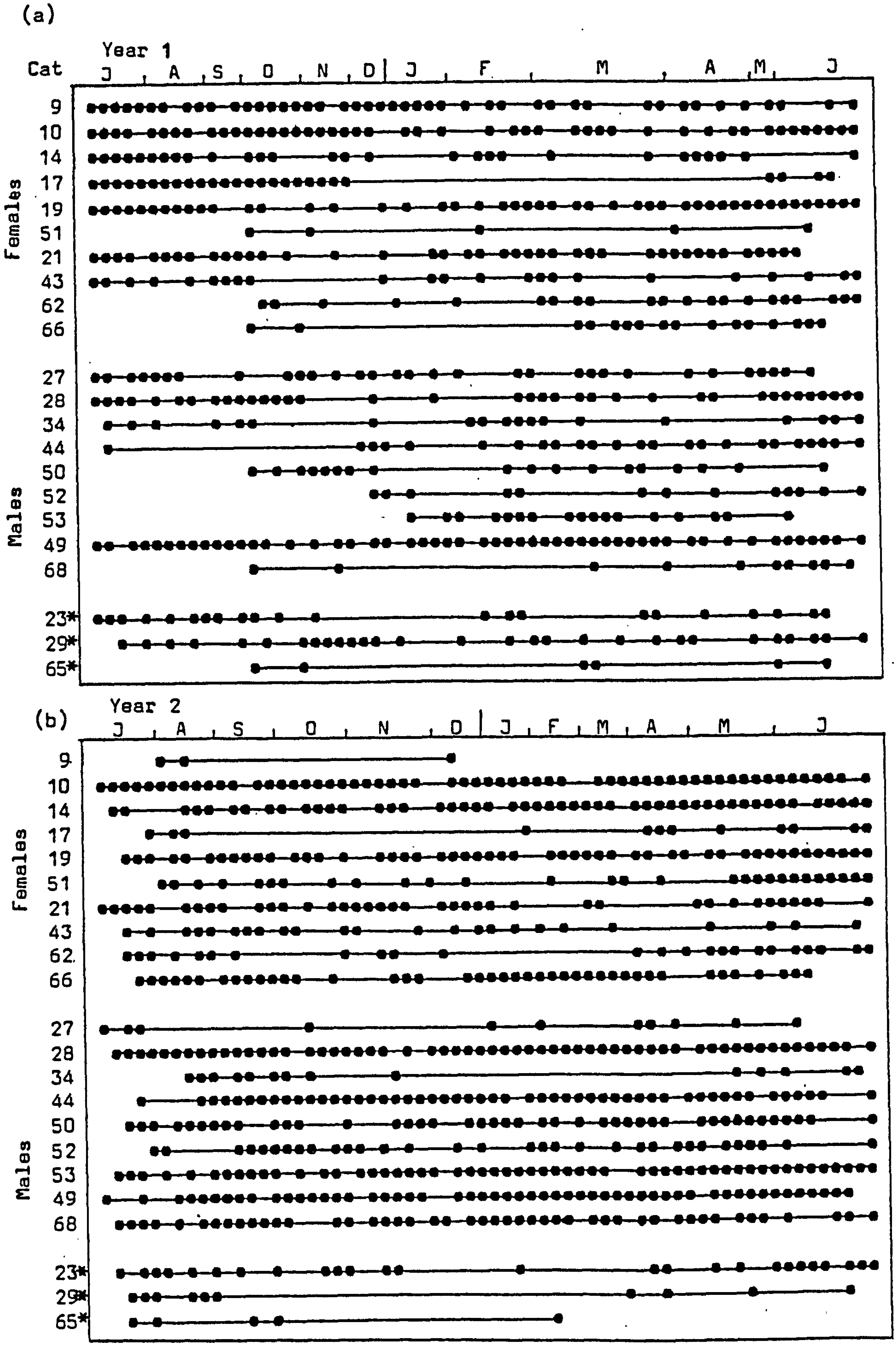



Fig. 8.4. Calendar of Sightings for the study cats for year 1 (a) and year 2 (b).

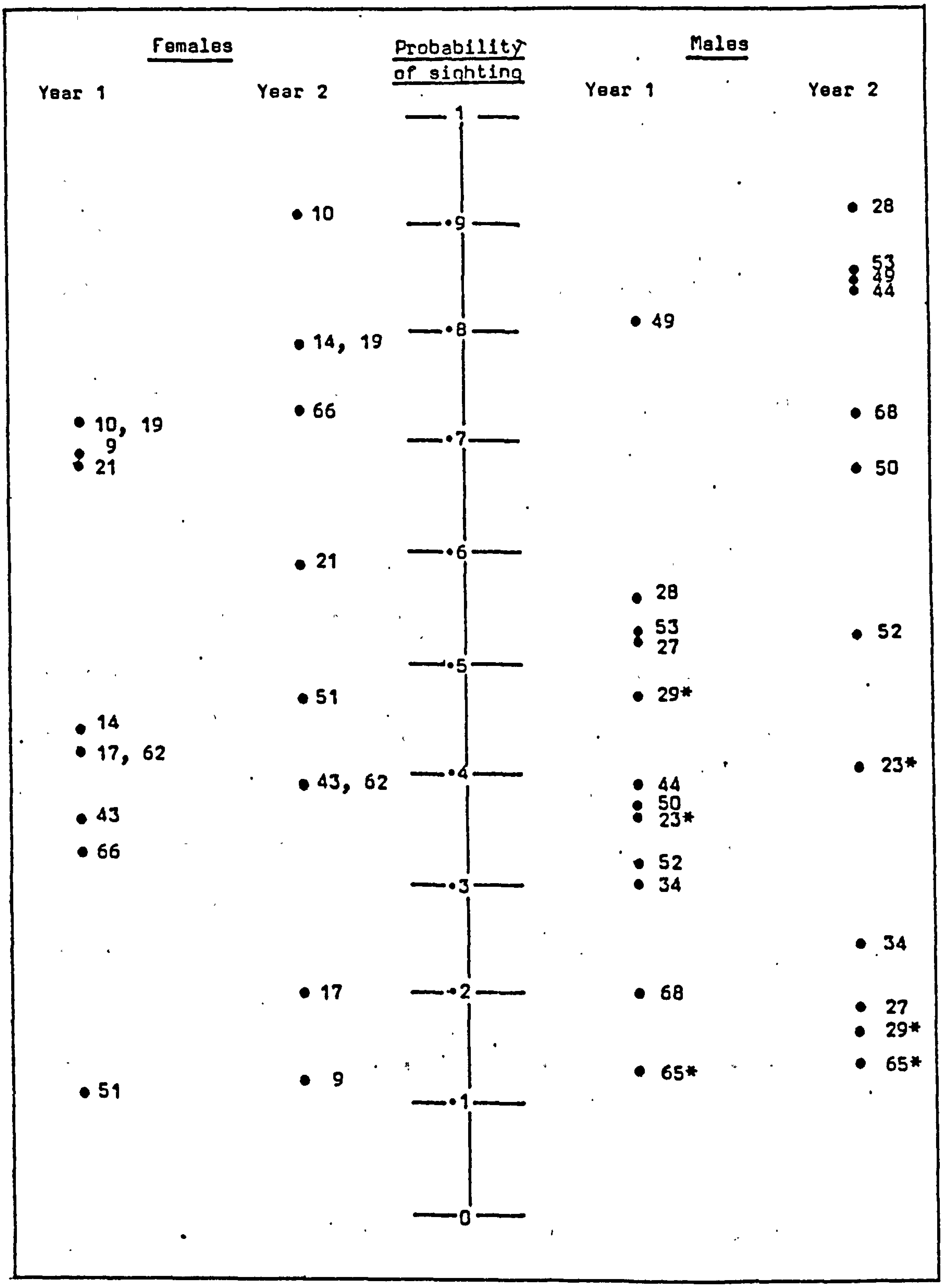



Fig. 8.5. Probability of sighting each cat in year 1 and year 2.

and 0.1 have been omitted from Fig. 8.5.

The $P_s$ values of both sexes showed an increase in range in year 2 (see Table 10.3. ) with more cats having high $P_s$ values than in year 1. However, it is not possible to generalise about the effects of neutering on $P_s$ since some cats of both sexes were seen more frequently in year 2 than in year 1, while others were seen less frequently in year 2, and some showed little or no change.

In both years of the study there were resident and nomadic cats of both sexes present in the colony. (see Chapter 7). This is reflected by the $P_s$ values calculated since, in general, resident cats (e.g. 10f, 19f, 28m and 49m) had higher $P_s$ values than nomadic cats (e.g. 17f, 23m* and 34m). Some cats changed from behaving like residents in year 1 to behaving like nomads in year 2 (e.g. 27m ), while the opposite was observed in other cats (e.g. 44m and 53m ). Many of the differences in $P_s$ observed between the two study years appear to have been related to changes which occurred in the home ranges of individual cats.

Little change in $P_s$ was seen between the two study years in males 34m and 49m or in females 19f, 43f and 62f. Earlier examination of the home ranges of these animals indicated that little change occured between years (see Chapter 7).

A high proportion of the remaining cats showed a substantial increase in $P_s$ in year 2. Female 14f was seen infrequently in year 1 after the disappearance of other cats from zone A. As discussed in Chapter 6 human disturbance to group A may have been responsible for this. In year 2, 14f was seen much more frequently. Female 10f and male 28m were both members of group D. They were seen more frequently in year 2 than in year 1, in spite of the movement of patients away from the ward in zone D for most of the year, which probably resulted in a decrease in the available food.

Members of group R (50m, 68m, 51f and 66f ) had a higher $P_s$ value in year 2, probably due to the increased provision of food in zone R discussed in chapter 7. It is possible that increased feeding made the animals more likely to be seen in the open near the windows from which they were being fed, and that even when food was not provided they waited here in anticipation.

Males 44m and 53m were seen more frequently in year 2 because they became permanent residents in groups D and A respectively, after migrating between groups in year 1 , making them less likely to be seen. Male 52m showed an increase in $P_s$ between the years apparently because he settled in and around zone AJ in year 2 , after wandering extensively in year 1 . However, it seems likely that he was present in the vicinity of zone AJ early in year 1 but remained undiscovered until later, thus making the observed change in $P_s$ unreliable.

Four of the study cats showed a considerable decrease in $P_s$. Female 21f appeared more timid in year 2 and consequently had a lower $P_s$. This may have been an effect of disturbance in zone D. After remaining in group D as a resident male in year 1, 27m moved away in year 2 and became nomadic, with a consequent decrease in $P_s$. Female 17f was not recorded in the colony for a considerable part of year 1 and was also absent for several periods in year 2. The total period of her absence was longer in year 2 resulting in a lower $P_s$. The movement of female 9f outside the study area in year 2 greatly reduced her $P_s$ but she was undoubtedly still part of the colony.

Among the control male cats, 23m* showed little change in $P_s$ between study years. The ward cat 29m* was seen less frequently in year 2 and appeared to have spent more time inside the hospital buildings in this second year. Male 65m* showed little change in $P_s$. However, in year 1 he was probably often hidden within the study area (as a kitten and young adult) whereas in year 2 he probably spent considerable periods outside the study area, when he was older.

## 8.4. DISPERSION OF SIGHTINGS IN TIME

The index of dispersion, I, may be used to indicate whether data follow a random, regular or clumped distribution (see Section 8.2.).

Males and females showed a variety of distributions in time in both years of the study, ranging from highly clumped to regular or random (Fig. 8.6.). In general the higher the value of I, the greater the degree of clumping i.e. the greater the tendency for the cat to exhibit specific periods of presence and absence.

Most of the females in year 1 had values of I between approximately 1.4 and 4.0, and between 1.0 and 3.3 in year 2. However, in both years a small number of females had values of I which were exceptionally high, indicating a high degree of clumping. The highest value of I recorded was approximately 32.1, for 17f in year 1 (see Section 8.5.).

The males exhibited a range of values of I from less than 1.0 to approximately 10.0 in year 1 with individuals more or less evenly spread within this range. In year 2, the maximum value of I increased to over 20.0, and three individuals (29m*, 34m and 65m*) appeared to exhibit distributions of sightings in time which were considerably more clumped than those of the other males.

Unfortunately the amount of data available for each

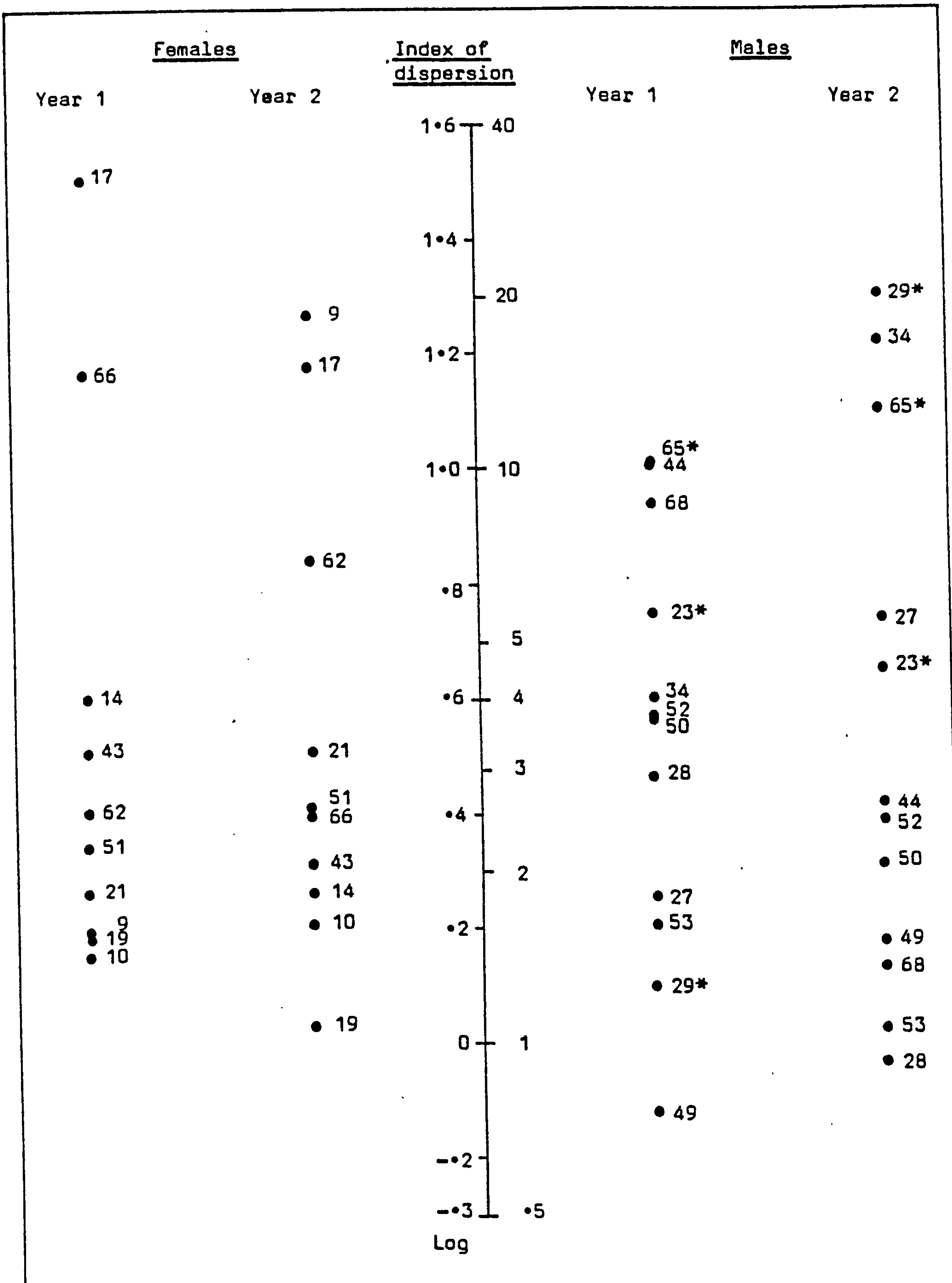



Fig. 8.6. Index of dispersion of sightings in time of each cat in year 1 and year 2. Note log scale.

cat was not sufficient to allow the fitting of a specific model to the distribution of its sightings in time since none of the cats was seen on more than 58 visits in any single year of the study. The calculated values of I are useful for examining differences in the distribution of sightings in time between the sexes in each year, and differences within the sexes before and after neutering. A statistical treatment of these differences is presented in Chapter 10.

The use of the chi - square test described in Section 8.2. (equation 8.4.) allows departures from a random distribution to be identified. The values of I were significantly greater than unity ($\underline{P} < 0.05$) for almost all cats in both years, indicating a clumped distribution of sightings. Only two females had values of I which were not significantly greater than 1 : 51f in year 1 ($\underline{P} = 0.09$) although this was based on only five sightings, and 19f in year 2 ($\underline{P} = 0.36$). Males with values of I not significantly greater than 1 were 49m ($\underline{P} = 0.87$) and 29m* ($\underline{P} = 0.16$) in year 1, 28m ($\underline{P} = 0.63$) and 68m ($\underline{P} = 0.06$) in year 2, and 53m in both years ($\underline{P} = 0.06$ in year 1 and $\underline{P} = 0.33$ in year 2 ). Of these only 49m in year 1 and 28m in year 2 had values of I which were less than 1, indicating a regular distribution of sightings. The remaining cats appeared to be recorded in the colony at random time intervals.

The index of dispersion is generally used to examine distributions in two-dimensional space, for example in studying the dispersion of plants. In such studies the meaning of I is well understood and the concepts of random, regular and clumped distributions in space are familiar. However, values of I calculated for distributions in time are difficult to interpret because sightings in time must have a definite temporal sequence (in one dimension) and this sequence can not be indicated by I itself. The sequence is important because it describes the behaviour of an individual cat in detail and this can only be studied by examining the Calendar of Sightings.

## 8.5. CHANGES IN THE DISTRIBUTION OF SIGHTINGS OF INDIVIDUAL CATS

### 8.5.1. Females

Most of the female cats were continuously present in the colony throughout year 1. Females 9f, 10f, 14f, 19f, 21f and 43f were all seen frequently. The animals were probably sheltering out of sight on the occasions when they were not recorded. Individual differences in the probability of sighting these cats were probably due to variation in the extent to which they used cover, how approachable the animals were, and the amount of disturbance they were subjected to during the year.

In year 2, 10f, 14f, 19f and 43f behaved almost exactly as in year 1 (although 43f tended to use the basement area zone DJ in year 2 which had previously been less accessible, and 14f was seen more frequently in year 2). Female 9f was using areas outside the study area and because of this she was rarely seen in year 2. As it appeared to have begun in year 1 this change in behaviour was not considered to have been an effect of neutering. Female 21f was considered to be continuously present during year 2, but was rarely seen during February, March and April.

The winter of 1978 - 9 (year 1) was severe and snow covered the ground in Winwick Hospital for long periods. It is possible that some cats which were sheltering at this time were seen more frequently and more regularly in year 2 because the winter was milder.

Females 62f and 66f were present continuously during year 1 but were often not recorded. Both cats were born during the study and were still kittens during the winter of year 1, when they were rarely seen. In year 2, 62f was also sheltering during the winter , probably in the basement zone DJ. Female 66f was seen almost continuously in year 2 except for the period between October and December. It is likely that she was seen more frequently in year 2 due to an increase in feeding by patients in zone R (see Section 7.5.1.).

Female 51f was seen on only five visits during year 1 at fairly regular intervals from October 1977 when she was first discovered. She was probably present in the colony continuously in year 1 but appeared to be spending most of her time in an inaccessible part of the hospital grounds (see Section 7.5.1.). She was seen more frequently in year 2, possibly due to the presence of food in zone R referred to above.

In year 1, 17f was present on each visit from July to the end of November 1978 and then she disappeared completely until May 1979. She was probably living outside the study area (but still within the hospital grounds) during this period (see Section 7.5.2.). This change in home range accounts for the high index of dispersion calculated for this cat. In year 2 she behaved similarly and appeared to be absent from the study area for extensive periods.

### 8.5.2. Males

The only male cat which showed no change in the distribution of sightings with time between the two study years was 49m. This cat was continuously present throughout the study and was never absent from recordings made on more than two consecutive visits. This stability in behaviour is interesting in view of the fact that 49m was born during the preliminary study period. The remaining male cats showed considerable changes in behaviour between the two years.

Male 27m was resident in group D in year 1 and he was frequently recorded. However, he apparently showed short periods of absence. In year 2 this cat was only seen occasionally and appeared to be absent for long periods, sometimes several months. At this time 27m was wandering more and he was possibly spending periods of time outside the study area (see Section 7.5.4.).

In year 1, 28m was seen frequently between June and October but only rarely during the winter, probably because he was sheltering. In the following spring and summer 28m was seen on most visits. In year 2 this cat was seen on all but six visits. This cat was considered to have been present continuously throughout the study.

Male 50m was not discovered until October 1978 but was probably present from the beginning of the study. It is likely that he was hiding in inaccessible areas on the east side of the hospital at this time. Even after he was discovered 50m had a low $P_s$. In year 2 he was much more frequently seen (with only short periods of apparent absence) possibly due to the provision of food in zone R. Male 50m was never observed leaving the colony and he was considered to have been a permanent resident in both years.

Male 68m was born during year 1 and was rarely seen as a kitten. In year 2 he was seen on most visits. Once again this may have been due to the presence of food in zone R. It is unlikely that this cat spent any time outside the colony during the study.

Male 34m was seen throughout year 1 but was known to have been visiting areas outside the study area. On occasions he was recorded on several consecutive visits to the colony but sometimes he appeared to be absent for periods of up to several months. In year 2, 34m still appeared to be visiting the colony throughout the year, but with an absence of some six months between November and May. He was, however, still recorded in the colony at the end of year 2.

In July of year 1, 44m was recorded for the first time, but he was not seen again until the following December. It is possible that 44m was living in an inaccessible part of the hospital during this period. Alternatively, he may have been living completely outside the study area. In year 2 he settled in zone D and was seen here consistently on almost every visit apart from an apparent absence immediately after neutering. Male 44m appeared to have immigrated into the colony in year 1 (see Section 7.5.4.).

Male 53m was first seen in January 1979 (year 1), and thereafter quite frequently in groups A and D. He also appeared to be an immigrant in year 1 but settled in group A in year 2. Male 53m was recorded in zone A on almost every visit, and was considered to have been continuously present here during the second year of the study. It is possible that this cat was continuously present in the colony from the time of his first appearance but was recorded less frequently in year 1 because of his movements.

Male 52m was not discovered until December of year 1 and thereafter he was only seen infrequently. He was more frequently observed in year 2, often resting in the vicarage gardens (zone AJ). It is possible that he was being fed here as the vicar had a pet cat. It is also likely that 52m originated from this area but was not seen in year 1 until he began wandering around the west side of the hospital (see Section 7.5.4.).

While clumping of sightings of female cats appears to have been due to difficulty in finding cats which were sheltering rather than periods of absence from the colony (except 17f) it seems likely that some male cats spent considerable periods outside the study area.

8.5.3. Control Males

One of the control males showed little change in the distribution of sightings between the two years. Male 23m* was seen frequently between July and early November 1978 but then appeared to be absent until February 1979 (year 1). In year 2 he was also seen frequently, apart from during the winter months. This cat was not continuously present in the colony during the study and was occasionally observed leaving the study area.

The ward cat 29m* , which was neutered throughout the study, showed apparent periods of absence during year 1 which were probably due to spending time inside hospital buildings. In year 2 he appeared to spend more time inside the buildings and was not recorded in the colony between August 1979 and the end of May 1980.

Male 65m* was born in year 1 and seen infrequently as a kitten. He was particularly timid and spent a considerable amount of time sheltering. In year 2, 65m* appeared to leave the colony and was only seen occasionally. He was, however, still appearing in the colony at the end of year 2.

It is clear that in the absence of neutering changes in the distribution of sightings may occur due to changes in the environment. It is therefore difficult to determine which changes are due to neutering and which are not.

## 8.6. DISCUSSION

The effects of neutering on the distribution of sightings of the cats in time are difficult to assess. It is possible that neutering made some cats more approachable (and therefore more likely to be seen) but it is also possible that familiarity with man and increased feeding may have had this effect. If the home range of a cat changed this may have affected the distribution of sightings in time, for example by increasing or decreasing the probability of sighting. Changes which occur with age may also have affected the distribution of sightings, for example kittens tend to be seen only rarely when young.

The distribution of sightings in time is influenced by many things. It is in part a function of the animal's response to its environment, but it is also affected by changes in the observer's ability to find the animal at different times. The measurement of the distribution of sightings in time of an individual animal may be affected by changes in the physical environment (for example disturbance to buildings, weather) or changes in the biological environment (for example changes in the vegetation cover or interactions between animals in the population). Chance also plays a part in determining whether or not an animal is seen.

If a cat was not recorded in the colony on any particular visit it could have been outside the study area or hidden within the study area. Clearly, which of these alternatives was true could not be determined except when the cat was observed outside the study area. Within the study area a cat could remain hidden in vegetation, inside, under or on the roofs of buildings or in the underground duct system. It is also possible that some cats spent some time in the inaccessible parts of the hospital which were excluded from the study (see Section 5.3.2.).

Obviously, it was not possible to know whether or not any cat was present in the colony on days when visits were not made to the hospital. Cats which appeared to be absent for many months could have been visiting the colony undetected, perhaps even on a day when the hospital was visited, but at a different time. However, some cats were seen so frequently in the colony that it must be assumed that those which were rarely seen were rarely present, except in cases where timid cats were known to use particular sheltering places or were only seen at particular times of the day (e.g. group F ).

In spite of the many difficulties encountered in interpreting data on the presence and apparent absence of cats throughout the study the behaviour of most cats was clear. Cats which had small home ranges and were frequently seen were undoubtedly residents which occasionally sheltered in places where they could not be detected. Other cats which utilised extensive ranges and were seen only infrequently were probably spending considerable periods outside the colony and could be considered to be nomadic visitors. In theory a nomadic cat with a $P_s$ of less than 0.5 was spending more than 50% of its time elsewhere. Some of the cats did not fit clearly into either of these categories, particularly the immigrant males which appeared to change their behaviour (from nomadic to residential ).

The precise effect of neutering on the pattern of appearance of cats in the colony could not be determined because of the variations in behaviour shown by individuals. This problem was encountered when the effect of neutering on home ranges was examined (Chapter 7 ). Some cats of both sexes appeared to be unaffected by neutering; some were nomadic before neutering and became residents after the operation; others were residents before the operation but became nomadic afterwards. The extent to which these changes would have occured if the animals had not been neutered could not be determined, but it was possible that environmental factors may have played a part. Changes in the social structure of the colony may also have been important (Chapter 6 ).

It is possible that some of the apparent changes in the distribution of sightings in time may have been a product of the experimental design. Care was taken during the study to conduct each visit in the same manner: the zones were examined in the same sequence on each occasion with heavily vegetated zones visited twice in an attempt to increase the chance of finding cats which were hidden. This was done in order to reduce the effect of vegetation cover on $P_s$ (the field methods used have been described in detail in Chapter 5). Unfortunately it was not possible to make the same number of visits to the colony in each month of each year. Ideally, the same number of visits should have been made each month, recordings should have covered different periods of the day and both years of the study should have been organised in precisely the same way. However, even if this had been possible there would have been no way of keeping environmental conditions (such as the weather, the amount of vegetation cover, access to sheltering places and food ) constant for a period of two years. Consequently, it would still have been impossible to clearly separate the effects of the environment from the effects of neutering.

The methods used here had a number of shortcomings. Nevertheless they have allowed a quantitative distinction to be made between cats which were seen frequently and cats which were seen very rarely. Animals which were present only for distinct periods of the year have also been identified. While the precise effect, if any, of neutering on the distribution of sightings in time could not be determined it is clear that the cats did not suddenly disappear or become more wary of man after neutering. The methods used here would certainly have been sensitive enough to detect such changes had they occurred.

# 9. INDEX OF SOCIABILITY

## 9.1. INTRODUCTION

Leyhausen (1979) considers that most species of cats (including the domestic cat) are asocial and that the only species which lives in social communities is the lion (Panthera leo). However, it is clear from recent studies that to categorise an entire species as social or asocial is an oversimplification. Different degrees of sociability may be observed between individuals of the same species and also the degree of sociability exhibited by any individual may change with time.

The feral cats studied by Dards (1979) in Portsmouth dockyard lived in small social groups but some individuals of both sexes had a solitary existence. Feral cats living on remote islands appear to be more solitary than those which have been studied in urban areas (van Aarde, 1978; Corbett, 1980). Schaller (1972) observed that members of a pride of lions are not always together but may be scattered singly and in groups within the confines of a pride area, and that tigers (Panthera tigris L.), although essentially solitary may occasionally meet and share a kill.

In order to quantify the degree of sociability exhibited by the cats at Winwick Hospital and to examine the effect of neutering on this aspect of their behaviour an index of sociability was calculated. The purpose of this index was to provide a single value for each individual animal which could be used to characterise its social behaviour in each year of the study. A detailed analysis of the social organisation of the population and the specific associations which were observed between individual cats is presented in Chapter 11.

## 9.2. METHODS

The index of sociability (S) is a simple measure of the extent to which any cat tended to be observed in a group, calculated as:

$$S = 1 - \frac{l}{T} \qquad (9.1.).$$

where $l$ is the number of occasions on which the cat was seen alone, and $T$ is the total number of occasions on which the cat was seen. A single value of $S$ was calculated for each year of the study. (Values of $T$ are given in Table 6.1.).

Values of $S$ may range from zero (completely asocial, always seen alone) to 1.0 (completely social, never seen alone).

In calculating $S$ the presence of kittens (individuals under six months old) was ignored. The inclusion of kittens as members of a group may have resulted in females with litters appearing particularly social even if they rarely associated with other adults. It may also have led to an apparent decrease in sociability after neutering due to the reduction in the kitten population.

The problem of determining when two individuals should be considered to be together has been discussed in Chapter 5 and the conventions described apply to the calculation of S. A statistical comparison of the mean values of S calculated for each sex in each year of the study is presented in Section 10.5.

## 9.3. CHANGES IN THE SOCIABILITY OF INDIVIDUAL CATS

### 9.3.1. Females

In the first year of the study six females (10f, 14f, 19f, 21f, 43f, and 62f) had an index of sociability greater than 0.8 and were therefore highly social (Fig. 9.1.). These animals showed little change in year 2. Females 14f and 19f lived in a group in zone A. The other four females all lived together in zone D. It is interesting that the three females which had the highest values of S in year 1 (21f, 43f and 62f) were all kittens for part of this period. Females 43f and 62f were born in zone D and remained here throughout the study.

Females 9f and 17f were essentially solitary throughout the study but occasionally associated with other cats.

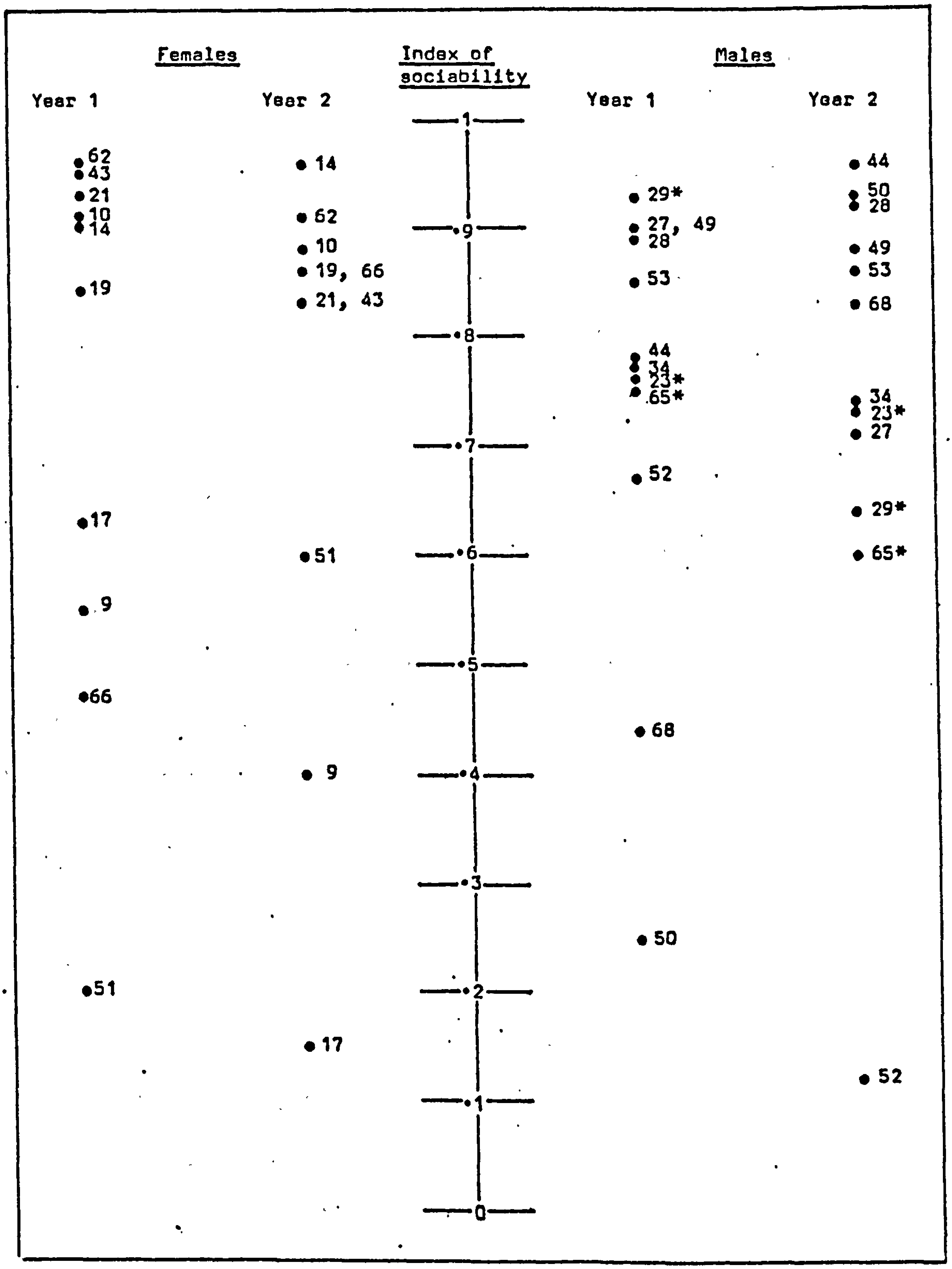



Fig. 9.1. Index of sociability for each cat in year 1 and year 2.

In year 1 female 9f sometimes associated with cats from groups A and D. In year 2 she moved to zone AL which was rarely visited by other cats. Female 17f lived in zone C in year 1 and was visited here by a number of cats, particularly males. She spent a considerable time outside the study area in both years of the study but appeared to be absent more frequently in year 2, thus reducing her opportunities to associate with other cats.

Females 51f and 66f were the least social females in year 1 but became more social in year 2, probably due to an increase in the availability of food in zone R which resulted in several cats being seen together in this area. In year 1, 51f was rarely seen, but was almost always alone. Female 66f was a kitten for part of this period and spent a considerable time alone.

## 9.3.2. Males

Most of the experimental males were social in year 1. Males 27m, 28m, 34m, 44m, 49m, 52m and 53m all had an index of sociability greater than 0.65. In year 2 a total of seven males had a value of S greater than 0.7.

Males 28m, 34m, 49m and 53m showed little change and remained social in year 2. Two of these animals, 28m and 49m, were resident in group D throughout the study, while 34m, who was less social, was nomadic and visited groups A and D in both years of the study. Male 53m visited these groups in year 1 and eventually settled in year 2 in zone A, where he was regularly observed with females 14f and 19f.

In year 1 male 27m lived in group D and was highly social. However, in year 2 he became nomadic, wandering between groups A and D. He was seen less frequently at this time and was more often alone. In year 2 male 52m also showed a decrease in sociability. (During the first year of the study he visited group A and the cats living on the east side of the hospital). In year 2 he moved away from these groups and appeared to take up a more or less solitary existence.

Male 44m became more social in year 2. He was nomadic in year 1, wandering between groups A and D. He eventually settled in group D where the chance of observing him with other cats was very high.

Male 68m was a kitten in year 1 (from the same litter as 66f and 65m* ) living in group R. Male 50m was also a member of this group. He was usually seen alone in year 1. In year 2 these cats were more social and tended to be more likely to be seen together and with other members of the group due to an increase in feeding in zone R.

9.3.3. Control males

Male 23m* showed little change in sociability in year 2. He had a value of S in each year which was almost identical to that of 34m. Both of these cats were nomadic and visited groups A and D in each year, but 34m was neutered in year 2 while 23m* remained entire.

The ward cat 29m* had the highest value of S recorded for any male in year 1. He associated with cats in group D and also with cats in zones B and C. Male 29m* was seen less frequently in year 2. He was often recorded in zone B where there were no resident cats for most of year 2.

In year 1, 65m* was a kitten and was observed with his mother and other members of the litter. In the second year of the study he appeared to leave the colony and only occasionally returned to associate with the other members of group R.

No consistent changes in sociability were recorded in the experimental animals after neutering. In each year of the study some individuals of each sex were highly social while others had an essentially solitary existence. After neutering some individuals of each sex showed an increase in sociability while others showed a decrease. Many showed little or no change at all. The extent to which the observed changes in sociability were due to neutering was difficult to assess especially in view of the fact that two of the control males also showed changes in year 2.

## 9.4. DISCUSSION

The degree of sociability exhibited by the feral cats at Winwick Hospital varied between individuals. Both sexes included social and asocial cats (before and after neutering) but the animals did not clearly fall into these two simple categories.

Dards (1979) observed a similar situation among the feral cats in Portsmouth dockyard. She classified the female cats into solitary animals or group members on the basis of their relationships to other cats and shared ranges. Dards examined the percentage of times 91 adult female cats were seen 'with' or 'near' other adult females. For individual females this percentage varied between zero and 92% , with a mean of 51.5% . The average percentage of occasions on which female cats were seen with other adult females was 58.9% for 70 group females, 7.4% for 13 solitary females, and 15.5% for eight females which were solitary for only part of the study period. Dards (1979) did not examine in detail the associations between females and males or between individual males and other males. However, some males in the dockyard assumed the rôle of the pride lions described by Schaller (1972) and were frequently seen with a particular social group, while others were more nomadic, and presumably more solitary.

Dards' (1979) figures for the percentage of occasions on which each adult female was seen with other adult females may be compared with the index of sociability calculated in this study by multiplying S by 100. (Means for S are given for each sex in each year in Table 10.5.). However, it must be remembered that S takes into account associations between all adult cats, regardless of sex.

In the Serengeti, Schaller (1972) found prides of lions to consist of two to four adult males, several adult females, and a number of subadults and cubs. Schaller divided the Serengeti lions into two basic types: residents and nomads. Of 3111 nomads recorded in 1099 groups 330 (10%) were alone. Approximately 30% of the groups were of solitary lions, while about 35% of the groups were pairs of animals. The maximum number of nomads recorded together was 13. Of the 330 lions seen alone 47% were adult males, 22% were subadult males, 27% were adult females, 3% were subadult females and 1% were large cubs. Among the nomadic male lions as many as five associated together but single animals or groups of two were the most common.

Interpretation of the values of S presented in Section 9.3. depends upon a clear understanding of the method used in its calculation. The value of S for any cat is not affected by the number of cats with which it associates on any single occasion. A cat which regularly associates with only one cat will have the same value of S as a cat which associates, on the same number of occasions, with many cats. Also, S can not indicate the total number of different individuals with which a cat associates over a long period,or their sex. It is therefore not possible to determine from values of S alone whether any cat associated with more or fewer cats after neutering or whether it was recorded in smaller or larger groups.

It would have been possible to devise an index which could take into account the number of individuals with which any cat associated, perhaps by calculating the mean number of animals in groups in which it was present. However, this could have been misleading since a small number of encounters with a large group may have made a cat appear social even if it spent most of its time alone. The approach taken here has been to keep the index of sociability as simple as possible and to use a more complex method of analysis elsewhere to examine the associations between individual cats in detail (Chapter 11.).

The calculation of S takes into account associations between the study cats and all of the other cats in the colony. Fewer adult cats were present in the colony in year 2 (38 cats) than in year 1 (45 cats). This could have resulted in a decrease in the index of sociability for some cats in year 2 simply due to a reduction in the number of cats available for association. For example, 24m and 26m both associated with 9f in year 1 , but these two males were not present in the colony in year 2. However, few of the cats showed a decrease in S in year 2 so the decrease in the number of adult cats present in this year probably had little effect.

It, is difficult to determine the causes of the observed changes in sociability in year 2 of the study. At least some of the changes in S appeared to be a result of changes in the environment which caused changes in home range. For example, the provision of food in zone R appeared to attract cats to this area and may have made it more likely that they would be observed together. It is thus possible that a change in S may be due to an alteration in some other characteristic of the animal which may or may not be an effect of neutering.

Sociability may have changed as a result of neutering. For example, it may have increased mutual tolerance among the males in the colony, thereby possibly increasing S. Associations between individuals of opposite sex may have been rarer after neutering, possibly causing a decrease in S. In order to determine the details of any changes in social relationships which occurred after neutering the precise nature of these associations must be examined (Chapter 11).

# 10. ECOLOGICAL AND BEHAVIOURAL AFFINITIES BETWEEN CATS

## 10.1. INTRODUCTION

A number of ecological and behavioural characteristics of the feral cats at Winwick Hospital have been quantified in the previous chapters and attempts have been made to identify differences between the sexes and the effects of neutering. However, it has become clear that the analysis of individual characteristics in isolation can be difficult to interpret if several different characteristics interact (Sections 8.5 and 9.3.). For example, a change in sociability may be a result of an alteration in home range. An attempt has been made in this chapter to examine the combined effects of the biological characteristics which gave each animal its individuality. Particular attention has been given to the differences due to sex and the possible effects of neutering.

## 10.2. METHODS

If $n$ ecological and behavioural characteristics of $x$ individual animals in a population are measured it should be possible to describe this population as a series of $x$ points plotted in $n$ - dimensions. From the positions of these points it may be possible to identify groups of ecologically and behaviourally similar individuals. Furthermore, if measurements of the chosen characteristics are made at different times any changes which occur may be detected.

This idea is similar to the model proposed by Hutchinson (1958) which describes the fundamental niche of a species as an n - dimensional hypervolume. The mathematical concept of multi - dimensional space has been discussed by Causton (1977) with particular reference to the niche concept. He has also described the use of multi - dimensional space in modern taxonomic studies, where the distances between points representing quantitative morphological characters are measured in order to identify morphologically similar organisms. A similar treatment of behaviour patterns has recently been suggested by Schleidt and Crawley (1980). They state that 'Behaviour patterns can be characterised objectively as locations in an n - dimensional feature space' . However, they refer only to very general methods of examining behaviour in this way, giving no specific mathematical techniques and only making brief reference to the 'increasing number of statistical methods available for multi - variate statistics'. The selection of a multivariate method to examine the ecologically and behavioural affinities of the cats studied here was made quite independently of the ideas suggested by Schleidt and Crawley (1980) but with the same basic concepts in mind.

Minimum spanning trees (M.S.T.) and single linkage cluster analysis (S.L.C.A.) have been used to examine four ecological and behavioural characteristics of the 22 study cats (including the control males) : home range size, probability of sighting, index of dispersion and index of sociability. These methods have been described by Gower & Ross (1969) and used by them to examine the evolutionary relationships of ten island races of white toothed shrew (Crocidura spp) studied by Delany and Healy (1966). Jeffers (1978) has described cluster analysis as 'the attempt to group sample points in multi - dimensional space into separate sets which, it is hoped, will correspond to observed features of the sample. The groups of points may themselves be grouped into larger sets, so that all the points are eventually classified hierarchically' . S.L.C.A. is one of the simplest forms of cluster analysis and allows relationships between points to be summarised in the form of a dendrogram. The method was first proposed by Sneath (1957) as a convenient way of summarising taxonomic relationships.

In single linkage cluster analysis the relationships between n samples are expressed in terms of distances between every pair of samples. The Euclidean distance between any two cats is calculated for the four characters studied as:

$$d_{ij} = \left[ (x_{1i} - x_{1j})^2 + (x_{2i} - x_{2j})^2 + (x_{3i} - x_{3j})^2 + (x_{4i} - x_{4j})^2 \right]^{\frac{1}{2}}$$

$$= \left| \sum_{k=1}^{4} (x_{ki} - x_{kj})^2 \right|^{\frac{1}{2}} \qquad (10.1)$$

where $d_{ij}$ is the Euclidean distance between the $i^{th}$ and $j^{th}$ cats and $x_{ki}$ is the value of the $k^{th}$ variate (ecological or behavioural character) for the $i^{th}$ cat standardised by subtracting the mean for the 22 cats and dividing by the standard deviation for the 22 cats.

So,

$$( x_{1i} - x_{1j} )^2 = \left( \frac{v_{1i} - \bar{x}_1}{s_1} - \frac{v_{1j} - \bar{x}_1}{s_1} \right)^2 \qquad (10.2.)$$

where $v_{1i}$ is the value of variate 1 for the $i^{th}$ cat, $v_{1j}$ is the value of this variate for the $j^{th}$ cat, $\bar{x}_1$ is the mean of this variate for all 22 cats, and $s_1$ is the standard deviation for all cats.

This calculation (10.1.) must be repeated for all possible pairs of cats so that ultimately a half matrix of distances between every pair of cats can be produced.

Points, representing the cats, may form clusters in n - dimensional space. S.L.C.A. consists of a sorting scheme that determines clusters at a series of increasing distance thresholds ( $d_1$ , $d_2$ .....). The clusters at level $d_i$ are constructed as follows:

(i) The samples (cats) are grouped by joining all segments of length $d_i$ or less. Each set is said to form a cluster at level $d_i$, and all segments joining two clusters defined at level $d_i$ will have lengths greater than $d_i$.

(ii) If sorting is done at a greater distance threshold $d_{i+1}$, all clusters at level $d_i$ remain, but some of these clusters may combine into larger clusters. Two clusters will combine when at least one link exists between them of length d, where $d_i < d \leqslant d_{i+1}$ (hence the name 'single linkage cluster analysis').

Continuous increments in the threshold values have been used here. A constant increment $\delta$ may be used, but this tends to produce a loss of detail, because several links may join between two threshold levels L and L + $\delta$ (Gower & Ross, 1969).

The construction of a dendrogram shows how clusters combine at successively higher distance threshold levels until all the points combine to form a single cluster. In practise the S.L.C.A. can be derived from a minimum spanning tree, i.e. a tree spanning all points by a set of straight line segments joining pairs of points such that:

(i) no closed loops occur

(ii) each point is visited by at least one line

(iii) the tree is connected

(iv) the sum of the lengths of the segments is a minimum.

The half matrix of distances between the cats must therefore be searched to find the shortest distance between any pair. These cats must then be linked by a straight line representing this distance. Then the half matrix must be searched for the next shortest distance and the pair of cats concerned also linked by a line, and so on until all the cats are connected, within the constraints listed above, forming the M.S.T. This is difficult to interpret directly so the information it contains is used to produce a dendrogram.

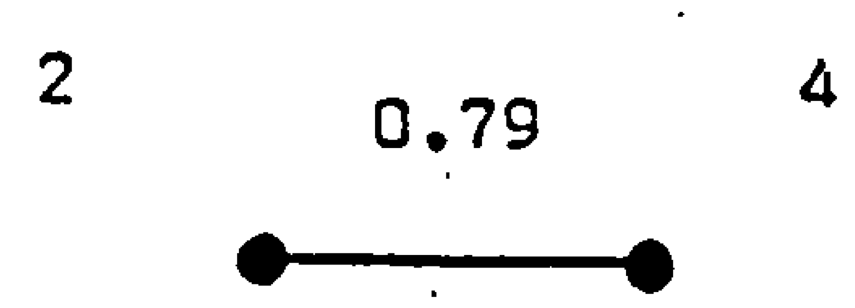
This technique is best illustrated with a simple example. A half matrix of distances between five hypothetical animals is given below, derived from equation 10.1.

| Animal | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | —— | | | | |
| 2 | 2.00 | | | | |
| 3 | 2.95 | 4.06 | | | |
| 4 | 1.70 | 0.79 | 2.90 | | |
| 5 | 3.57 | 1.84 | 3.86 | 4.24 | —— |

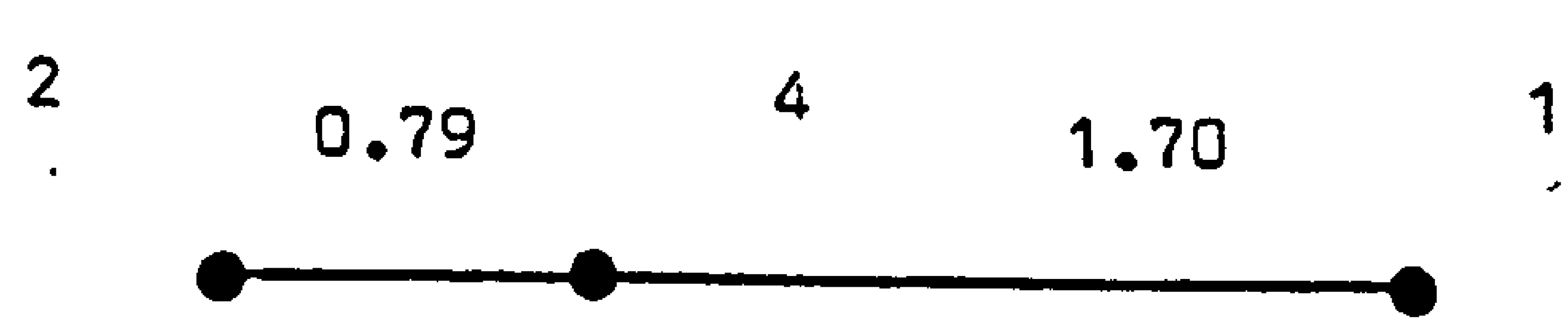
These distances must be ranked from the shortest to the longest.

| Rank | Animal i | | j | $d_{ij}$ |
|---|---|---|---|---|
| 1 | 2 | - | 4 | 0.79 |
| 2 | 1 | - | 4 | 1.70 |
| 3 | 2 | - | 5 | 1.84 |
| 4 | 1 | - | 2 | 2.00 |
| 5 | 3 | - | 4 | 2.90 |
| 6 | 1 | - | 3 | 2.95 |
| 7 | 1 | - | 5 | 3.57 |
| 8 | 3 | - | 5 | 3.86 |
| 9 | 2 | - | 3 | 4.06 |
| 10 | 4 | - | 5 | 4.24 |

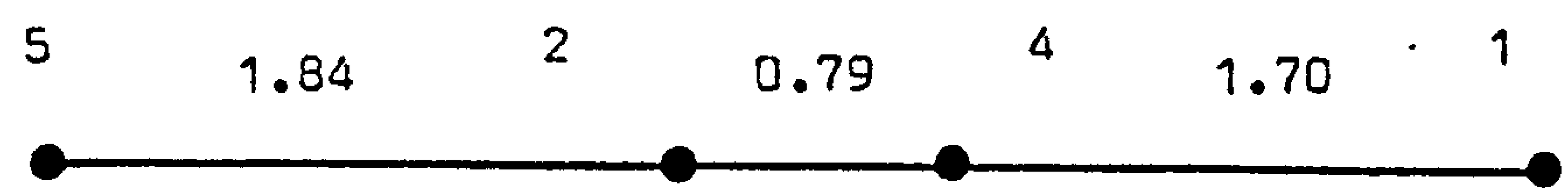
To construct a minimum spanning tree for these data the two cats which are the shortest distance apart must be joined by a line representing this distance:



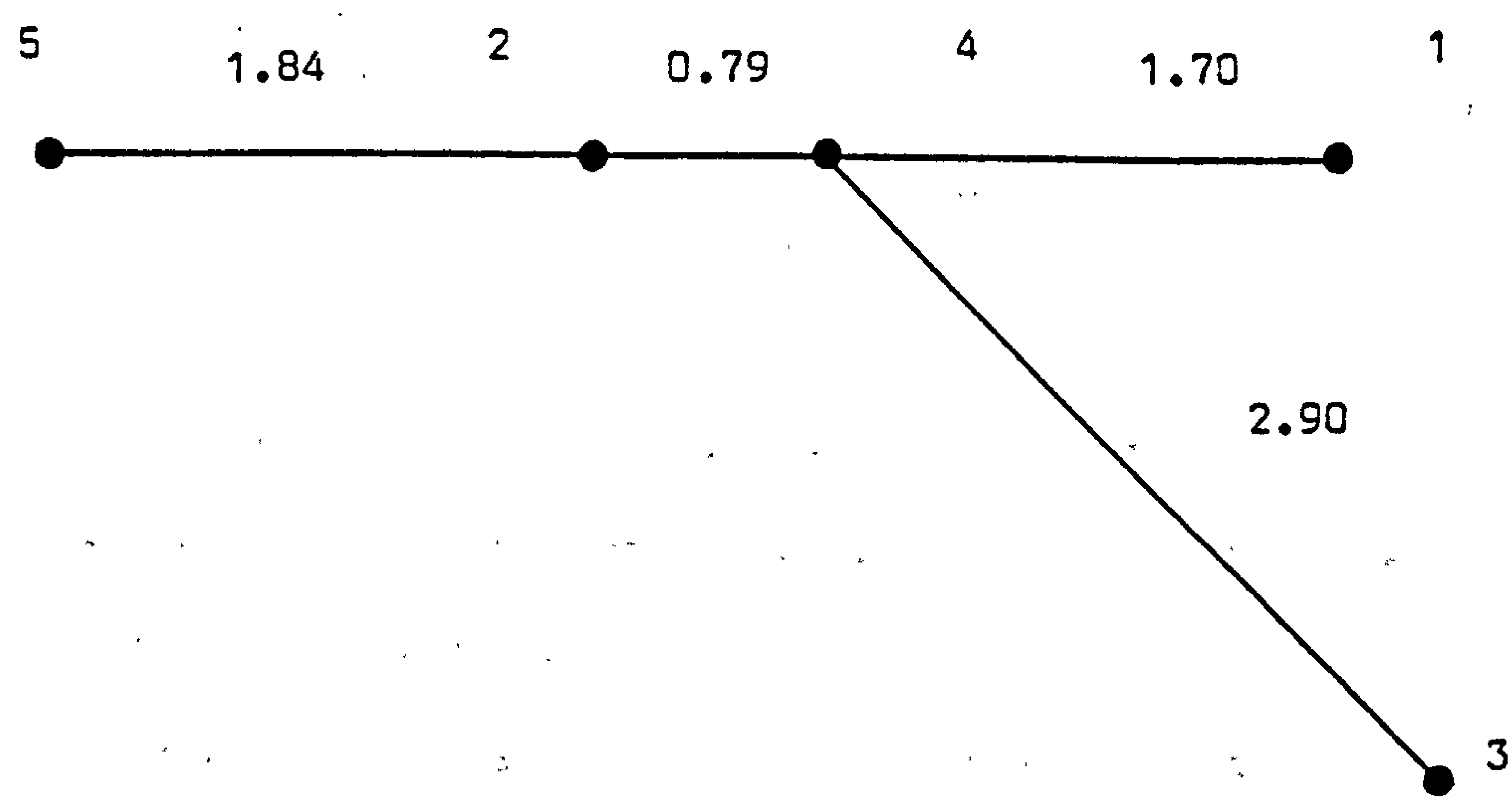

Now the two cats which are the next shortest distance apart must be joined by a line. This second line joins the existing line in this particular example but this is not invariably the case:



The third shortest distance is between animals 2 and 5 :

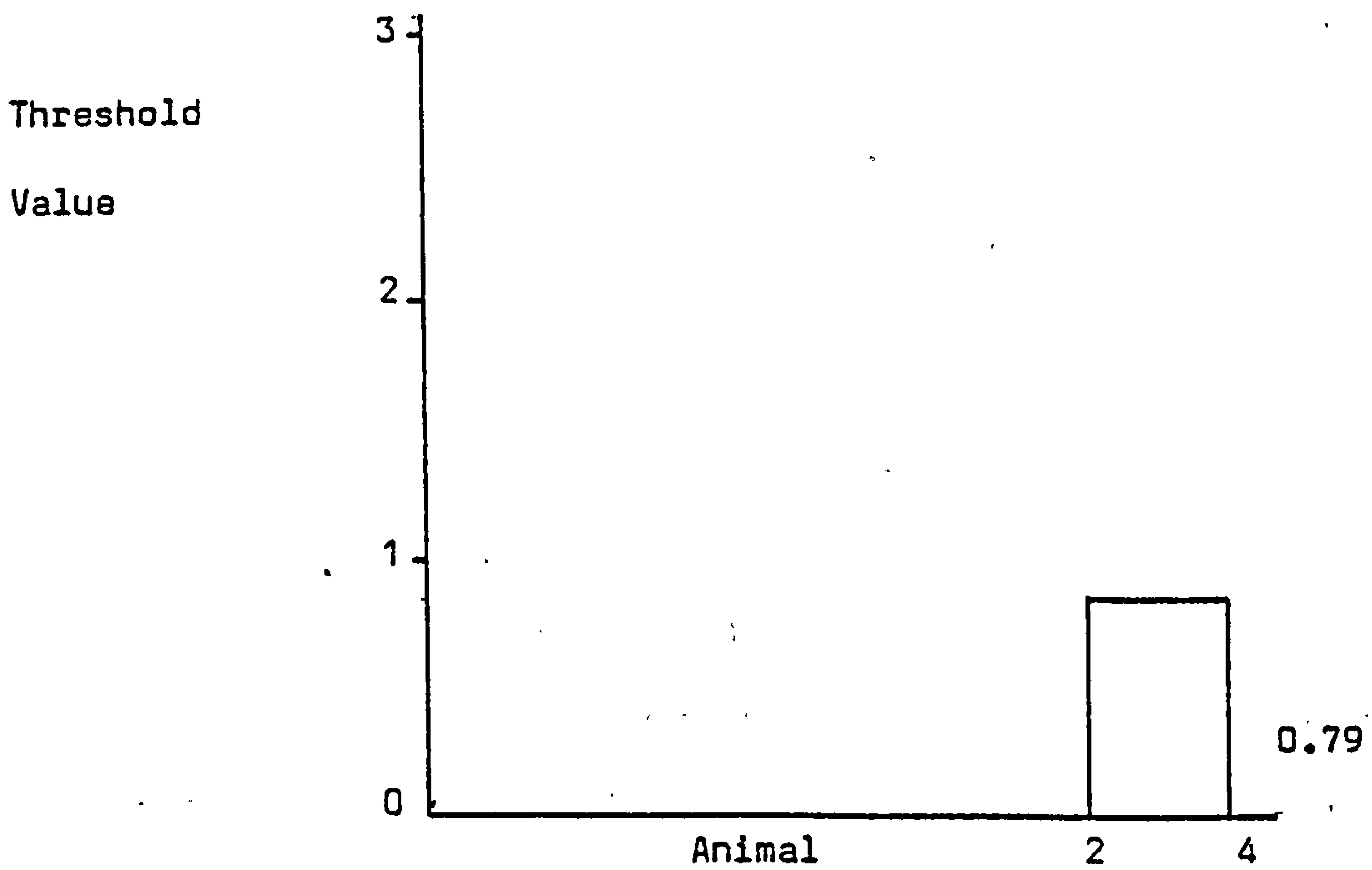



The next shortest distance is between animals 1 and 2. A line drawn between these animals would form a loop involving animals 1, 2 and 4. The M.S.T. can not have any closed loops so this line is omitted and the next shortest distance considered. This is between animals 3 and 4 and a line between these animals will not form a loop:



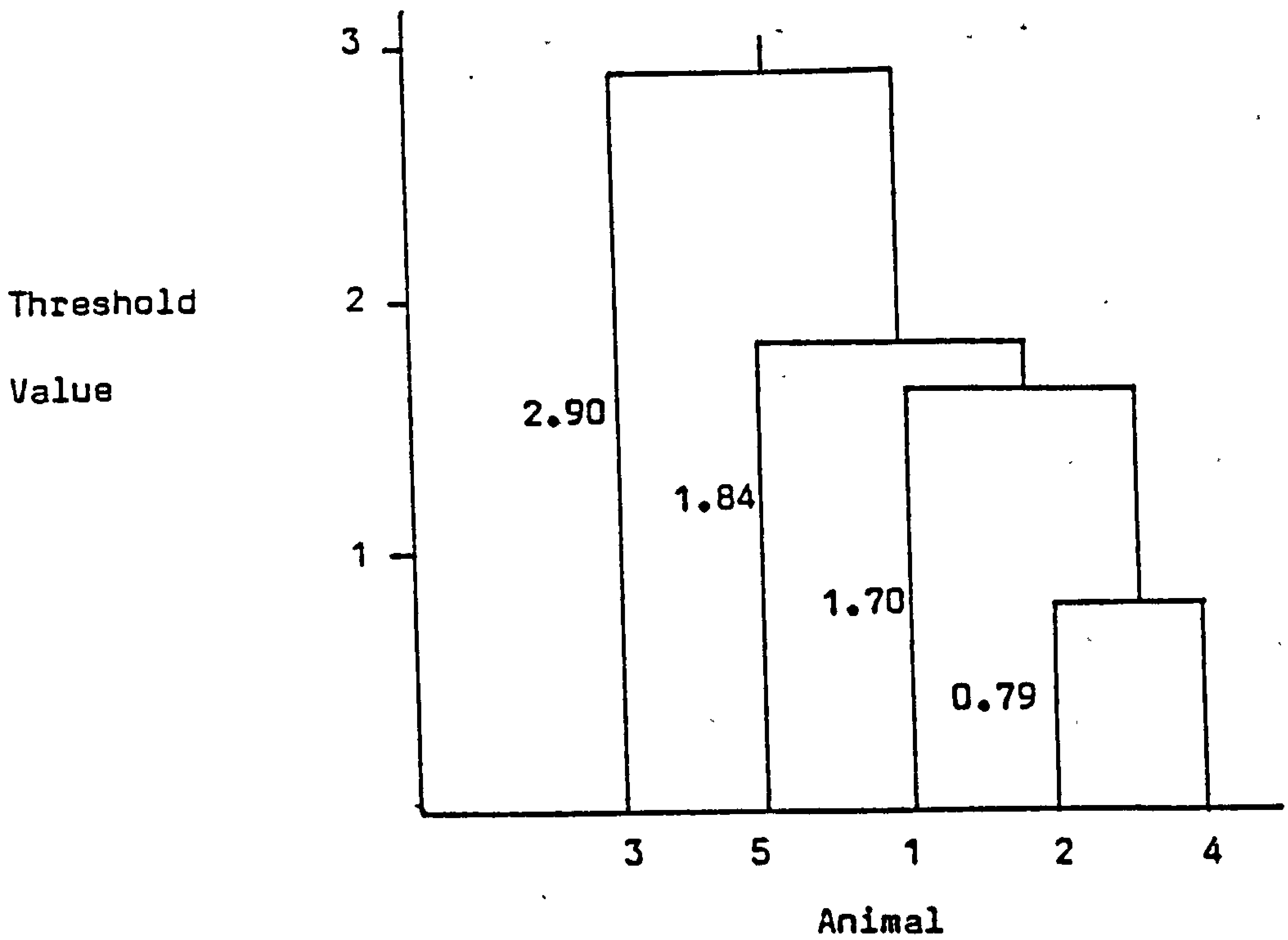

The M.S.T. is now complete since all animals are joined together, each being visited by at least one line, with no closed loops, and the sum of the lengths of these lines is a minimum.

A dendrogram may now be constructed by first linking the two animals connected by the shortest line in the M.S.T. on a graph where the ordinate represents the length of this line.




The next shortest line in the M.S.T. is then determined and the animals connected by this line are added to the dendrogram. In this example only one new cat (animal 1 ) is involved. This process is continued until all of the animals are included and the cluster analysis is then complete.

In this particular hypothetical example animals 2 and 4 are the most similar (in terms of the characteristics studied) and animal 3 stands out as the least similar to all the others.




A simple two - dimensional representation of the distances between each animal and every other, of necessity loses much information. Nevertheless clusters at different threshold levels can be identified with similar animals grouped together (e.g. animals 2 and 4 ), while animals which are markedly different from the others (e.g. animal 3) stand apart. The lower the threshold level at which animals are linked, the greater their similarity.

The clusters in this hypothetical example have no meaning since the number and nature of the variables used to distinguish between individual animals have not been defined. However in an example from the real world the clusters formed, especially at lower levels, should reflect the observed similarities and differences between individuals while also indicating less obvious relationships. Cluster analysis assumes little or no knowledge of the structure of the data set, and Jeffers (1978) has emphasised that the use of this technique is not a satisfactory alternative to clear thinking. However, he has suggested that when cluster analysis is used as only one of the models of a systems analysis the results may be revealing.

To supplement the information provided by the cluster analysis two graphs are presented (one for each year of the study ) which show the position of each cat in three - dimensional space with respect to home range size, probability of sighting and index of sociability. From these graphs similarities and differences between the cats can be determined by inspection. The index of dispersion has been omitted because this was considered to be the least useful of the variables measured.

A Wilcoxon - Mann - Whitney rank - sum test has been used to examine the differences between the means of the four variables measured, between the sexes in each year and between the years for each sex (excluding the three control males). This test is non - parametric so it may be used to compare statistical populations which have the same distribution even if the nature of this distribution is unknown. Its use is appropriate here because little was known about the distributions of the variables.

## 10.3. CLUSTER ANALYSIS

### 10.3.1. Interpretation

The raw data used in this analysis is presented here for home range size, $P_s$ , I and S (Table 10.1.) as only graphs of these values have been given previously (Figs. 7.1., 8.5., 8.6., and 9.1.).

The Euclidean distances between all pairs of cats (Table 10.2 (a) and (b) ) were used to construct minimum spanning trees (Fig. 10.1 (a) and (b) ) and from the information contained in the M.S.T. a dendrogram was constructed for each year of the study (Fig. 10.2 (a) and (b) ).

The identification of groups of ecologically and behaviourally similar cats depends upon the recognition of clusters in the dendrograms. A continuous scale of threshold values has been used in Fig. 10.2 (a) and (b) so clusters may form at any level. If clusters had been considered only at threshold intervals of, for instance, 0.25 units, the complexity of the dendrograms would have been reduced, because a smaller number of more distinct clusters would have formed. However, the resolution of the analysis would have been reduced (see Section 10.2.).

Determination of the significance of the clusters which form at different threshold levels is a subjective process.

Table 10.1.

Ecological and behavioural characteristics of cats.

| Cat | Index of dispersion | | Probability of sighting | | Home range size | | Index of sociability | |
|---|---|---|---|---|---|---|---|---|
| | Year 1 | Year 2 | Year 1 | Year 2 | Year 1 | Year 2 | Year 1 | Year 2 |
| 9f | 1.57 | 18.20 | 0.69 | 0.12 | 7 | 4 | 0.55 | 0.40 |
| 10f | 1.41 | 1.59 | 0.72 | 0.91 | 3 | 4 | 0.91 | 0.88 |
| 14f | 3.98 | 1.80 | 0.44 | 0.79 | 1 | 1 | 0.90 | 0.96 |
| 17f | 32.06 | 14.73 | 0.42 | 0.20 | 4 | 4 | 0.63 | 0.15 |
| 19f | 1.52 | 1.06 | 0.72 | 0.79 | 2 | 4 | 0.84 | 0.86 |
| 51f | 2.19 | 2.53 | 0.11 | 0.47 | 5 | 4 | 0.20 | 0.61 |
| 21f | 1.82 | 3.23 | 0.68 | 0.59 | 2 | 5 | 0.93 | 0.83 |
| 43f | 3.23 | 2.02 | 0.36 | 0.39 | 2 | 4 | 0.95 | 0.83 |
| 62f | 2.50 | 6.91 | 0.42 | 0.39 | 2 | 5 | 0.96 | 0.91 |
| 66f | 14.52 | 2.42 | 0.33 | 0.73 | 6 | 6 | 0.47 | 0.86 |
| 27m | 1.82 | 5.58 | 0.52 | 0.19 | 5 | 7 | 0.90 | 0.71 |
| 28m | 3.00 | 0.93 | 0.56 | 0.92 | 8 | 3 | 0.89 | 0.92 |
| 34m | 4.05 | 16.77 | 0.30 | 0.25 | 8 | 6 | 0.77 | 0.74 |
| 44m | 10.16 | 2.65 | 0.39 | 0.84 | 12 | 4 | 0.78 | 0.96 |
| 50m | 3.72 | 2.06 | 0.37 | 0.68 | 8 | 5 | 0.25 | 0.93 |
| 52m | 3.77 | 2.46 | 0.32 | 0.53 | 8 | 4 | 0.67 | 0.12 |
| 53m | 1.63 | 1.07 | 0.53 | 0.86 | 6 | 1 | 0.85 | 0.86 |
| 49m | 0.78 | 1.52 | 0.81 | 0.85 | 3 | 7 | 0.90 | 0.88 |
| 68m | 8.84 | 1.36 | 0.20 | 0.73 | 3 | 4 | 0.44 | 0.83 |
| 23m* | 5.67 | 4.57 | 0.36 | 0.41 | 9 | 6 | 0.76 | 0.73 |
| 29m* | 1.26 | 20.35 | 0.47 | 0.17 | 4 | 4 | 0.93 | 0.64 |
| 65m* | 10.27 | 12.68 | 0.13 | 0.14 | 3 | 4 | 0.75 | 0.60 |

Table 10.2.

Euclidean distances between all pairs of cats in year 1 (a) and year 2 (b).

(a)

| Cat | 9 | 10 | 14 | 17 | 19 | 51 | 21 | 43 | 62 | 66 | 27 | 28 | 34 | 44 | 50 | 52 | 53 | 49 | 68 | 23 | 29 | 65 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 9 | - | | | | | | | | | | | | | | | | | | | | | |
| 10 | 2·10 | | | | | | | | | | | | | | | | | | | | | |
| 14 | 2·91 | 1·66 | | | | | | | | | | | | | | | | | | | | |
| 17 | 4·73 | 4·85 | 4·34 | | | | | | | | | | | | | | | | | | | |
| 19 | 2·15 | 0·47 | 1·56 | 4·80 | | | | | | | | | | | | | | | | | | |
| 51 | 3·47 | 4·53 | 3·82 | 4·99 | 4·39 | | | | | | | | | | | | | | | | | |
| 21 | 2·41 | 0·42 | 1·34 | 4·79 | 0·45 | 4·51 | | | | | | | | | | | | | | | | |
| 43 | 3·02 | 1·94 | 0·59 | 4·45 | 1·96 | 3·72 | 1·68 | | | | | | | | | | | | | | | |
| 62 | 2·87 | 1·62 | 0·49 | 4·55 | 1·66 | 3·89 | 1·36 | 0·34 | | | | | | | | | | | | | | |
| 66 | 2·69 | 3·54 | 3·04 | 2·75 | 3·49 | 2·46 | 3·57 | 3·02 | 3·14 | | | | | | | | | | | | | |
| 27 | 1·91 | 1·24 | 1·47 | 4·56 | 1·49 | 3·78 | 1·33 | 1·36 | 1·19 | 2·85 | | | | | | | | | | | | |
| 28 | 1·70 | 1·93 | 2·50 | 4·61 | 2·25 | 4·01 | 2·17 | 2·34 | 2·22 | 2·86 | 1·08 | | | | | | | | | | | |
| 34 | 2·31 | 2·88 | 2·58 | 4·35 | 3·05 | 2·92 | 2·97 | 2·24 | 2·34 | 2·13 | 1·69 | 1·47 | | | | | | | | | | |
| 44 | 2·83 | 3·81 | 3·94 | 4·24 | 4·06 | 4·00 | 4·01 | 3·67 | 3·71 | 2·59 | 2·84 | 2·00 | 1·70 | | | | | | | | | |
| 50 | 2·19 | 3·87 | 3·78 | 4·63 | 3·82 | 1·73 | 4·01 | 3·74 | 3·79 | 1·98 | 3·18 | 3·02 | 2·34 | 2·89 | | | | | | | | |
| 52 | 2·06 | 2·93 | 2·69 | 4·33 | 3·05 | 2·59 | 3·04 | 2·42 | 2·50 | 1·92 | 1·82 | 1·60 | 0·45 | 1·77 | 1·89 | | | | | | | |
| 53 | 1·60 | 1·45 | 1·83 | 4·58 | 1·70 | 3·64 | 1·62 | 1·72 | 1·58 | 2·72 | 0·42 | 0·76 | 1·47 | 2·54 | 2·90 | 1·56 | | | | | | |
| 49 | 2·17 | 0·48 | 2·10 | 5·09 | 0·65 | 4·85 | 0·79 | 2·41 | 2·09 | 3·86 | 1·66 | 2·18 | 3·25 | 4·06 | 4·10 | 3·28 | 1·80 | | | | | |
| 68 | 3·12 | 3·58 | 2·59 | 3·65 | 3·42 | 1·66 | 3·48 | 2·56 | 2·76 | 1·49 | 2·90 | 3·35 | 2·42 | 3·59 | 2·24 | 2·22 | 2·90 | 3·95 | | | | |
| 23 | 2·16 | 2·93 | 2·86 | 4·22 | 3·13 | 3·17 | 3·08 | 2·58 | 2·63 | 2·09 | 1·82 | 1·30 | 0·52 | 1·24 | 2·31 | 0·63 | 1·53 | 3·26 | 2·68 | | | |
| 29 | 2·28 | 1·35 | 1·12 | 4·63 | 1·53 | 3·76 | 1·29 | 0·95 | 0·77 | 2·97 | 0·45 | 1·49 | 1·83 | 3·14 | 3·38 | 2·00 | 0·83 | 1·81 | 2·83 | 2·06 | | |
| 65 | 3·57 | 3·41 | 2·09 | 3·54 | 3·37 | 2·79 | 3·23 | 1·84 | 2·13 | 2·02 | 2·56 | 3·08 | 2·13 | 3·39 | 3·21 | 2·22 | 2·68 | 3·86 | 1·43 | 2·47 | 2·36 | - |

(b)

| Cat | 9 | 10 | 14 | 17 | 19 | 51 | 21 | 43 | 62 | 66 | 27 | 28 | 34 | 44 | 50 | 52 | 53 | 49 | 68 | 23 | 29 | 65 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 9 | - | | | | | | | | | | | | | | | | | | | | | |
| 10 | 4·35 | | | | | | | | | | | | | | | | | | | | | |
| 14 | 4·68 | 2·04 | | | | | | | | | | | | | | | | | | | | |
| 17 | 1·22 | 4·49 | 4·90 | | | | | | | | | | | | | | | | | | | |
| 19 | 4·10 | 0·44 | 2·01 | 4·24 | | | | | | | | | | | | | | | | | | |
| 51 | 2·92 | 1·94 | 2·70 | 2·90 | 1·57 | | | | | | | | | | | | | | | | | |
| 21 | 3·49 | 1·36 | 2·78 | 3·72 | 1·04 | 1·22 | | | | | | | | | | | | | | | | |
| 43 | 3·28 | 1·87 | 2·49 | 3·56 | 1·44 | 0·97 | 1·00 | | | | | | | | | | | | | | | |
| 62 | 3·03 | 2·15 | 3·10 | 3·55 | 1·84 | 1·61 | 0·99 | 1·07 | | | | | | | | | | | | | | |
| 66 | 4·06 | 1·47 | 3·31 | 4·24 | 1·34 | 1·92 | 0·84 | 1·80 | 1·57 | | | | | | | | | | | | | |
| 27 | 3·10 | 3·37 | 4·63 | 3·39 | 3·05 | 2·29 | 2·03 | 2·22 | 1·72 | 2·19 | | | | | | | | | | | | |
| 28 | 4·56 | 0·68 | 1·40 | 4·71 | 0·83 | 2·18 | 1·83 | 2·04 | 2·48 | 2·10 | 3·86 | | | | | | | | | | | |
| 34 | 2·00 | 3·67 | 4·58 | 2·82 | 3·45 | 2·78 | 2·58 | 2·75 | 1·91 | 2·90 | 1·91 | 4·05 | | | | | | | | | | |
| 44 | 4·27 | 0·45 | 1·97 | 4·52 | 0·52 | 1·98 | 1·24 | 1·70 | 1·88 | 1·43 | 3·25 | 0·78 | 3·47 | | | | | | | | | |
| 50 | 4·00 | 1·08 | 2·65 | 4·26 | 0·83 | 1·67 | 0·56 | 1·30 | 1·30 | 0·74 | 2·43 | 1·57 | 2·98 | 0·89 | | | | | | | | |
| 52 | 3·12 | 3·46 | 4·14 | 2·28 | 3·24 | 2·06 | 3·05 | 3·01 | 3·48 | 3·44 | 3·41 | 3·69 | 3·82 | 3·69 | 3·50 | | | | | | | |
| 53 | 4·68 | 1·97 | 0·50 | 4·79 | 1·98 | 2·63 | 2·81 | 2·59 | 3·25 | 3·31 | 4·69 | 1·35 | 4·68 | 2·02 | 2·72 | 3·86 | | | | | | |
| 49 | 4·65 | 1·97 | 3·94 | 4·79 | 1·97 | 2·64 | 1·63 | 2·57 | 2·26 | 0·79 | 2·54 | 2·63 | 3·35 | 2·00 | 1·45 | 3·91 | 3·92 | | | | | |
| 68 | 3·90 | 0·67 | 2·05 | 4·03 | 0·25 | 1·32 | 0·88 | 1·22 | 1·68 | 1·33 | 2·87 | 1·01 | 3·29 | 0·71 | 0·81 | 3·06 | 2·02 | 2·02 | | | | |
| 23 | 3·07 | 2·35 | 3·69 | 3·29 | 2·04 | 1·45 | 1·03 | 1·43 | 1·07 | 1·31 | 1·04 | 2·84 | 2·03 | 2·26 | 1·49 | 2·92 | 3·72 | 1·87 | 1·86 | | | |
| 29 | 1·07 | 4·11 | 4·39 | 2·24 | 3·89 | 3·03 | 3·27 | 3·12 | 2·63 | 3·83 | 3·08 | 4·29 | 1·52 | 3·93 | 3·70 | 3·80 | 4·49 | 4·43 | 3·71 | 2·98 | | |
| 65 | 1·22 | 3·47 | 3·81 | 1·93 | 3·16 | 2·00 | 2·49 | 2·14 | 1·94 | 3·16 | 2·32 | 3·66 | 1·62 | 3·33 | 2·99 | 2·93 | 3·88 | 3·84 | 2·93 | 2·15 | 1·24 | - |

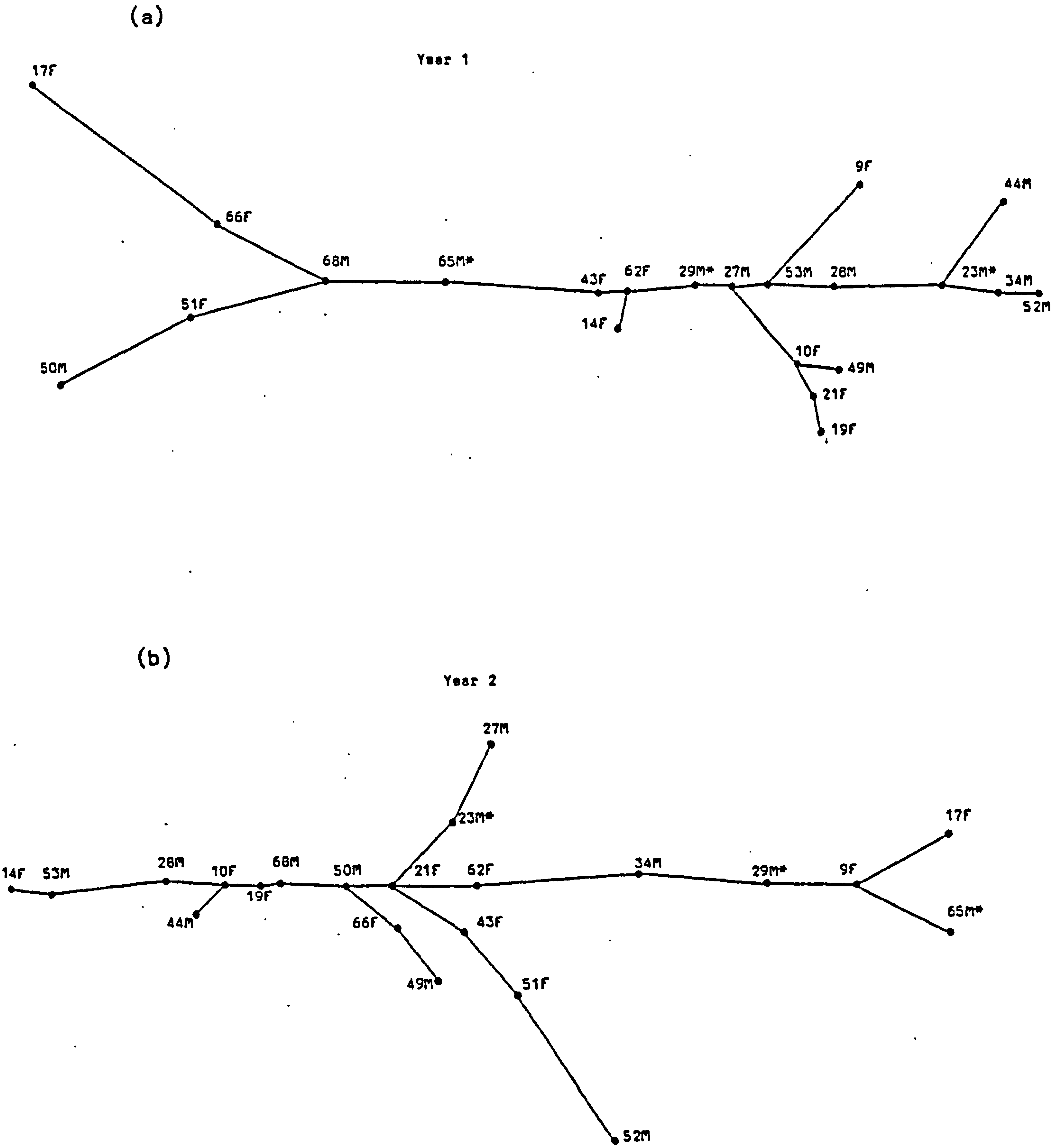
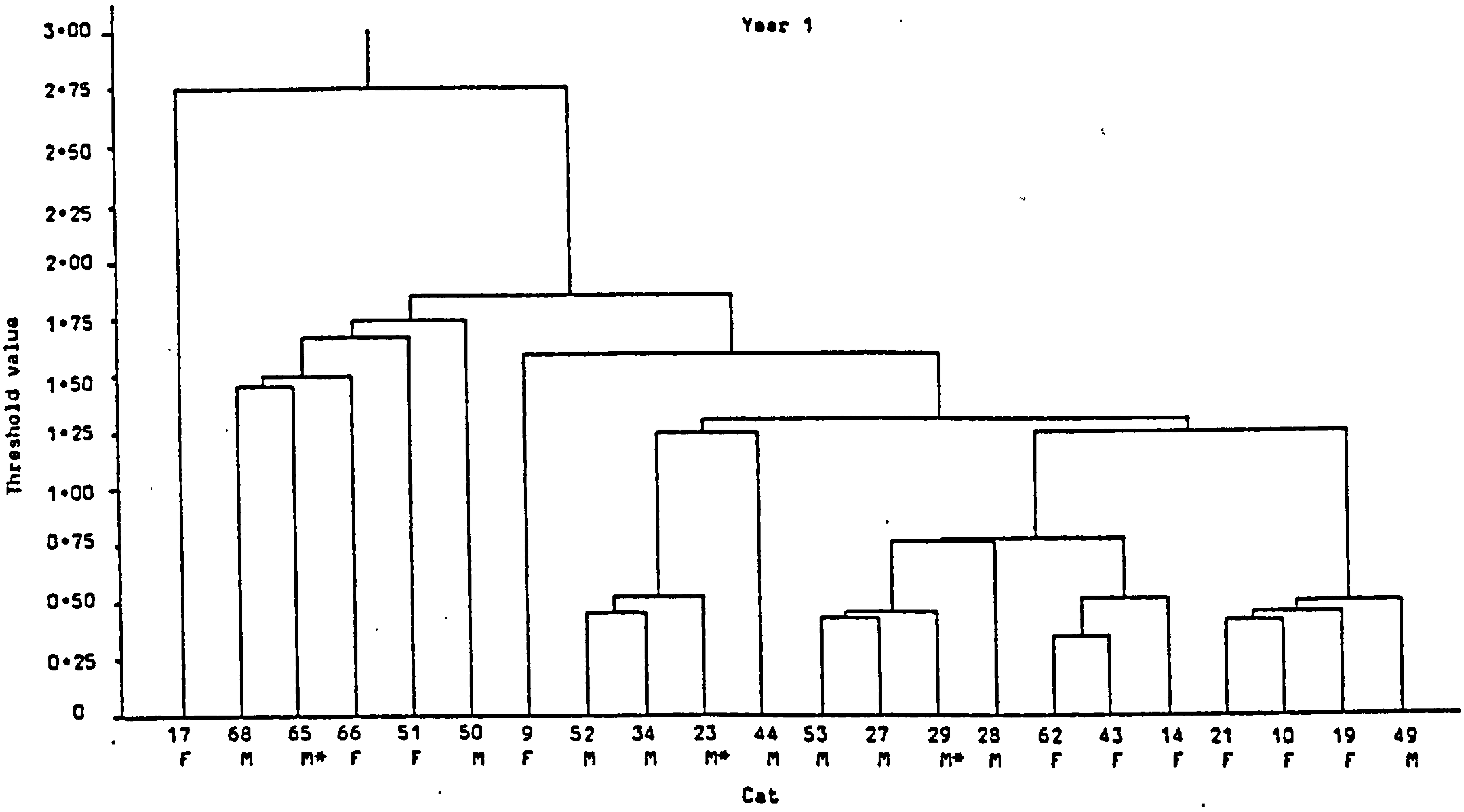



Fig. 10.1. Minimum spanning trees for year 1 (a) and year 2 (b).

(a)




(b)

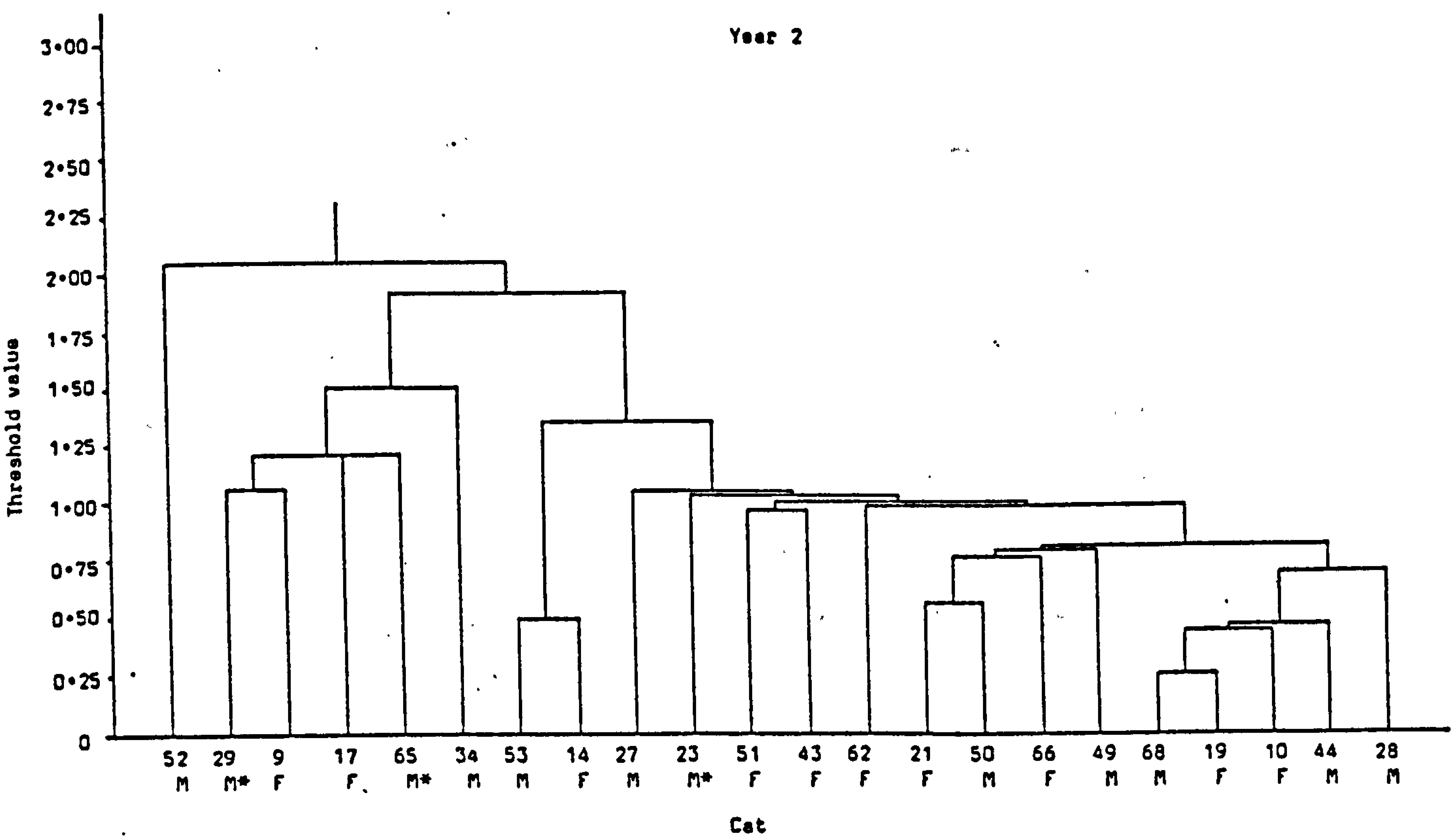



Fig. 10.2. Dendrograms indicating ecological and behavioural similarities between cats in year 1 (a) and year 2 (b).

Ultimately all of the individuals form a single large cluster and clustering at high thresholds is therefore of little interest since it only shows distant relationships. The most interesting clusters are those which form at the lowest threshold levels as they indicate which individuals show the greatest degree of similarity.

It should be remembered that the groups of cats identified here are defined on the basis of similarities in their biology and this definition of groups is generally independent of the social groups referred to in previous chapters and described in detail in Chapter 11.

## 10.3.2. Ecological and behavioural affinities in year 1

In the first year of the study separate male and female clusters occurred at the lowest threshold levels, indicating similarities between cats of the same sex. However, not all animals of the same sex occurred in the same cluster. At a threshold level of around 0.5 four distinct groups are apparent. Two of the groups are exclusively male, one is exclusively female and the last contains three females and one male:

Cluster 1a. 23m*, 34m, 52m (44m)

Cluster 1b. 27m, 29m* , 53m (28m)

Cluster 1c. 14f, 43f, 62f

Cluster 1d. 10f, 19f, 21f, 49m

Cluster 1a contains nomadic males and at a threshold level of 1.24 44m joins this group. Cluster 1b contains resident males (53m was nomadic for part of this period) and 28m joins this group at a threshold level of 0.76. The third cluster (1c) consists of resident females with small home ranges but which were infrequently seen (compared with the females in cluster 1d ). Females 43f and 62f were born during the study and all three cats were timid. Cluster 1d contains three frequently seen resident females and a young male (49m) who was born during the preliminary visits which were made to the colony before the beginning of year 1. He had a small home range and was highly social.

It is interesting that the resident males (cluster 1b) and the group of resident females which contains the less frequently seen individuals (cluster 1c) cluster together at a relatively low threshold level (0.77). All of the four clusters identified thus far join together eventually but the group containing the nomadic males (1a) remains separate from the others until a threshold value of 1.3 is reached. This suggests that the resident males (1b) are more similar to the females in cluster 1c and 1d than they are to the nomadic males.

A fifth cluster containing individuals of both sexes occurs at a much higher threshold level than the others (1.73):

Cluster 1e. 51f, 66f, 50m, 65m*, 68m.

These animals all lived in social group R and were not identified before the beginning of year 1 (see Section 6.3.). The ecological and behavioural relationships between these cats and the others were difficult to determine as individuals within cluster 1e were not particularly similar to each other (they cluster at relatively high threshold values) and they do not join with the remainder of the animals until after the other four clusters (1a to 1d) have already merged into a single large cluster. It may be significant that each cat in cluster 1e had a relatively low probability of sighting and appeared relatively asocial. Also, 65m*, 66f and 68m were young during year 1 as they were born during the study.

Female 9f remains separate from clusters 1a to 1d until a threshold value of 1.6 is reached. She was a solitary female who wandered extensively. A second solitary female, 17f, appears to differ considerably from the other cats in its ecological and behavioural characteristics. This may be largely due to the very high value of I calculated for this cat (Table 10.1. .) as a result of her long absence from the study area in year 1.

## 10.3.3. Ecological and behavioural affinities in year 2

In year 2 the 22 cats form a single cluster at a lower threshold level (2.06) than in year 1 (2.75). This suggests a greater similarity between the cats in the second year. However, fewer small clusters are observed at low threshold levels in year 2 compared with year 1 and those that occur contain individuals of both sexes. Males and females could not, therefore, be separated into distinct groups on the basis of similarities and differences in their ecological and behavioural characteristics. This contrasts strongly with the clear separation of groups of males and females at low threshold levels in year 1.

Below a threshold level of 0.79 three clusters can be identified:

| | |
|---|---|
| Cluster 2a. | 14f, 53m |
| Cluster 2b. | 10f, 19f, 28m, 44m, 68m |
| Cluster 2c. | 21f, 66f, 49m, 50m |

Cluster 2a contains two cats which were resident in social group A. Both cats were frequently seen and had small home ranges. Cluster 2b contains resident cats of both sexes (44m had been nomadic in year 1). Female 10f lived in group D with 28m and 44m. The third cluster 2c contains two resident females and two resident males. This group clusters with those in cluster 2b at a relatively low threshold level (0.81) indicating a close similarity between cats in 2b and 2c. All of these cats were frequently seen and highly social.

A fourth cluster exists, containing only two cats:

Cluster 2d. 51f, 43f

At a threshold level of around 1.0 this cluster and three other individuals (23m*, 27m and 62f) join the existing clusters 2b and 2c. Of these three individuals 62f was the most similar to the resident cats in clusters 2b and 2c. Males 23m* and 27m were nomads.

Nomadic cats of both sexes which were seen less frequently than 23m* and 27m form a separate cluster:

Cluster 2e. 9f, 17f, 29m*, 34m, 65m*.

Male 29m* the neutered pet cat was absent from the colony at various times and was probably living in one of the wards, thus giving the impression of being nomadic.

Male 52m was the last cat to cluster with the rest of the animals. He moved away from the social groups within the colony in year 2 and appeared to be solitary but with a small home range. The other solitary males were all nomadic and had relatively large home ranges.

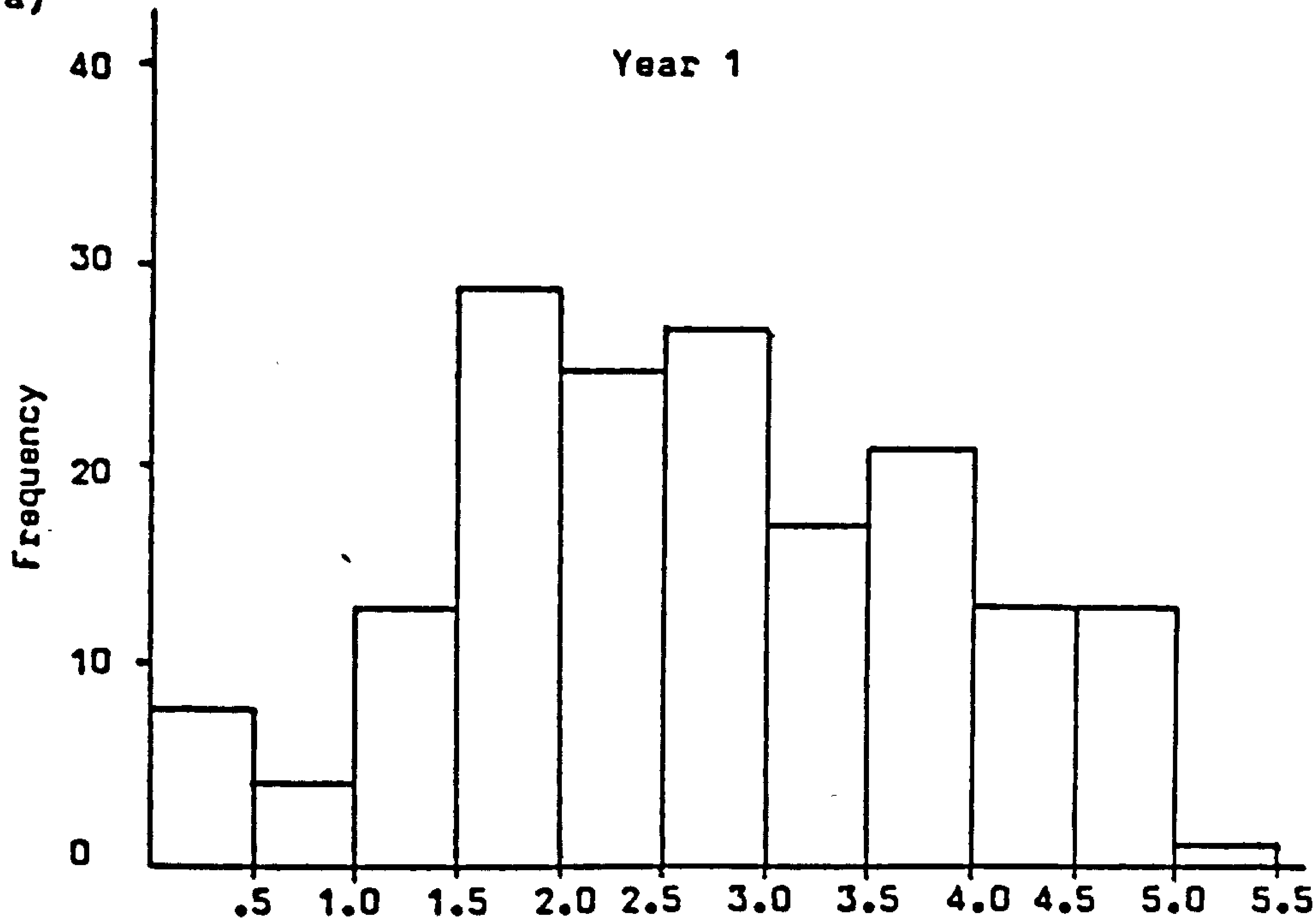
## 10.3.4. Distribution of Euclidean distances between pairs of cats

Single linkage cluster analysis considers only a small number of the Euclidean distances between the animals studied. The sum of the distances between the points in the M.S.T. (which is used to produce the dendrogram) is a minimum, and all other distances between pairs of cats are ignored.

Changes which occurred in the cats between years 1 and 2 may be examined by comparing the distribution of all the Euclidean distances between pairs of cats for these two periods. For each year 231 distances were calculated for the 22 study cats (Table 10.2 (a) and (b)). Only 171 of these values were considered in this analysis as the control males (23m*, 29m* and 65m* ) were excluded.

The mean distance between pairs of cats decreased from 2.68 ($\underline{s}$ = 1.16) in year 1 to 2.52 ($\underline{s}$ = 1.21) in year 2. However, there is no significant difference between these means ($\underline{d}$ = 1.25, $\underline{P} > 0.10$). The moment coefficient of skewness ($a_3$) is zero for a normal distribution. For the distribution of Euclidean distances between pairs of cats

(a)




(b)

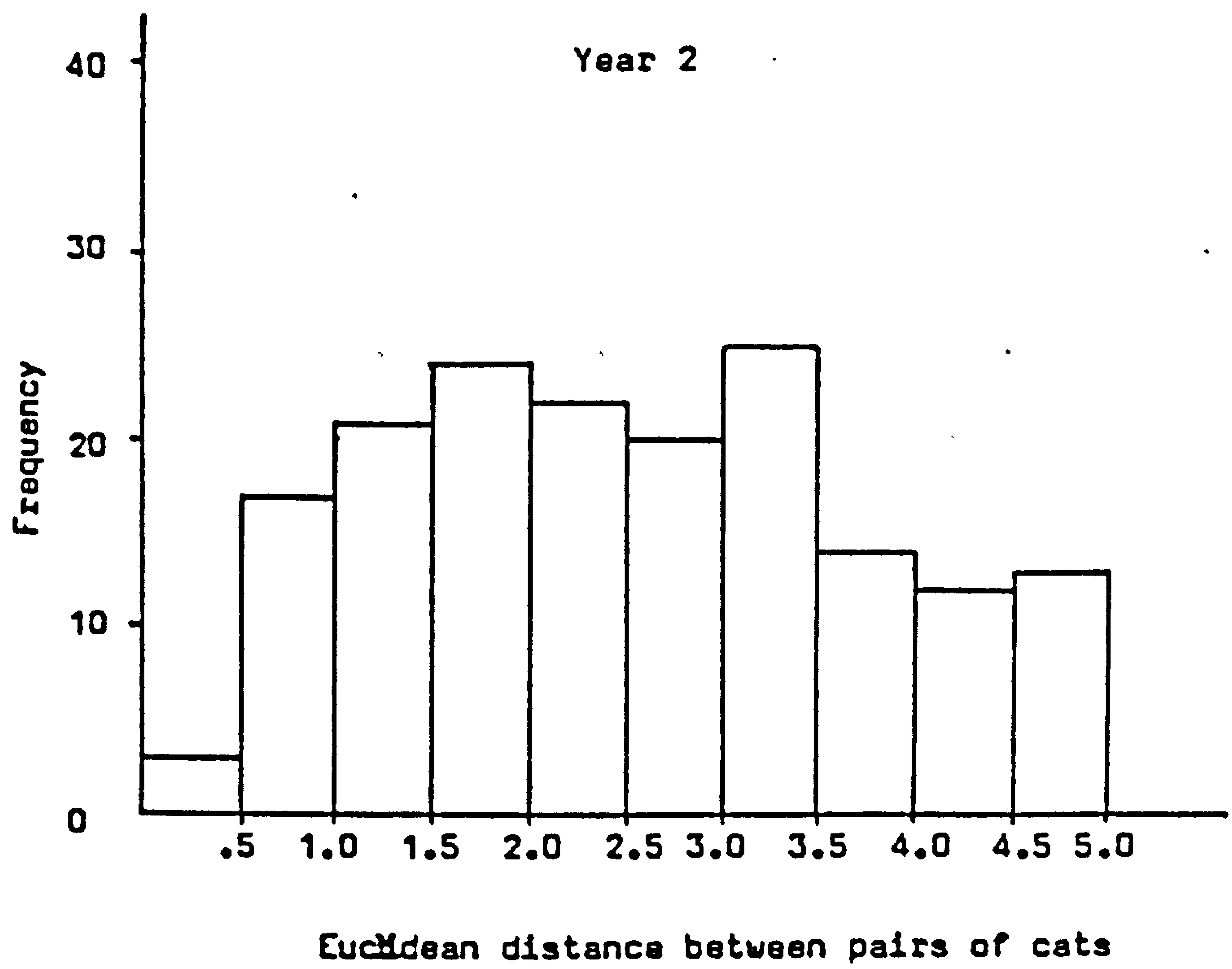



Fig. 10.3. The distribution of Euclidean distances between pairs of cats in year 1 (a) and year 2 (b).

$a_3$ = 0.06 in year 1, and 0.16 in year 2, indicating a positive skew in both cases. The distribution is slightly more positively skewed in year 2 than in year 1 (i.e. has moved to the left), indicating a tendency for cats to become more similar (Fig. 10.3. (a) and (b)). The moment coefficient of kurtosis ($a_4$) for a normal distribution is 3.0 . For the distributions of Euclidean distances, $a_4$ = 2.25 in year 1 and 2.01 in year 2. Both distributions are therefore platykurtic with flattening of the distribution most pronounced in year 2 when the ecological and behavioural similarities between the cats appear to have increased. The methods of calculation of the moment coefficients of skewness and kurtosis have been described by Spiegel (1972).

## 10.4. GRAPHICAL ANALYSIS

Three - dimensional graphs (Figs. 10.4 (a) and (b)) have been used to examine the similarities between the cats in terms of home range size, probability of sighting and sociability. The precise positions of the points in Figs. 10.4 (a) and (b) are difficult to visualise in three - dimensions so to aid interpretation the position of each point has been plotted in two dimensions against each pair of axes (Figs. 10.5 (a) - (f)). It should be noted that the horizontal axes in Figs. 10.5 (a) - (d) increase in magnitude from right to left and that the position of the zero on this axis in all six graphs represents the corner of the base of the three - dimensional


Fig. 10.4. Three-dimensional graphs illustrating similarities between the cats in terms of home range size, $P_s$, and S in year 1 (a) and year 2 (b). Males (●) and females (o) shown separately.

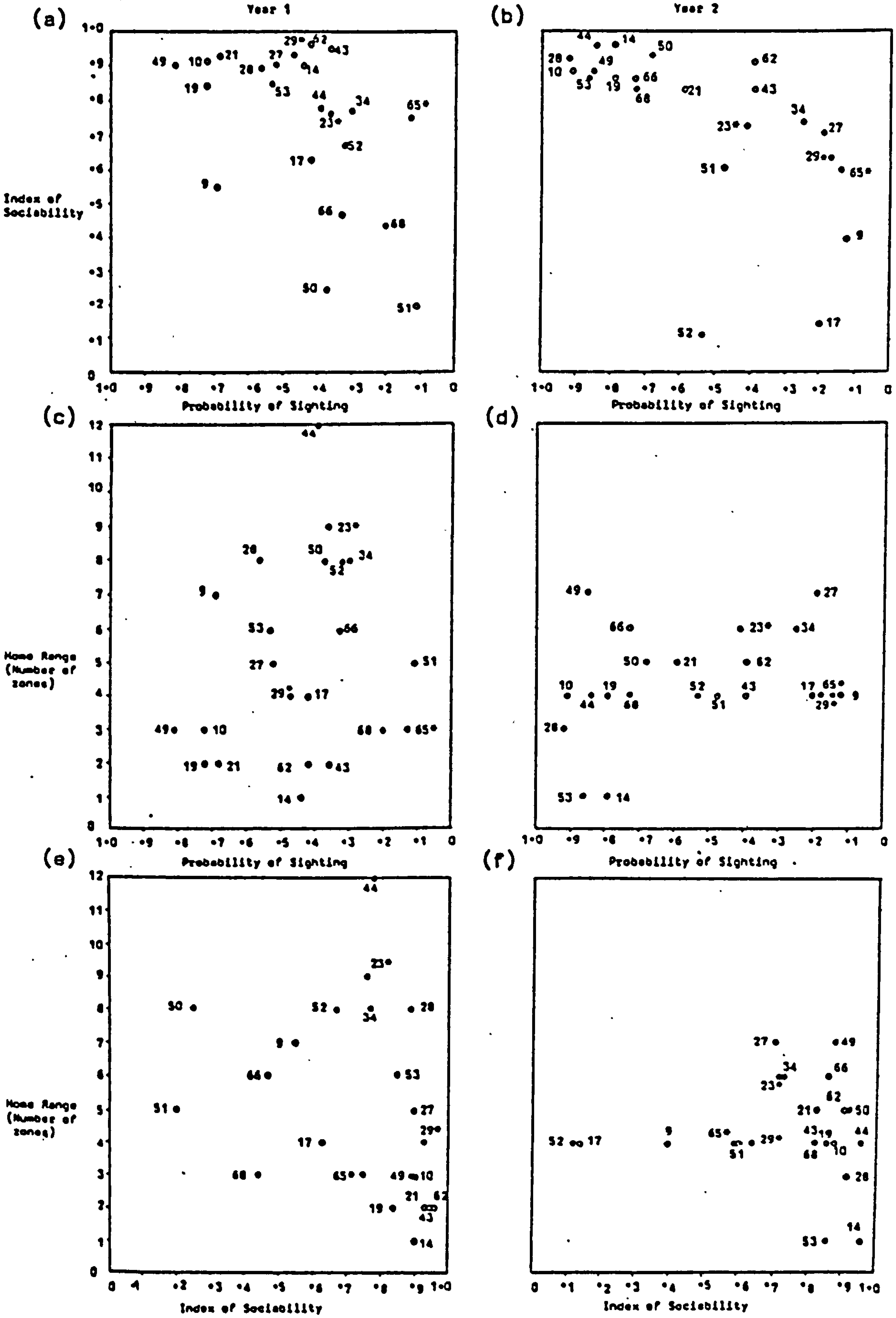



Fig. 10.5. Projection of points from Fig. 10.4. against pairs of axes for home range size, $P_s$ , and S for year 1 (a, c and e) and year 2 (b, d, and f). Males (•) and females (o) shown separately.

graphs (Figs. 10.4 (a) and (b)) which is nearest to the reader.

As values for the index of dispersion of sightings in time have not been included the groups of points in this graphical analysis are not identical to the clusters identified by the cluster analysis. In particular, cats with very high values of I have not separated out from the others. Nevertheless, some broad similarities can be seen between the results obtained from the two methods.

In Figs. 10.5 (a), (c) and (e) groups of cats representing the five clusters 1a to 1e defined by the cluster analysis in year 1 can be recognised. The groups representing clusters 1b and 1c (which form a single cluster at a low threshold) are located close to each other and not far from the group which forms cluster 1d (with which 1b and 1c later cluster). Individuals in cluster 1e were not considered to be very similar in their ecological and behavioural characteristics as they clustered at a high threshold level. These individuals (51f, 66f, 50m, 65m* and 68m) are widely separated in Figs. 10.5 (a), (c) and (e).

In year 2 the groups representing the five clusters 2a to 2e are quite well defined but with some overlap, for example between the groups which represent clusters 2b and 2c

(Fig. 10.5 (b)). In general the graphs which represent the second year of the study (Figs. 10.5 (b), (d) and (f)) contain points which are closer together than those in the corresponding graphs for year 1 , and the groups are not as well separated. This corresponds broadly with the conclusions drawn from the cluster analysis.

No attempt has been made to delineate groups of similar individuals from the information provided by the graphical analysis alone. If this had been attempted differences would have been found between the groups defined in this way and those suggested by the cluster analysis. These differences would have been due to the omission of values of I from the graphical analysis and the greater degree of subjectivity required to identify groups simply from a scatter of points. The object of the graphical analysis was to aid the interpretation of the cluster analysis and to provide a visual impression of the difficulties involved in defining groups.

## 10.5. STATISTICAL ANALYSIS

Considering the 19 experimental cats together there appeared to be a tendency for the home range size to decrease in year 2, while the probability of sighting increased. There was a slight increase in sociability and the index of dispersion of sightings in time decreased, suggesting less temporal clumping of sightings. These are very general trends which can be seen in Figs. 10.4 (a) and (b) (with the exception of changes in I) and are apparently confirmed by comparison of the mean values for each variable (5.00, 0.47, 5.40, 0.73 in year 1 and 4.32, 0.59, 4.68, 0.75 in year 2, for home range size, $P_s$, I and S respectively).

A comparison of the means for each sex in the two study years (Table 10.3.) suggests that in females home range size increased slightly, the probability of sighting increased, the index of dispersion of sightings in time decreased and sociability remained the same in year 2. In males in year 2, home range size decreased, $P_s$ increased, I decreased and S increased slightly.

A statistical comparison was made of the home range size, $P_s$, I and S between the sexes for each year and between years 1 and 2 within each sex using the Wilcoxon - Mann - Whitney rank sum test (Table 10.3.). The only differences which could possibly be attributed to neutering were those which occurred in the latter type of comparison.

Only two of the 16 pairs of samples compared showed a statistically significant difference ($\underline{P} < 0.05$) : males had a greater range than females in year 1 ($\underline{P} < 0.01$) and the probability of sighting of the males in year 2 was greater than in year 1 ($\underline{P} < 0.05$). If a significance

Table 10.3.

Comparisons of ecological and behavioural characteristics of the cats between the sexes within each year of the study, and between the years for each sex.

| | x | | | | y | | | | Wilcoxon-Mann-Whitney rank-sum test | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | $\bar{x}$ | s | N | Range | $\bar{y}$ | s | N | Range | $z_x$ | $z_y$ | P(z) |
| **Index of Dispersion** | | | | | | | | | | | |
| f & m Year 1 | 6·48 | 9·81 | 10 | 1·41 – 32·06 | 4·20 | 3·22 | 9 | 0·78 – 10·16 | +0·49 | –0·49 | 0·69 |
| f & m Year 2 | 5·45 | 6·08 | 10 | 1·06 – 18·20 | 3·82 | 5·05 | 9 | 0·93 – 16·77 | –0·90 | +0·90 | 0·82 |
| Year 1 & 2 ff | 6·48 | 9·81 | 10 | 1·41 – 32·06 | 5·45 | 6·08 | 10 | 1·06 – 18·20 | +0·30 | –0·30 | 0·62 |
| Year 1 & 2 mm | 4·20 | 3·22 | 9 | 0·78 – 10·16 | 3·82 | 5·05 | 9 | 0·93 – 16·77 | –1·02 | +1·02 | 0·85 |
| **Probability of Sighting** | | | | | | | | | | | |
| f & m Year 1 | 0·49 | 0·21 | 10 | 0·11 – 0·72 | 0·44 | 0·18 | 9 | 0·20 – 0·81 | –0·65 | +0·65 | 0·74 |
| f & m Year 2 | 0·54 | 0·27 | 10 | 0·12 – 0·91 | 0·65 | 0·27 | 9 | 0·19 – 0·92 | +1·06 | –1·06 | 0·86 |
| Year 1 & 2 ff | 0·49 | 0·21 | 10 | 0·11 – 0·72 | 0·54 | 0·27 | 10 | 0·12 – 0·91 | +0·76 | –0·76 | 0·78 |
| Year 1 & 2 mm | 0·44 | 0·18 | 9 | 0·20 – 0·81 | 0·65 | 0·27 | 9 | 0·19 – 0·92 | +1·72 | –1·72 | <u>0·96</u> |
| **Index of Sociability** | | | | | | | | | | | |
| f & m Year 1 | 0·73 | 0·26 | 10 | 0·20 – 0·96 | 0·72 | 0·23 | 9 | 0·25 – 0·90 | –0·73 | +0·73 | 0·77 |
| f & m Year 2 | 0·73 | 0·26 | 10 | 0·15 – 0·96 | 0·77 | 0·26 | 9 | 0·12 – 0·96 | +0·73 | –0·73 | 0·77 |
| Year 1 & 2 ff | 0·73 | 0·26 | 10 | 0·20 – 0·96 | 0·73 | 0·26 | 10 | 0·15 – 0·96 | –0·45 | +0·45 | 0·67 |
| Year 1 & 2 mm | 0·72 | 0·23 | 9 | 0·25 – 0·90 | 0·77 | 0·26 | 9 | 0·12 – 0·96 | +0·84 | –0·84 | 0·80 |
| **Home Range** | | | | | | | | | | | |
| f & m Year 1 | 3·40 | 2·01 | 10 | 1·00 – 7·00 | 6·78 | 2·86 | 9 | 3·00 – 12·00 | +2·78 | –2·78 | <u>0·99</u> |
| f & m Year 2 | 4·10 | 1·29 | 10 | 1·00 – 6·00 | 4·56 | 1·94 | 9 | 1·00 – 7·00 | +1·39 | –1·39 | <u>0·92</u> |
| Year 1 & 2 ff | 3·40 | 2·01 | 10 | 1·00 – 7·00 | 4·10 | 1·29 | 10 | 1·00 – 6·00 | +1·36 | –1·36 | 0·91 |
| Year 1 & 2 mm | 6·78 | 2.86 | 9 | 3·00 – 12·00 | 4·56 | 1·94 | 9 | 1·00 – 7·00 | –1·55 | +1·55 | 0·94 |

Values of x and y correspond to females (f) and males (m) respectively or individuals of the same sex (mm or ff) in years 1 and 2 respectively. Underlined values of P(z) indicate a statistically significant difference between x and y ($P < 0.05$).

level of 10% is used, all of the comparisons of home range size show a significant difference between samples, suggesting that male ranges were larger than female ranges in both years, male ranges decreased in year 2, but female ranges increased. However, it must be remembered that home range size has not been calculated using any standard units of area (Section 7.2.).

The sample sizes used in these comparisons were small (10 females and 9 males). The reasons for excluding the other members of the colony from this analysis have been discussed in Section 6.4. If the sample sizes had been larger it is likely that more of the comparisons would have shown statistically significant differences, since a number of the values of P(z) approach 0.90 (Table 10.2.).

Statistical comparisons of this type ignore changes which occurred within individuals in year 2. These changes were inconsistent within each sex and it is not possible to attribute them to neutering with certainty. The factors which may have contributed to the observed changes in the ecological and behavioural characteristics which were studied have been discussed earlier (in particular, Sections 7.7., 8.6., 9.4.).

## 10.6. DISCUSSION

Hutchinson (1958) proposed that the fundamental niche of an organism could be defined in terms of an n - dimensional hypervolume whose dimensions represent environmental variables. This concept has a number of practical difficulties (Krebs, 1972), in particular the problem of working in n dimensions. Nevertheless, Hutchinson's ideas have stimulated others to take a multivariate approach to the description and analysis of ecological systems.

Multivariate techniques have been widely used to examine ecological communities. Cody (1968) has examined resource partitioning by songbird species by constructing a three - dimensional graph of average ecological differences between species pair combinations for ten grassland bird communities. Allen & Skagen (1973) have discussed the use of a variety of techniques in the study of algal communities including polar ordinations, principal component ordination, discriminant analysis, canonical analysis and numerical classification. Such techniques may be divided into predictive models and descriptive models (Jeffers, 1978). The technique used here, cluster analysis, is of the latter type. Dendrograms have been used to examine the ecological association of bird species and habitats in Eastern Australia (Kikkawa, 1968) and Hodkinson (1975) has used this method in a community analysis of a benthic insect fauna.

Multivariate analyses do not appear to have been used to study the ecological or behavioural characteristics of individuals within animal populations. This is possibly due to the fact that studies of individually recognisable animals for which a number of quantitative ecological or behavioural mearurements have been made are rare. Often in field studies only a single characteristic of individuals is measured, for example home range size.

The results obtained from the particular analytical methods used here must be interpreted with care. Single linkage cluster analysis gives equal importance to all of the characteristics studied. If one particular characteristic is considered to be more important than the others in separating the individuals into groups the analytical method used must take this into account. The three - dimensional graphs (Figs. 10.4 (a) and (b)) show a separation of points which depends upon the scales used on the axes. By increasing the length of any single axis a greater degree of separation may be achieved for the variable measured against that axis. Decreasing the length of the axis would have the opposite effect. The precise scatter of points in three - dimensions is therefore greatly influenced by the relative lengths of the three axes. Increasing the number of variables studied should increase the separation between individuals. In Fig. 10.5 (f) 43f and 68m occupy the same position with respect to axes for home range size and the index of sociability. However in Fig. 10.4 (b) , where a third axis for the probability of sighting is added, these individuals clearly separate out.

Allen & Skagen (1973) have emphasised that statistical testing in hypervolumes should be approached with great caution and that full interpretation of multivariate analyses demands knowledge of the data from a biological standpoint. Many multivariate techniques assume that the data conform to a normal distribution. Allen and Skagen have pointed out that this assumption is frequently invalid. The statistical analyses of the individual variables studied here made no such assumption and the comparisons made have used a non - parametric technique. However, the distribution of Euclidean distances between pairs of cats appeared to conform to a normal distribution and was treated as such.

Many of the groups of similar cats identified in Section 10.3. were apparent before any type of analysis had been attempted, and personal knowledge of the individual cats undoubtedly played an important part in the interpretation of the cluster analysis. The cluster analysis itself has simply served to quantify known relationships, to indicate less obvious affinities and to communicate these to persons with no experience of the animals. Unfortunately it is of little use in determining the biological basis for the observed differences and similarities between individual animals. It is possible that genetics plays an important part in determining individual differences in ecology and behaviour.

these animals had been neutered. The most interesting feature of the cluster analysis performed after neutering was the inability of the method to distinguish separate male and female groups corresponding to those identified in year 1. This suggests that males and females became more similar in year 2.

Neutering cannot affect the genetic component of behaviour (or ecology) . However, it may alter the physiology of the animal (particularly hormone balance) which was originally genetically determined and may have been influencing behaviour. It is possible that changes in hormone balance in the males made them appear more like females after neutering. (Interactions between hormones and behaviour are discussed in Chapter 15). Whether the animals are entire or neutered their genes and the environment interect to produce individual phenotypes, including aspects of ecology and behaviour. Since changes in individual cats of the same sex were not consistent after neutering it is not possible to isolate the effects of genetics, environment and neutering on their ecology and behaviour.

# 11. ASSOCIATIONS

## 11.1. INTRODUCTION

### 11.1.1. Network analysis and animal associations

The social organisation of mammals has been widely studied, particularly in the last twenty years. Recent intensive studies based on the recognition of individual animals have given much insight into the relationships between the members of social groups (for example in chimpanzees (Lawick - Goodall, 1971), African elephants, (Douglas - Hamilton, 1972) and feral cats (Dards, 1979)). These studies have been largely descriptive in nature and little attempt appears to have been made to analyse social organisation in mathematical terms. Furthermore as the social organisation of mammals is not fixed (Manning, 1972) a quantitive approach lends itself to the study of changes which occur with time and in different conditions.

Social organisation may be investigated by examining the associations between individual animals. If the population is divided into a number of groups, group size may be a function of these associations. It is possible to measure the degree of grouping by analysing associations. A theoretical basis for the process of grouping and a method of measuring grouping have been developed in order to examine the social organisation of the feral cat colony at Winwick Hospital.

The associations between animals in a population may be examined by considering the animals and their associations to form a network. A network is simply a number of objects connected together in a particular way. Until recently networks have not been used extensively by mathematicians (Potts, 1978). Consequently there is a lack of uniformity in the terminology used in network analysis. The only terms used here which have been obtained from this field of study are 'vertices' (the objects) and 'edges' (the connections).

Network analysis is not a single mathematical technique. The general concepts of networks have been examined under the title 'graph theory' , while network models have been developed and solved under the general title 'operational research' . Networks have been used to solve well-defined optimisation problems in engineering, electronics and even sociology where some quantity has to be maximised or minimised subject to certain constraints. A good example is the 'travelling salesman problem' which attempts to find the shortest tour of a group of cities so that each city is visited only once. Other examples of the use of networks have been discussed by Potts (1978).

Ecologists have used networks to examine the functioning of ecosystems but the term 'network' does not appear to have been widely used. Diagrams presented by Odum (1971) showing energy flows and biogeochemical cycles are network diagrams. Quantitative diagrams of this type indicate flow rates along the edges of the network. These ecosystem models have been constructed for the purposes of description, interpretation and the prediction of the effects of perturbations.

The use of network analysis to examine associations between animals in a population allows the precise description of these associations. It also enables groups to be distinguished within the population using a graphical method (though this process is rather subjective). Its usefulness is, therefore, in the description and measurement of form and complexity rather than optimisation.

Networks have been used to examine associations between the biological components of ecosystems. Agnew (1961) has drawn 'constellations' showing the associations between species in plant communities in North Wales. Within these communities he was able to distinguish groups. Ovington (1965) has constructed separate networks showing differences in potassium circulation in adjacent oak and pine woodlands using lines (edges) of different widths to indicate flow rates between the components (vertices) of the ecosystems. Similarly networks may be used to describe and measure changes in the pattern or degree of association between animals within a population.

Detailed studies of the associations between animals within an entire population do not appear to have been made but behavioural work has been done with small groups of animals.

For example, Macdonald & Apps (1978) have made calculations of 'interaction frequencies' between four semi-dependent farm cats using simple behavioural categories such as 'aggression', 'amicable behaviour' and 'sleeping together'. They expressed the relationships between these cats as a series of network diagrams.

Much attention has been paid to dominance systems operating within populations. Wilson (1980) has given examples of hierarchical dominance systems in animals and has redrawn figures from Murchison (1935) showing such a system in roosters in the form of networks. Wilson has actually used the term 'network' in discussing dominance orders.

Generally, animal studies of the type described above, have only used small numbers of individuals, probably because of the approximately exponential increase in the number of possible interactions between individuals as the group size increases. For example, Guhl (1956) used only twelve birds in a study of the social order of chickens.

Studies of associations between individuals have the same inherent problems and consequently they too have been confined to small groups. Schaller (1972) examined the degree of association between eleven lionesses (_Panthera leo_ (L.)) in one pride and seven lionesses in a second pride using an index of association (see Section 11.2.). Dards (1979) has made similar calculations for separate groups of three, six, seven and nine female feral cats in Portsmouth dockyard. Both authors simply presented a matrix of values for the association index. No tests were made for the statistical significance of the associations and males were excluded from the studies. No attempts were made to express the results as networks. Matrices of data are difficult to interpret and consequently the treatment of associations in both of these studies was superficial.

### 11.1.2. The mathematics of network analysis

Associations between animals may be expressed algebraically and geometrically (graphically). Using algebraic methods, a series of associations may be defined by listing the animals (vertices) , for example

1, 2, 3, 4 ........................10

and the individual associations (edges) may be listed, for example

(1,2), (1,3), (1,4) ...............(9,10)

The set of vertices is defined as

$$V = \{1, 2, 3, 4 \ldots\ldots\ldots\ldots 10\}$$

and the set of edges as

$$E = \{(1,2), (1,3), (1,4) \ldots\ldots (9,10)\}$$

Algebraic methods are useful in the mathematical analysis of associations because the elements of the set $V$ are clearly defined and therefore easily examined, while the elements of the set $E$ may be assigned numerical values (representing the degree of association ) and are amenable to statistical analysis. This allows the comparison of the elements of both $V$ and $E$ at different times and under different conditions.

Geometrical (graphical) methods of defining animal associations are useful in enabling groups to be identified within the set $V$ from the matrix of associations defined by the set $E$, for example Fig. 11.1. Here again the edges may be assigned numerical values. It is not possible to represent the values of the edges by lines of different lengths because this would require more than three dimensions. Different line widths may be used (see for example Macdonald & Apps, 1978) but on a small scale the differences would be difficult to distinguish, especially where large numbers of edges must be represented. The positioning of the vertices is a subjective process and must be performed with care since it determines the pattern formed by the edges, and thus the apparent pattern of grouping. This is difficult without some prior knowledge of the groups present.

### 11.1.3. The mathematics of animal associations

The mathematical methods that may be used to study associations between animals are similar to those used in the

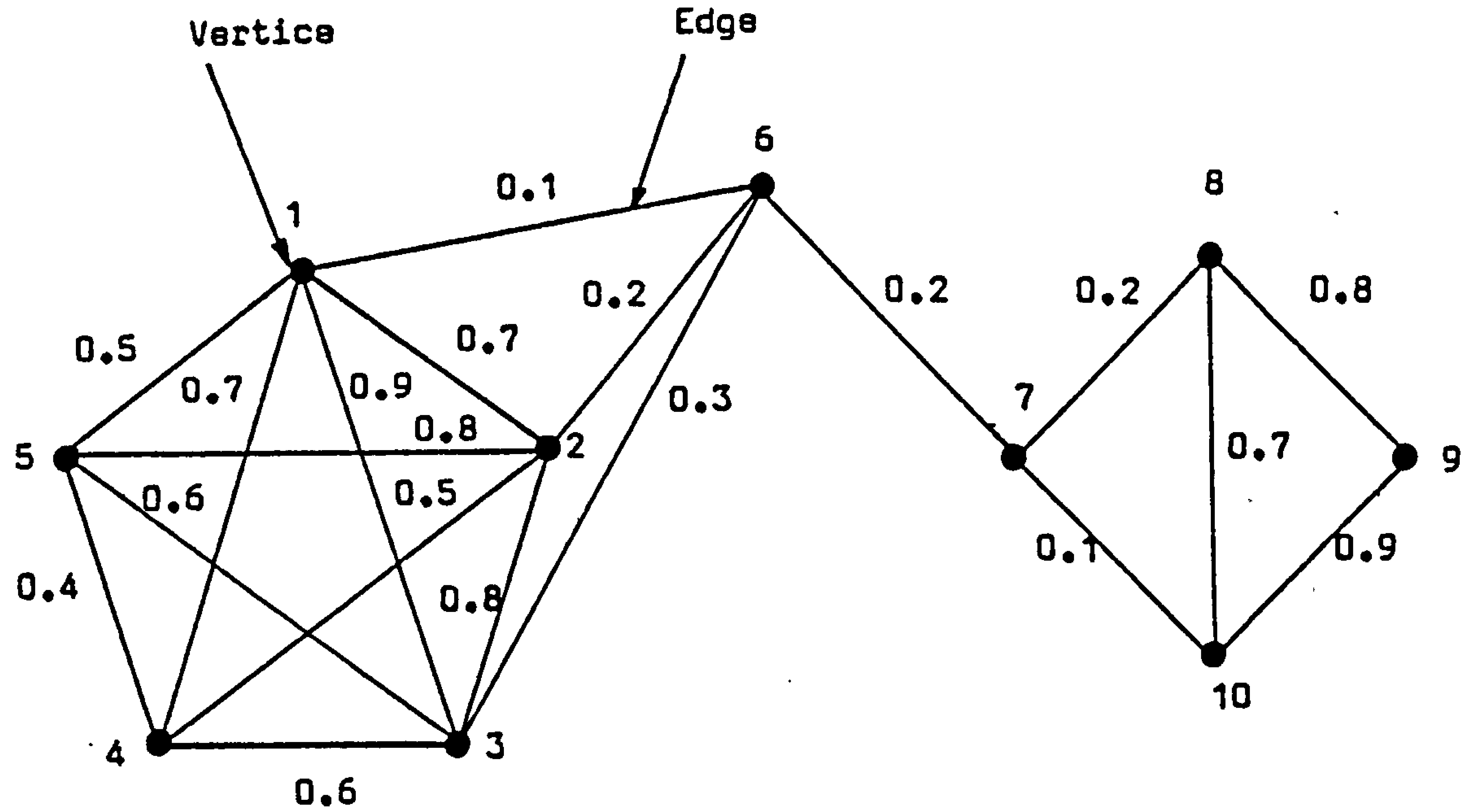



Fig. 11.1. Network of associations in an hypothetical animal population. Circles represent the animals (vertices), lines (edges) represent the degree of association between the animals.

calculation of permutations and combinations of any objects divided into groups.

The number of permutations of $n$ objects taken $r$ at a time is given by

$$P\binom{n}{r} = \frac{n!}{(n-r)!} \qquad (11.1.)$$

A combination of $n$ different objects taken $r$ at a time is a selection of $r$ out of the $n$ objects with no attention given to the order of arrangement. The number of combinations of $n$ objects taken $r$ at a time is given by

$$C\binom{n}{r} = \frac{P\binom{n}{r}}{r} = \frac{n!}{r!\,(n-r)!} \qquad (11.2.)$$

To calculate the number of possible combinations of pairs of animals in a group (associations) equation 11.2. may be used. Since $r$ has a value of 2 in this case this equation may be simplified to

$$C\binom{n}{r} = \frac{n!}{2\,(n-2)!} \qquad (11.3.)$$

It should be noted that the equation for calculating the number of possible combinations is used here to calculate the number of associations because the association animal 1, animal 2 is the same as the association animal 2, animal 1, that is, the order is not relevant.

Calculations involving factorials are time consuming, and, in the present case, unnecessary. Equation 11.3. may be further simplified by removing the factorials so the equation becomes

$$A_g = \frac{n\ (n-1)}{2} \qquad (11.4.)$$

where $n$ is the number of animals in the group and $A_g$ is the number of possible associations between animals in this group. With a slight modification this equation may be used to calculate the maximum number of associations ( $A_{max}$ ) possible in a population of size $p$

$$A_{max} = \frac{p\ (p-1)}{2} \qquad (11.5.)$$

For the purposes of the present discussion (i.e. where $r = 2$ ) equations 11.2, 11.3., 11.4. and 11.5. are equivalent and are essentially of the form $A = p^2/2$ (Fig. 11.2.). Even in relatively small populations the number of possible associations of the individual animals in pairs is high. If population size is increased by a factor of x, $A_{max}$ will be increased by a factor of approximately $x^2$. For example a X 2 increase in $p$ from 20 to 40 will result in an increase in $A_{max}$ from 190 to 780 (an increase of approximately X 4.2).

If a population is divided into a number of exclusive groups (where each cat is included in only one group) the total

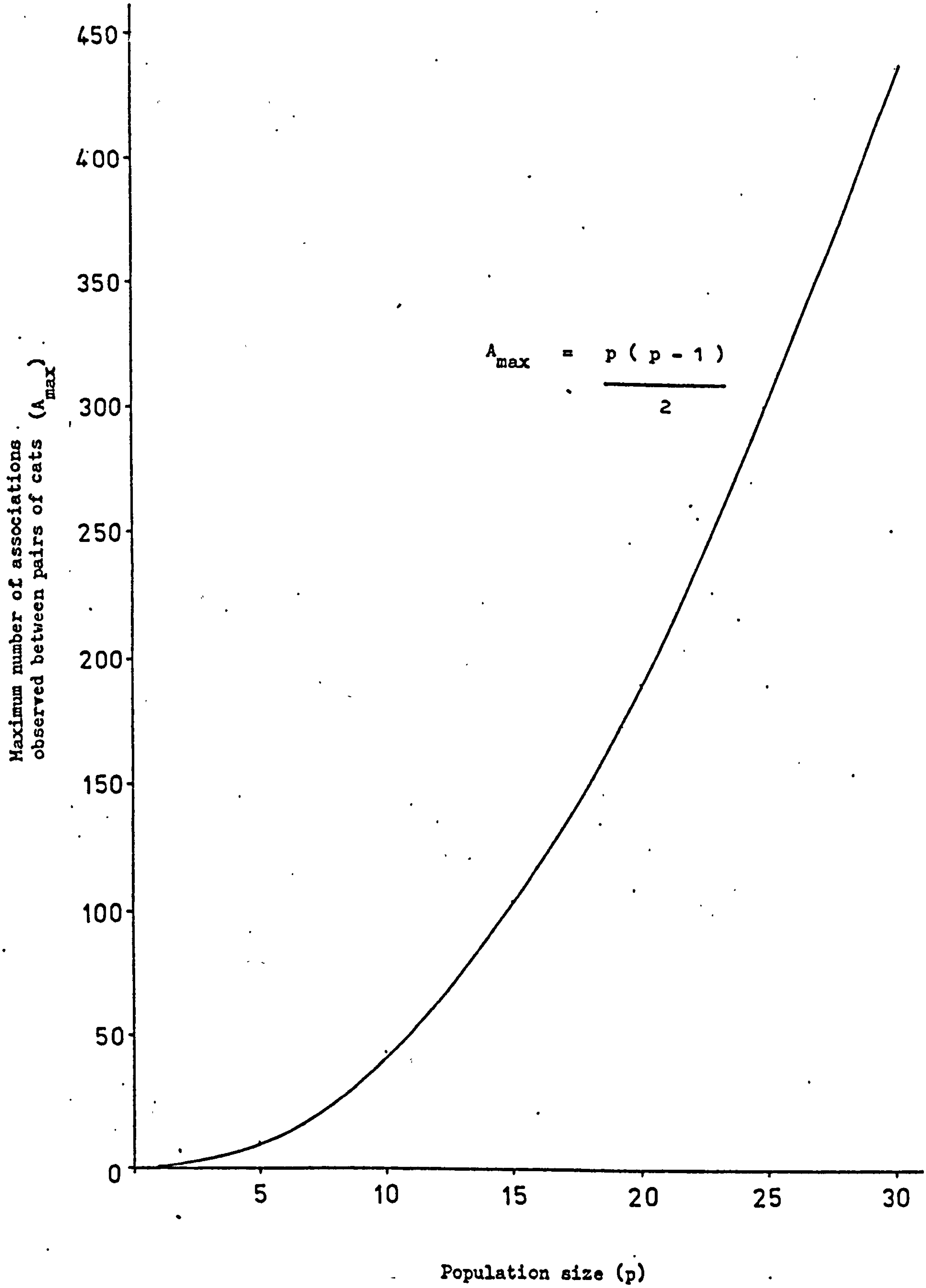



Fig. 11.2. The relationship between population size (p) and the maximum number of associations which may be observed between pairs of individuals ($A_{max}$).

number of associations in the population ( $A_{pop}$ ) is calculated as:

$$A_{pop} = \sum_{i=1}^{g} \frac{n_i \, (n_i - 1)}{2} \qquad (11.6.)$$

where $n_i$ is the number of animals in the $i^{th}$ group and $g$ is the number of groups in the population. $A_{pop}$ is always less than $A_{max}$ provided that $g$ is greater than one.

In the special case where the population is divided into a number of exclusive groups of equal size:

$$A_{pop} = \frac{g. \; n_i \, (n_i - 1)}{2} \qquad (11.7.)$$

where $n_i$ has only one value. Clearly, for equation 11.7. to be used the size of $n_i$ (group size) must be known.

If the population is divided into a number of approximately equal exclusive groups (which are assumed to be equal) but whose sizes are not known, the number of possible associations between all individuals in the population is given by:

$$A_{pop} = \frac{p \, (p/g - 1)}{2} \qquad (11.8.)$$

where $p$ is the population size and $g$ is the number of groups into which it is divided. Equation 11.8. is useful for estimating the total number of associations between individuals in a population of known size divided into a known number of groups, but where the precise size of the individual groups is not known.

### 11.1.4. Two hypothetical populations

If a population is divided into two or more exclusive groups $A_{pop}$ will always be less than $A_{max}$. The effect of dividing a population into two exclusive groups on $A_{pop}$ can be demonstrated by condidering an hypothetical population (Fig. 11.3.). If a population of 20 animals forms a single group where each animal associates with all of the others, $A_{pop} = A_{max} = 20(20 - 1)/2 = 190$.

If the population is divided into two groups ($n_1$ and $n_2$) $A_{pop}$ decreases as the ratio of the group sizes approaches 1 : 1. $A_{pop}$ is a maximum when there is only one group of 20 animals (i.e. $A_{pop} = A_{max}$), and a minimum (i.e. 90) when the population is divided into two equal groups (of ten).

When the two groups are approximately equal $A_{pop}$ is almost the same as when the groups are equal. When $n_1 = 7$ and $n_2 = 13$ ( a ratio of approximately 1 : 2 ) $A_{pop}$ is only 10% greater than the value obtained when the groups are equal. The ratio of the group sizes does not statistically differ from 1 : 1 (at the 5% level of significance) until $n_1 = 5$ and $n_2 = 15$, ( $\underline{P} = 0.025$ , $\underline{d.f.} = 1$). With these group sizes $A_{pop} = 115$, or 27.8% greater than the minimum value.

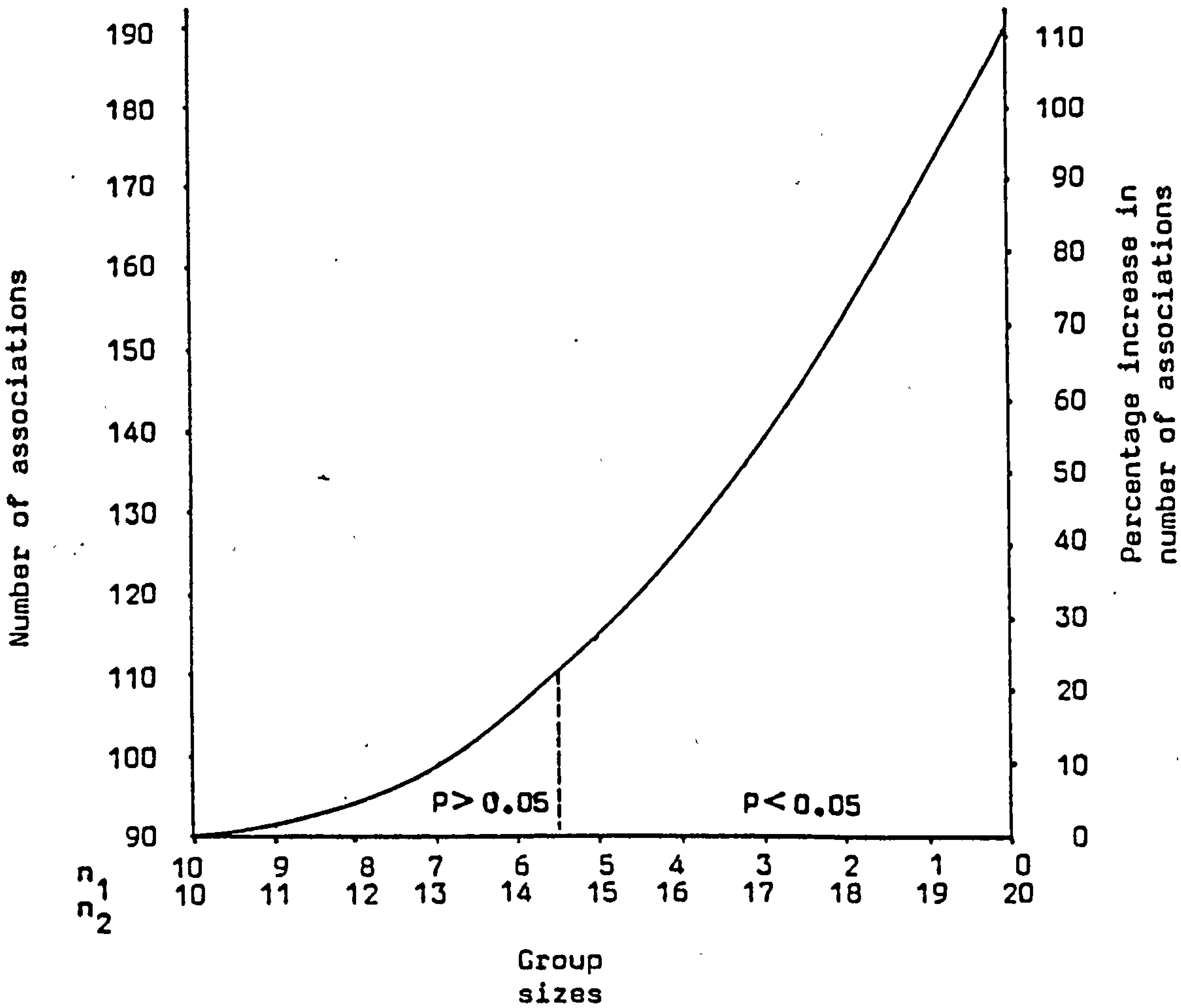



Fig. 11.3. The effect of dividing an hypothetical population of 20 individuals into two exclusive groups on the number of associations observed ($A_{pop}$). Group sizes to the left of the broken line do not significantly differ from a 1 : 1 ratio.

While group sizes remain approximately equal equation 11.8 is a good approximation to equation 11.6.

The effect on $A_{pop}$ of dividing a similar hypothetical population into three groups ($n_1$, $n_2$ and $n_3$) is shown in Fig. 11.4. (A population of 21 animals has been used because 20 cannot be divided into three equal groups). Fig. 11.4. is a half matrix of the values of $A_{pop}$ for any permutation of sizes of three exclusive groups whose sum is 21. The size of two of the groups is given by a value from each of the axes $n_1$ and $n_2$ and the size of the third group, $n_3$, is given by $n_3 = 21 - (n_1 + n_2)$ The value of $A_{pop}$ for any population of three groups is given by the value in the element of the half matrix which is in column $n_1$ and row $n_2$. For example, when $n_1 = 10$, $n_2 = 5$ $n_3 = 21 - (10 + 5) = 6$, and $A_{pop} = 70$.

It is interesting that this population may be divided into three groups in two quite different ways and yet still produce the same value for $A_{pop}$, for example:

| Group | $n_1$ | $n_2$ | $n_3$ | $A_{pop}$ |
|---|---|---|---|---|
| Population 1. | 10 | 3 | 8 | 76 |
| Population 2. | 11 | 4 | 6 | 76 |

Populations with the same values for $A_{pop}$ are joined by lines in Fig. 11.4.

$n_1$

| 19 | 18 | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | $n_2$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 171 | 154 | 139 | 126 | 115 | 106 | 99 | 94 | 91 | 90 | 91 | 94 | 99 | 106 | 115 | 126 | 139 | 154 | 171 | 1 |
| | 154 | 138 | 124 | 112 | 102 | 94 | 88 | 84 | 82 | 82 | 84 | 88 | 94 | 102 | 112 | 124 | 138 | 154 | 2 |
| | | 139 | 124 | 111 | 100 | 91 | 84 | 79 | 76 | 75 | 76 | 79 | 84 | 91 | 100 | 111 | 124 | 139 | 3 |
| | | | 126 | 112 | 100 | 90 | 82 | 76 | 72 | 70 | 70 | 72 | 76 | 82 | 90 | 100 | 112 | 126 | 4 |
| | | | | 115 | 102 | 91 | 82 | 75 | 70 | 67 | 66 | 67 | 70 | 75 | 82 | 91 | 102 | 115 | 5 |
| | | | | | 106 | 94 | 84 | 76 | 70 | 66 | 64 | 64 | 66 | 70 | 76 | 84 | 94 | 106 | 6 |
| | | | | | | 99 | 88 | 79 | 72 | 67 | 64 | 63 | 64 | 67 | 72 | 79 | 88 | 99 | 7 |
| | | | | | | | 94 | 84 | 76 | 70 | 66 | 64 | 64 | 66 | 70 | 76 | 84 | 94 | 8 |
| | | | | | | | | 91 | 82 | 75 | 70 | 67 | 66 | 67 | 70 | 75 | 82 | 91 | 9 |
| | | | | | | | | | 90 | 82 | 76 | 72 | 70 | 70 | 72 | 76 | 82 | 90 | 10 |
| | | | | | | | | | | 91 | 84 | 79 | 76 | 75 | 76 | 79 | 84 | 91 | 11 |
| | | | | | | | | | | | 94 | 88 | 84 | 82 | 82 | 84 | 88 | 94 | 12 |
| | | | | | | | | | | | | 99 | 94 | 91 | 90 | 91 | 94 | 99 | 13 |
| | | | | | | | | | | | | | 106 | 102 | 100 | 100 | 102 | 106 | 14 |
| | | | | | | | | | | | | | | 115 | 112 | 111 | 112 | 115 | 15 |
| | | | | | | | | | | | | | | | 126 | 124 | 124 | 126 | 16 |
| | | | | | | | | | | | | | | | | 139 | 138 | 139 | 17 |
| | | | | | | | | | | | | | | | | | 154 | 154 | 18 |
| | | | | | | | | | | | | | | | | | | 171 | 19 |

$A_{pop}$

Fig. 11.4. The effect of dividing an hypothetical population of 21 individuals into three exclusive groups ($n_1$ , $n_2$ and $n_3$ ) on the number of associations observed. Identical values of $A_{pop}$ are joined by lines. See text for explanation.

$$n_3 = 21 - ( n_1 + n_2 )$$

As a population is divided into more groups the relationship between group sizes and $A_{pop}$ becomes more complex. However, the same general principle applies : the maximum number of associations is found when the population is undivided; the minimum number of associations is found when the population is divided into equal groups.

In this second hypothetical population of 21 animals $A_{max}$ = 210 (i.e. when the population is undivided ). When it is divided into three equal groups of seven animals $A_{pop}$ = 63 (its minimum value).

If the group sizes are such that two of the groups are twice the size of the third there is only a small increase in $A_{pop}$ above the minimum value. For example if $n_1$ = 4, $n_2$ = 8, and $n_3$ = 9 , $A_{pop}$ is only 11.1% greater than when the groups are equal. When the population is divided so that one group is very large and the other two are very small, $A_{pop}$ approaches $A_{max}$. The permutations of group sizes which statistically differ from a 1:1:1 ratio are shown in Fig. 11.5. The ratio first differs from this when the groups have the sizes 3 : 6 : 12 ($\underline{p}$ = 0.0498, $\underline{d.f.}$ = 2) and $A_{pop}$ = 84, or 33.3% greater than its mimimum value.

In both of the hypothetical populations considered here when the ratio of group sizes does not differ statistically from equality (at the 5% level) $A_{pop}$ will be less than approximately 30%

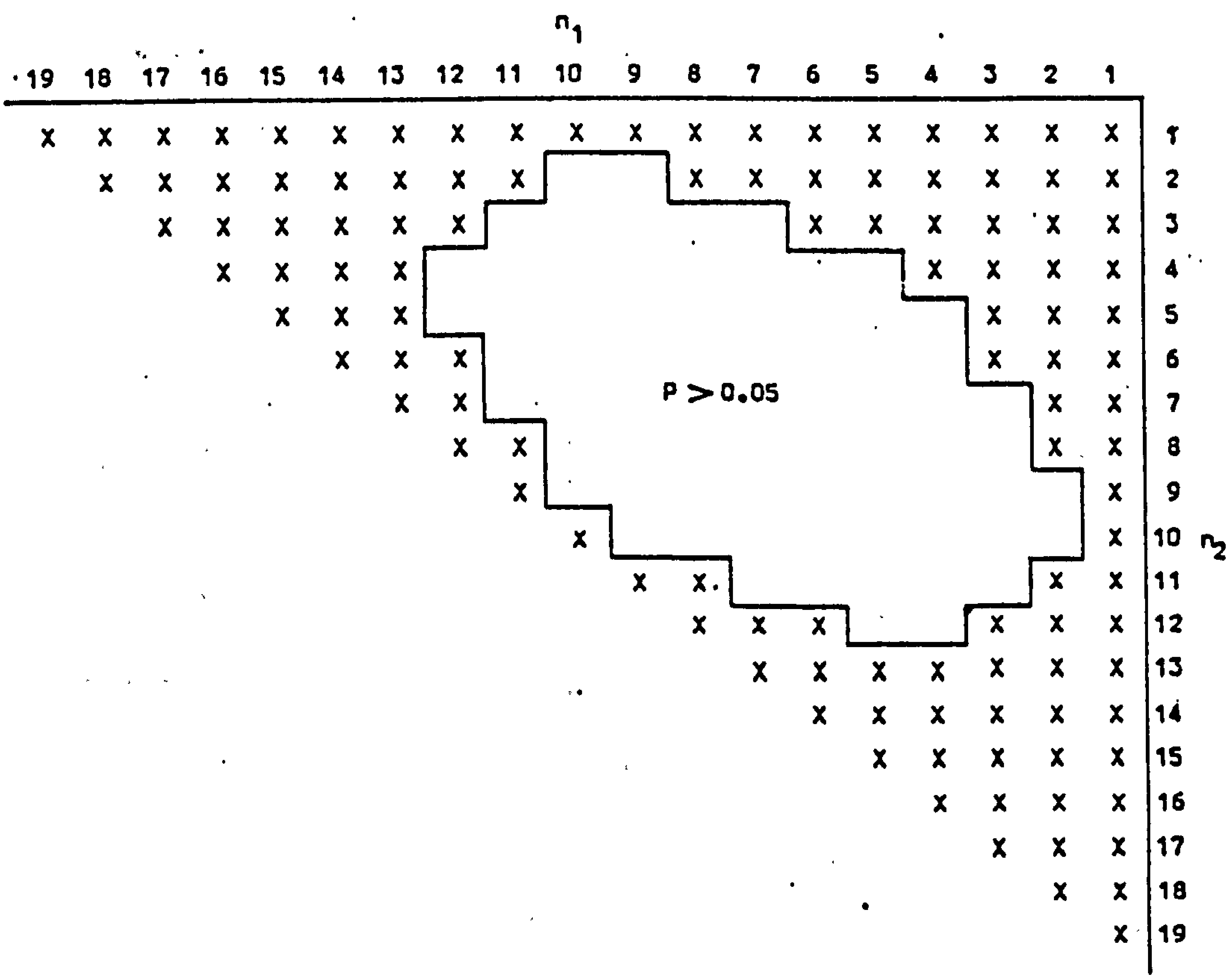



Fig. 11.5. The permutations of group sizes ($n_1$, $n_2$ and $n_3$) which significantly differ from a 1 : 1 : 1 ratio (X). See text for explanation.

more than its minimum value, for the appropriate number of groups. The relationships between $A_{pop}$, $\chi^2$ and the ratio of group sizes in larger populations and populations divided into more than three groups have not been examined.

Some important general conclusions may be drawn from this examination of hypothetical populations:

(i) The number of associations formed by pairs of individuals in any population ($A_{pop}$) is a maximum ($A_{max}$) when the population (p) exists as a single group.

(ii) $A_{pop}$ may be reduced by dividing the population into a number of exclusive groups (g), where individuals only associate with animals in their own group.

(iii) $A_{pop}$ in a population of fixed size will decrease as the number of groups (g) is increased.

(iv) $A_{pop}$ in a population with a fixed number of groups (g) will be a minimum when the groups are of equal size. (For practical purposes there is little difference between $A_{pop}$ when the group sizes are equal and when they are only approximately equal).

11.1.5. The measurement of grouping

In order to reduce the number of associations between individuals in any population ($A_{pop}$) it must be divided into a number of groups (g) of approximately equal size. The relationship between $A_{pop}$, g, and the population size (p) is shown in Fig. 11.6., where the groups are of equal size. It is clear from Fig. 11.6. that not only can $A_{pop}$ be calculated from p and g, but also, if $A_{pop}$ and p are known the number of groups can be calculated. For example, if 100 associations are observed within a population of 30 animals, this population must consist of four exclusive groups.

Equation 11.8. may be rearranged to calculate the number of groups (g) directly from $A_{pop}$ and p :

$$g = \frac{p^2}{2.\ A_{pop} + p} \qquad (11.9.)$$

Instead of being used to calculate $A_{pop}$ from p and g, the theory that has been developed above may now be used to calculate the number of groups into which a real population of known size is divided by obtaining a value for $A_{pop}$ by observation. The observed number of associations in a population will be called $A_{obs}$.

Equation 11.9. produces spuriously accurate estimates of the number of groups (g) in a population. For example, if $p = 50$, and $A_{pop} = 121$ then $g = 8.56$. A more useful measure of the degree of grouping is obtained by expressing $A_{obs}$ as a percentage of $A_{max}$. For a real population, where $A_{obs}$

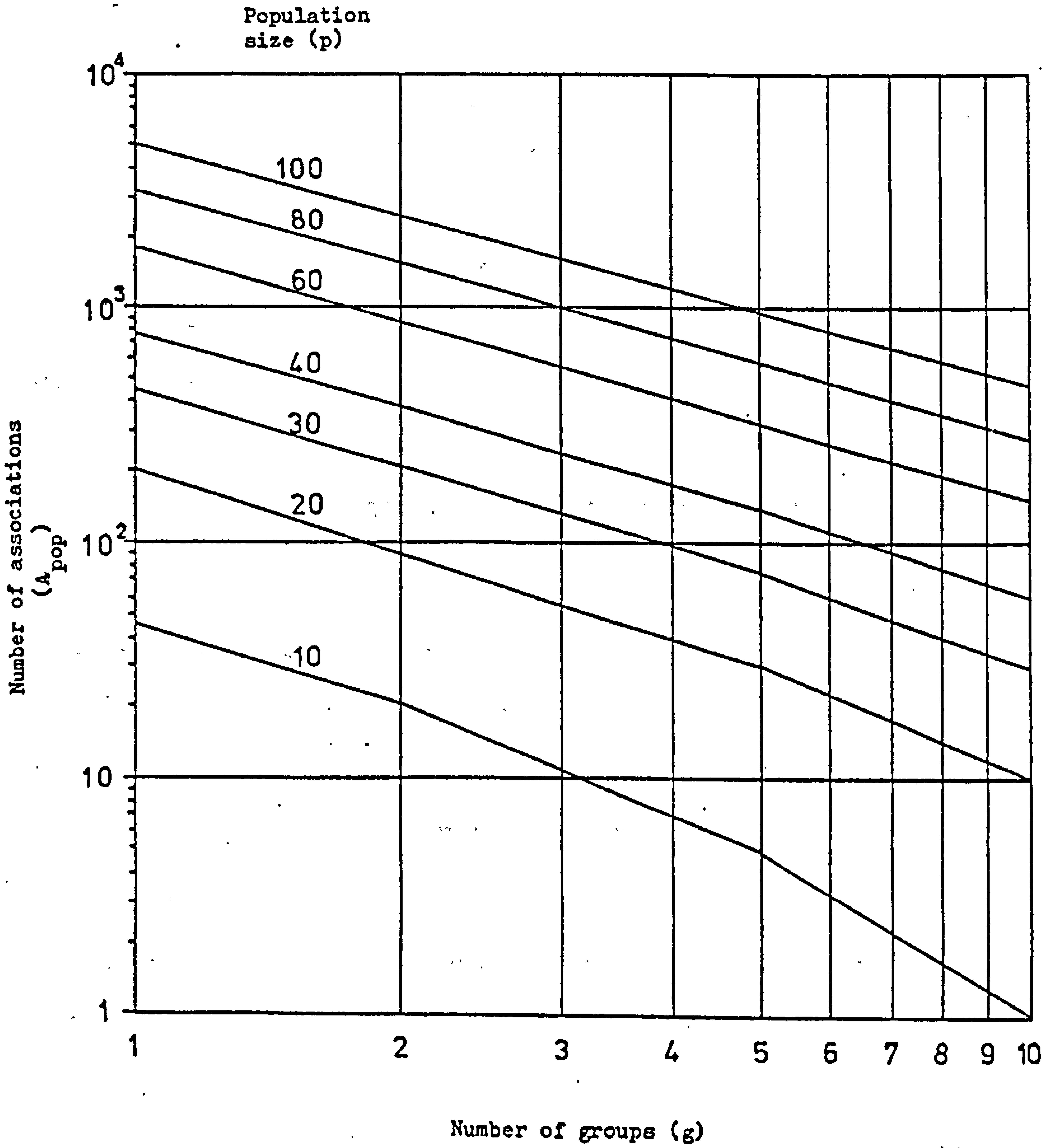



Fig. 11.6. The relationship between population size (p), the number of groups (g) into which a population is divided and the number of associations ($A_{pop}$). All groups are assumed to be equal in size in any population.

has been estimated, this percentage (m) is calculated as :

$$m = \frac{A_{obs}}{p\ (p - 1)\ /\ 2} \times 100 \qquad (11.10.)$$

In the example given above where $p = 50$ and $A_{pop}$ $(A_{obs})$ $= 121$, $m = 9.88\%$ . For a theoretical population, m is calculated as:

$$m = \frac{p\ (\ p\ /\ g\ -\ 1\ )\ /\ 2}{p\ (\ p\ -\ 1\ )\ /\ 2} \times 100$$

where the population (p) is divided into a number of equal groups (g). This equation may be simplified to :

$$m = \frac{100\ (\ p\ /\ g\ -\ 1\ )}{p\ -\ 1} \qquad (11.11.)$$

If equation 11.11. is rearranged g may be calculated from m and p :

$$g = \frac{p}{m\ (\ p\ -\ 1\ )\ /\ 100\ \ +1} \qquad (11.12.)$$

In fact this yields the same values for g as equation 11.9. and is therefore of little practical use. It will, however, be referred to below.

Fig. 11.7. shows the relationship between p , g and m

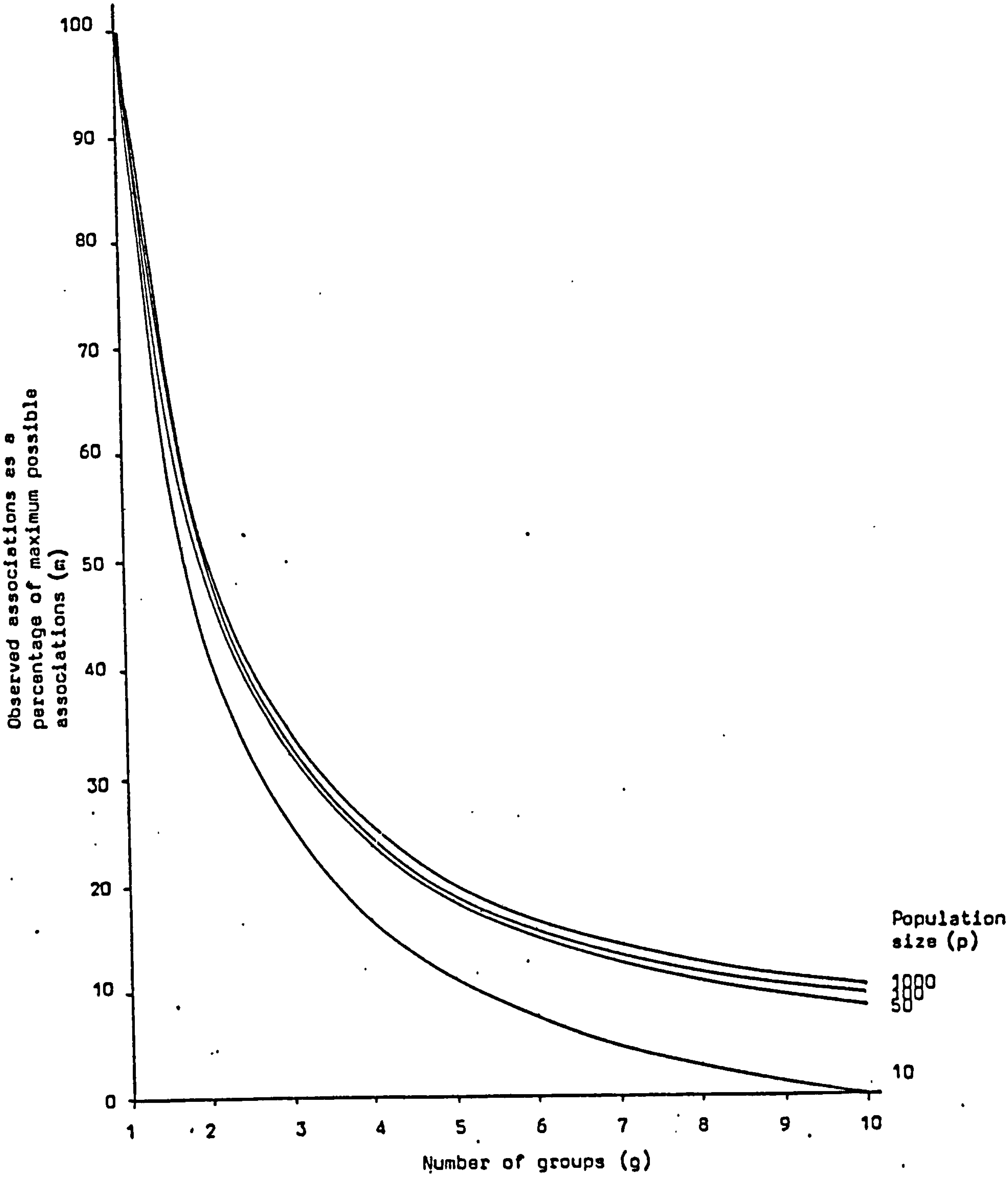



Fig. 11.7. The relationship between population size (p) the number of groups into which a population is divided (g) and the number of associations observed expressed as a percentage of the maximum number of associations possible (m). The groups in any population are assumed to be equal in size.

in theoretical populations. Clearly, the lower the value of $m$ the greater the number of groups in the population (or the greater the degree of grouping). It is interesting that, when $p$ is large, the relationship between $g$ and $m$ is almost constant regardless of the size of $p$. The reason for this can be seen by examining equation 11.12. When $p$ is large $p - 1 \approx p$ and the effect of increasing the divisor by 1 is negligible. Equation 11.12. may therefore be reduced to :

$$g \approx \frac{p}{m.\ p\ /\ 100}$$

$$\approx \frac{100}{m} \qquad (11.13.)$$

and rearranging,

$$m \approx \frac{100}{g} \qquad (11.14.)$$

These equations allow the estimation of $g$ from $m$ or $m$ from $g$ for a large population whose actual size is unknown. Table 11.1. shows the extent to which equation 11.13. approximates to equation 11.12. for a range of values of $p$ and $m$. It is clear that even with a population of only 100 animals estimates of $g$ from equation 11.13. are a good approximation to those obtained from equation 11.12. Equation 11.13. is useful if the exact size of $p$ is unknown, but $p$ must be known

Table 11.1.

A comparison of estimates of g (the number of groups in a population) calculated from equations 11.12 and 11.13.

| Population size (p) | Estimate of g | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Eq | 11.12 | 11.13 | 11.12 | 11.13 | 11.12 | 11.13 | 11.12 | 11.13 |
| 5 | 3.571 | 10.0 | 2.500 | 4.0 | 1.667 | 2.0 | 1.250 | 1.333 |
| 10 | 5.263 | | 3.077 | | 1.818 | | 1.290 | |
| 20 | 6.897 | | 3.478 | | 1.905 | | 1.311 | |
| 50 | 8.475 | | 3.774 | | 1.961 | | 1.325 | |
| 100 | 9.174 | | 3.883 | | 1.980 | | 1.329 | |
| 200 | 9.569 | | 3.941 | | 1.990 | | 1.331 | |
| 500 | 9.823 | | 3.976 | | 1.996 | | 1.332 | |
| 1000 | 9.911 | | 3.988 | | 1.998 | | 1.333 | |
| 2000 | 9.955 | | 3.994 | | 1.999 | | 1.333 | |
| 5000 | 9.982 | | 3.998 | | 2.000 | | 1.333 | |
| | m = 10 | | m = 25 | | m = 50 | | m = 75 | |

Equation 11.12
$$g = \frac{p}{m(p-1)/100 + 1}$$

Equation 11.13
$$g \approx \frac{100}{m}$$

in order to calculate $m$ for a real population, (see equation 11.10.). Equation 11.13. is therefore only really useful in estimating $g$ when estimates of $m$ are available for large populations whose exact size is unknown. Equation 11.14. is perhaps more useful as it allows the estimation of $m$ for a population of unknown size which is divided into a known number of groups.

The relationship between each combination of group sizes and $m$ in the two hypothetical populations described in Section 11.1.4. is indicated in Fig. 11.8. and 11.9. The minimum value of $m$ for each population is observed when the groups are of equal size: 47.4% in the population divided into two groups, and 30.0% in the population divided into three groups.

If $m = 100\%$, then $A_{pop}$ (or $A_{obs}$) $= A_{max}$, and therefore the population is organised as a single group with each individual associating with all other individuals. The lower the value of $m$ for a population of fixed size, the greater the tendency to form small exclusive groups of approximately equal size. If $m = 0$ the animals are all solitary, and no associations are observed.

None of the theoretical calculations made above takes account of animals which wander between groups. These nomadic animals may associate with a relatively large number of others. Their presence will increase $A_{obs}$ in a population divided into

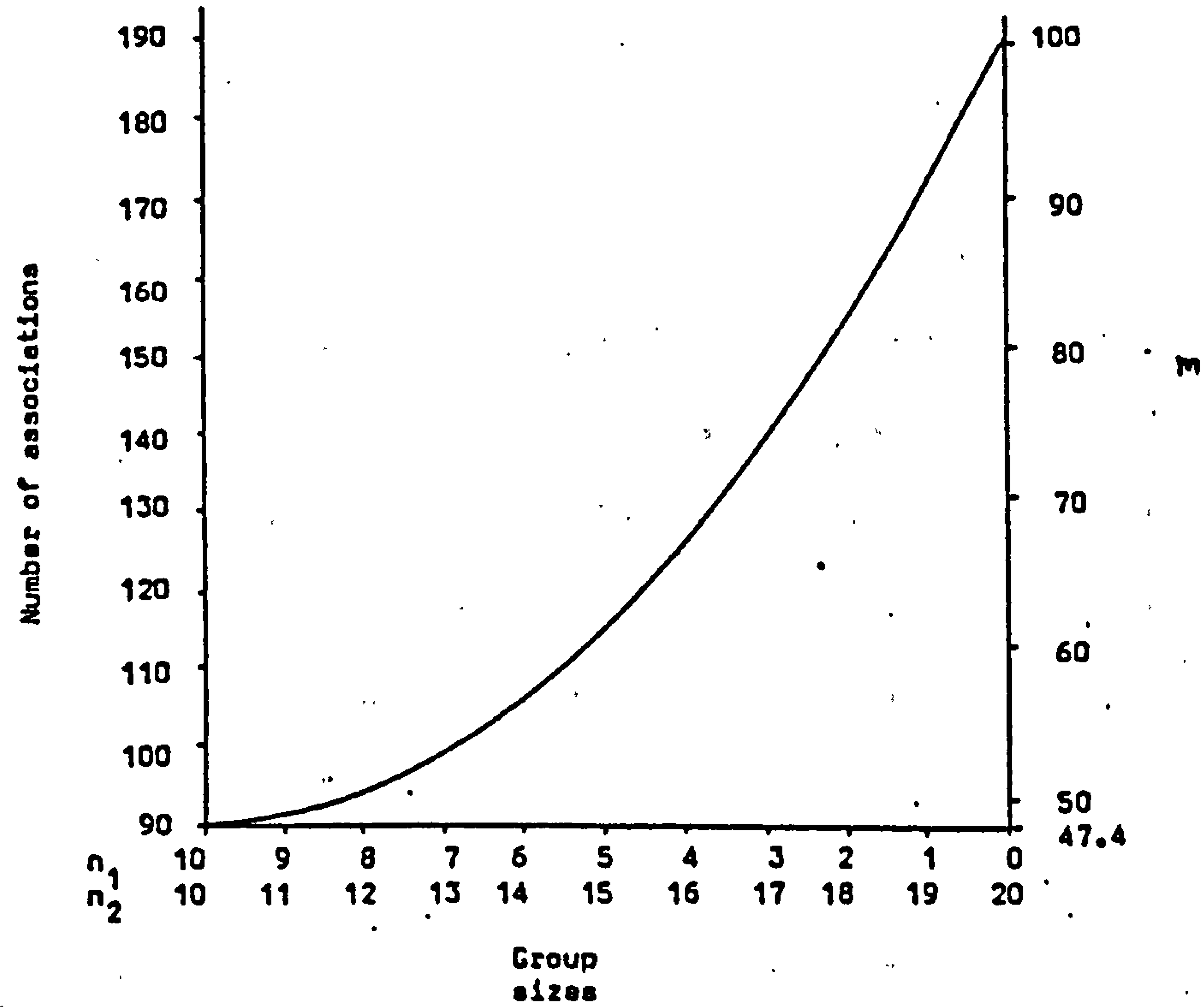



Fig. 11.8. The relationship between group sizes and m in an hypothetical population of 20 individuals divided into two groups. See Fig. 11.3.

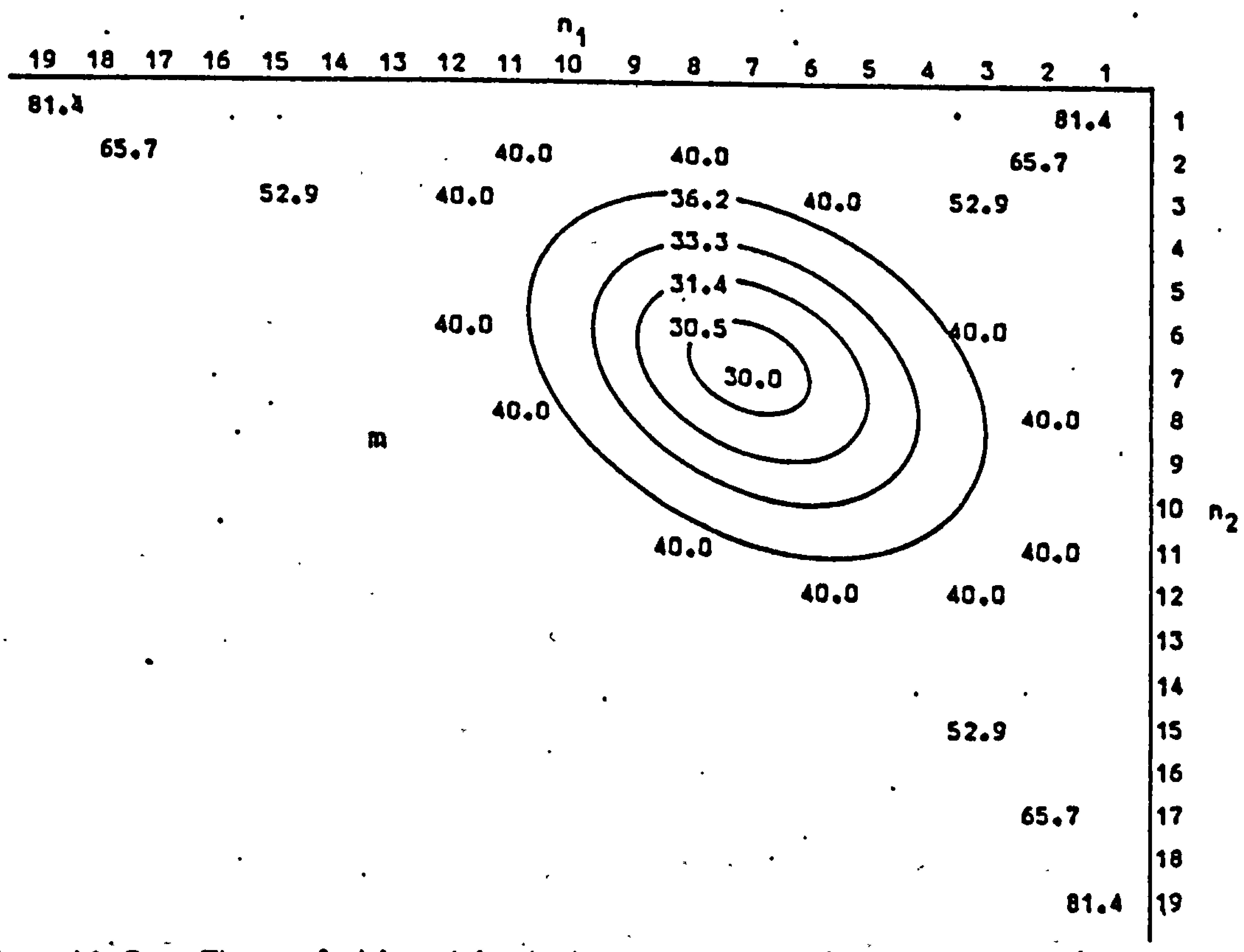



Fig. 11.9. The relationship between group sizes and m in an hypothetical population of 21 individuals divided into three groups. Many values of m have been omitted. Ellipses indicate the positions of similar values. See Fig. 11.4.

groups so that it approaches $A_{max}$ . However, two other factors tend to decrease $A_{obs}$ . First, some potential associations between animals living within the same group may never be observed due to the effects of chance. Second, some animals may only be seen alone. Their presence will increase $p$ but not $A_{obs}$ . If the proportion of mobile animals in a population is low it seems reasonable to assume that it behaves as if it is divided into a number of exclusive groups.

It is now possible to consider the reasons why the value of $m$ in a population of fixed size may decrease. This may be due to one or more of the following events:

(i) An increase in the number of groups (and a consequent decrease in the size of each group).

(ii) A tendency for the groups to become approximately equal in size (i.e. a decrease in the size of large groups and an increase in the size of small groups).

(iii) A decrease in the movements of nomadic animals between groups.

### 11.1.6. The ecology of group living

It has been shown above that the number of associations in a population may be reduced by dividing the population into a number of groups of approximately equal size. It has also been shown that the extent to which a population tends to form small, equal groups may be measured by examination of the number of associations. Clearly, the number of associations is a function of group size, but is it possible that there is some limit to the number of associations that each animal can maintain and, therefore, that the number of associations in some way determines group size?

In species with complex social systems each individual may only be able to assess its social position (perhaps in a dominance hierarchy) when it is in a relatively small group. In very large groups such systems may not function efficiently because of the large number of animals with which each individual must interact. This suggests that complex animal societies are only likely to evolve when a population exists as a number of small groups.

There appears to be some support for these ideas. Bertram (1978) has noted that species such as wildebeest (_Connochaetes taurinus_ (Burchell)) weaver birds (Ploceidae) and starlings (Sturnidae) live in huge associations apparently devoid of social structure. He has also observed that animals which are habitually in groups, particularly in small groups, are often in permanent groups, for example wolves (Mech, 1970) and lions (Schaller, 1972; Bertram, 1975). Bertram has argued that one result of this stability of group composition is that members of the same group are able to recognise one another and can learn a great deal about one another. This has allowed the development of complex relationships between group members (for example dominance hierarchies and co- operative behaviour). Wilson (1980) has cited many examples of the ability of mammals to discriminate between individuals of their own kind, emphasising the importance of visual and olfactory communication.

If the individuals of a species live in groups it is reasonable to assume that this grouping confers some advantages upon these individuals. If, however, the population does not exist as one large group there must be some disadvantages to individuals living in large social units.

Odum (1971) has suggested reasons why populations show aggregations of individuals. Clutton - Brock & Harvey (1977) have classified the advantages and disadvantages of group life in a discussion of primate ecology and social organisation. Bertram (1978) has considered separately the variety of selective pressures which operate on animals in groups, particularly those concerned with predation (Table 11.2.).

Odum (1971) has noted that aggregations may increase competition between individuals for nutrients, or space, but this is often more than counter - balanced by increased survival of the group. Allee et al (1949) suggested that undercrowding (or lack of aggregation), as well as overcrowding, may limit

Table 11.2.

Reasons for group living.

| |
|---|
| Reasons why populations show aggregations of individuals (Odum, 1971) |
| In response to local habitat differences<br>In response to daily and seasonal weather changes<br>As the result of reproductive processes<br>As the result of social interactions (in higher animals) |
| The advantages and disadvantages of group life (Clutton-Brock & Harvey, 1977) |
| Advantages:<br>Detection avoidance, or defense against predators<br>Food finding, handling, defense or exploitation<br>Direct reproductive advantage, including regular access to the opposite sex<br>Facilitation of the learning process, resulting from the presence of several older animals<br><br>Disadvantages:<br>Makes individuals more conspicuous to predators<br>Decreases feeding rate either through mutual interference at food sources or through indirect competition for food supplies |
| The selective pressures which operate on animals in groups (Bertram, 1978) |
| Advantages to prey by reducing predation:<br>Avoiding detection by the predator<br>Deterring the predator<br>Detecting the predator<br>Confusing the predator<br>Diluting the predator's effects<br>Avoiding being the victim<br>Advantages to predators in obtaining food:<br>Improved location of food<br>Improved chance of catching prey<br>Catching larger prey<br>Competing better for food with other competing species |

population growth. In some populations growth and survival are greatest when population size is small. In others, intraspecific protocooperation results in an intermediate sized population being the most favourable. This may have implications for the size of groups as well as the size of populations.

The kinds of social organisation exhibited by advanced vertebrate societies may be regulatory in preventing overgrowth (Odum, 1971). Wynne - Edwards (1962) has discussed the control of populations by social mechanisms but he has been criticised for invoking group selection as the mechanism responsible for altruistic behaviour in these populations (Williams, 1966). There has been much recent discussion of the genetic basis for altruistic behaviour within groups of related animals. Darwin (1859) originated the concept of kin selection to explain such behaviour in the sterile worker castes of insect societies. The modern genetic theory of kin selection is the work of Hamilton (1964) whose most important concept is 'inclusive fitness' : the sum of an individual's own fitness plus the sum of all the effects it causes to the related parts of the fitnesses of all its relatives.

Williams (1966) has suggested that a 'statistical summation of adaptive individual reactions' underlies all group action. Many animal groups gain benefits from grouping which are not related to the evolutionary processes which have produced the social habit. As an example Williams refers to the retention of warmth by closed groups of mammals. He asserts that there is no more reason to assume that a herd is designed for warmth retention than to assume that it is designed for transmitting disease. This is important because it is easy to fall into the almost tautological trap of saying that if a species lives in groups then group living must be adaptive and then postulating advantages to be gained from living in groups. Indeed there are many examples in the literature of researchers postulating an adaptive function for a particular character of a species only to subsequently find their ideas refuted by experimentation. Popper (1978) has highlighted these difficulties with evolutionary theory. While acknowledging that the Darwinian theory of evolution has been invaluable in shedding light upon practical researches he maintains that 'there is hardly any possibility of testing a theory as feeble as this' .

When examining the function of grouping a distinction must be made between a function and an effect (Williams, 1966). When a population is divided into groups disease transmission may be reduced. But this is more likely to be an effect of grouping rather than its primary function. Similarly, inbreeding may be an effect of grouping. Any discussion of the reasons for group living must have a sound genetic basis and be supported by experimental evidence.

Returning to the hypothetical populations discussed earlier, Fig. 11.10. is a three - dimensional model which relates the

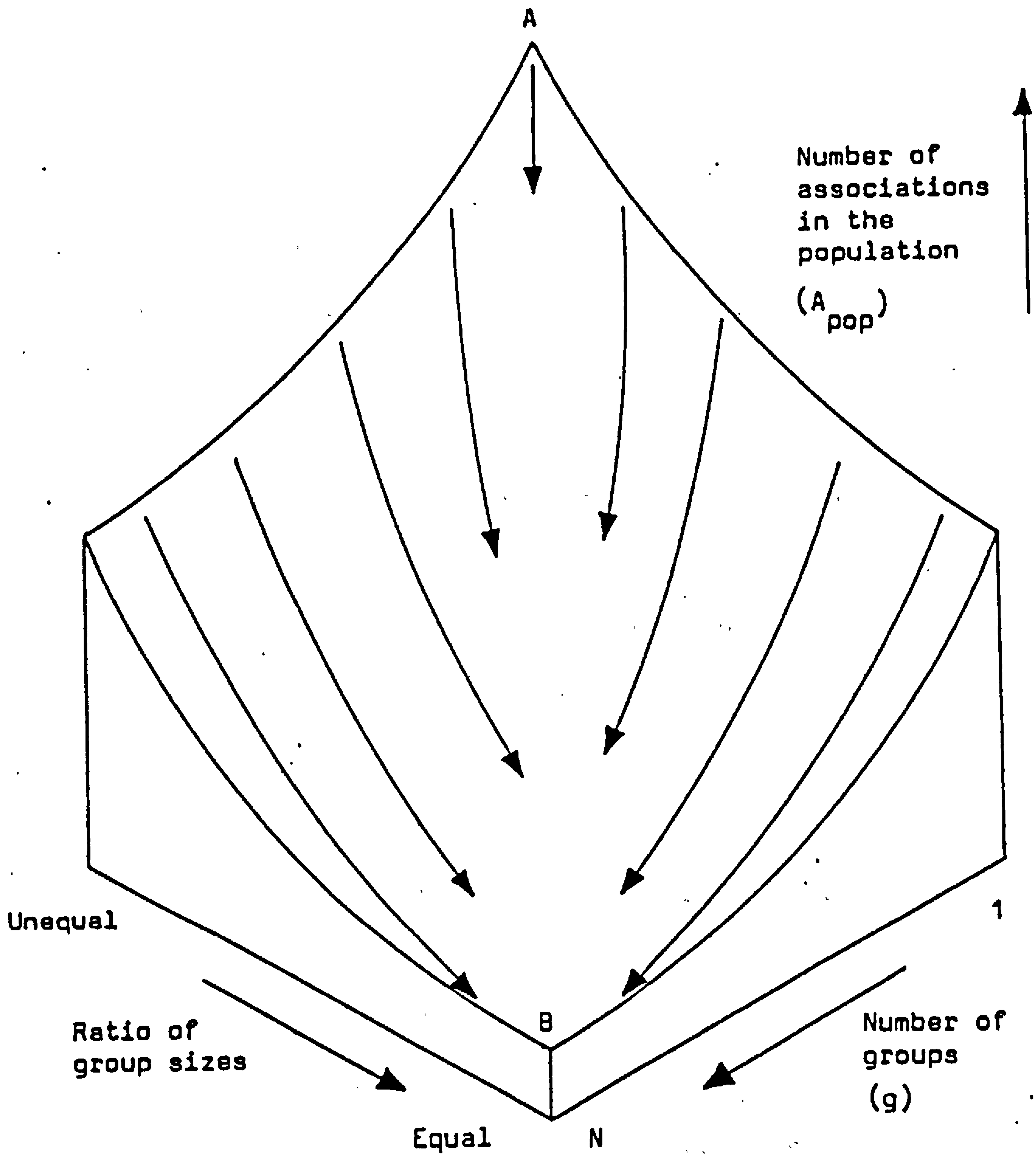



Fig. 11.10. A model of the relationships between the number of associations in a population ($A_{pop}$), the number of groups (g) and the relative sizes of these groups.

number of associations in the population ($A_{pop}$) to the number of groups (g) and the relative sizes of these groups. A ball (representing a population) placed on this surface will tend to roll towards point B under the influence of factors tending to favour the division of the population into a number of approximately equal groups. Factors tending to cause the population to form a single large group will force the ball up towards point A. All of the factors affecting the position and movement of the ball (population) over this surface may be considered together as the various selection pressures which are collectively called natural selection. Natural selection does not, however, act upon populations; it acts upon individuals. How, then, could natural selection act upon the individuals within a population in a way which would cause it to exist as a number of approximately equal groups ?

### 11.1.7. A model of group size equalisation processes

There must be an optimum group size which can be supported in a particular place at a particular time. This will be determined by the availability of resources (food, shelter etc.) and possibly by interactions between group members, as discussed above. If a group exceeds its optimum size increased mortality and / or emigration may reduce the number of animals. Decreased natality and / or immigration may also contribute to this reduction. Emigration of animals from social groups is common in nature, particularly as a result of the rejection of young animals by the older group members. Schaller (1972) has observed emigration of subadults of both sexes from prides of lions (Panthera leo (L)), while Dards (1979) reports mainly emigration of male feral cats from their natal social groups. Which sex stays and which emigrates varies according to the species and its social system (Bertram, 1978). If the size of a group falls below its optimum, reduced mortality and / or emigration along with increased natality and / or immigration may cause an increase in the number of animals. Only some of these processes need occur to alter group size but the balance of losses and gains within each group will determine its size.

Permanent intrapopulation movements of animals (from one group into another) may be an important factor in the redistribution of individuals resulting in equalisation of group sizes without affecting overall population size. It may also be important in increasing the gene flow between groups and thereby reducing inbreeding. These processes are summarised in the model of a population divided into four groups presented in Fig. 11.11.

Large populations may arise from a number of small groups with separate origins. Some new groups may arise by dispersal of individuals from pre-existing groups as the original groups grow in size. There is therefore no need to postulate a novel mechanism for the division of a population into a number of groups. The processes of animal movement, birth and death are all regulated by the effects of natural selection on individual animals.

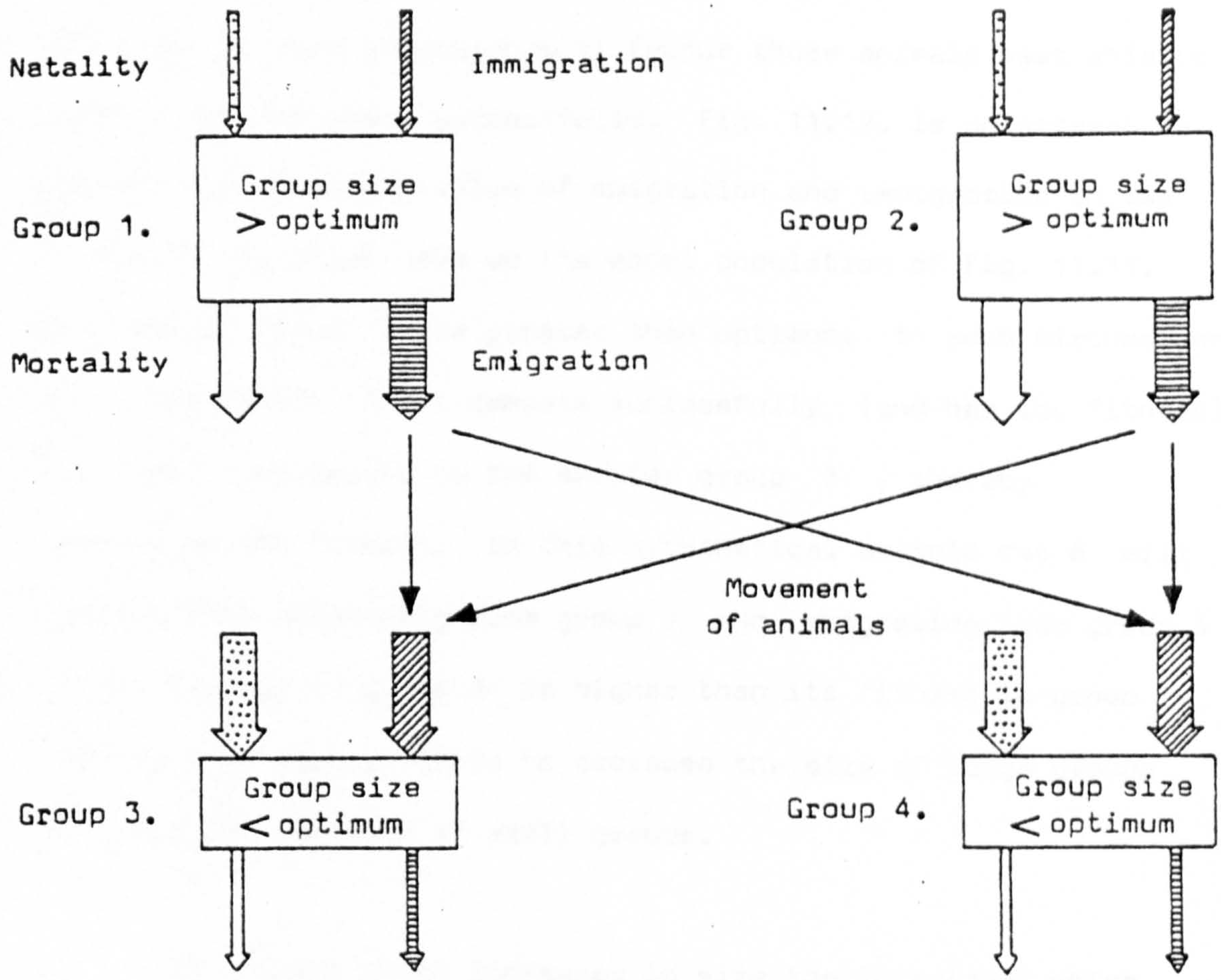



Fig. 11.11. A model of the processes which may result in the equalisation of the sizes of social groups in a population.

Natural selection acts by increasing or reducing the fitness of individuals : their ability to leave more young than others in the population. The way in which selection acts upon natality and mortality is well established. If a population or group increases in size selection will favour those animals best able to compete and reproduce successfully. Fig. 11.12. is an attempt to explain the selective value of emigration and immigration in two of the groups which make up the model population of Fig. 11.11. The size of group 1 is greater than optimum. In such circumstances, any animal which cannot compete successfully (and has low fitness) may benefit by moving to the smaller group 3 , thereby increasing its fitness. In this hypothetical example cat 6 will benefit from emigrating from group 1 and immigrating into group 3 if its fitness in group 3 is higher than its fitness in group 1. Clearly this process tends to decrease the size of large groups and increase the size of small groups.

In a group which increases in size the individual which cannot compete and does not emigrate will contribute little or nothing to the gene pool of the next generation. Natural selection will, therefore, favour animals which can either compete and reproduce successfully in the group into which they are born, or those which emigrate and reproduce successfully in another group.

It appears that the effects of natural selection upon individuals within any population are adequate to account for

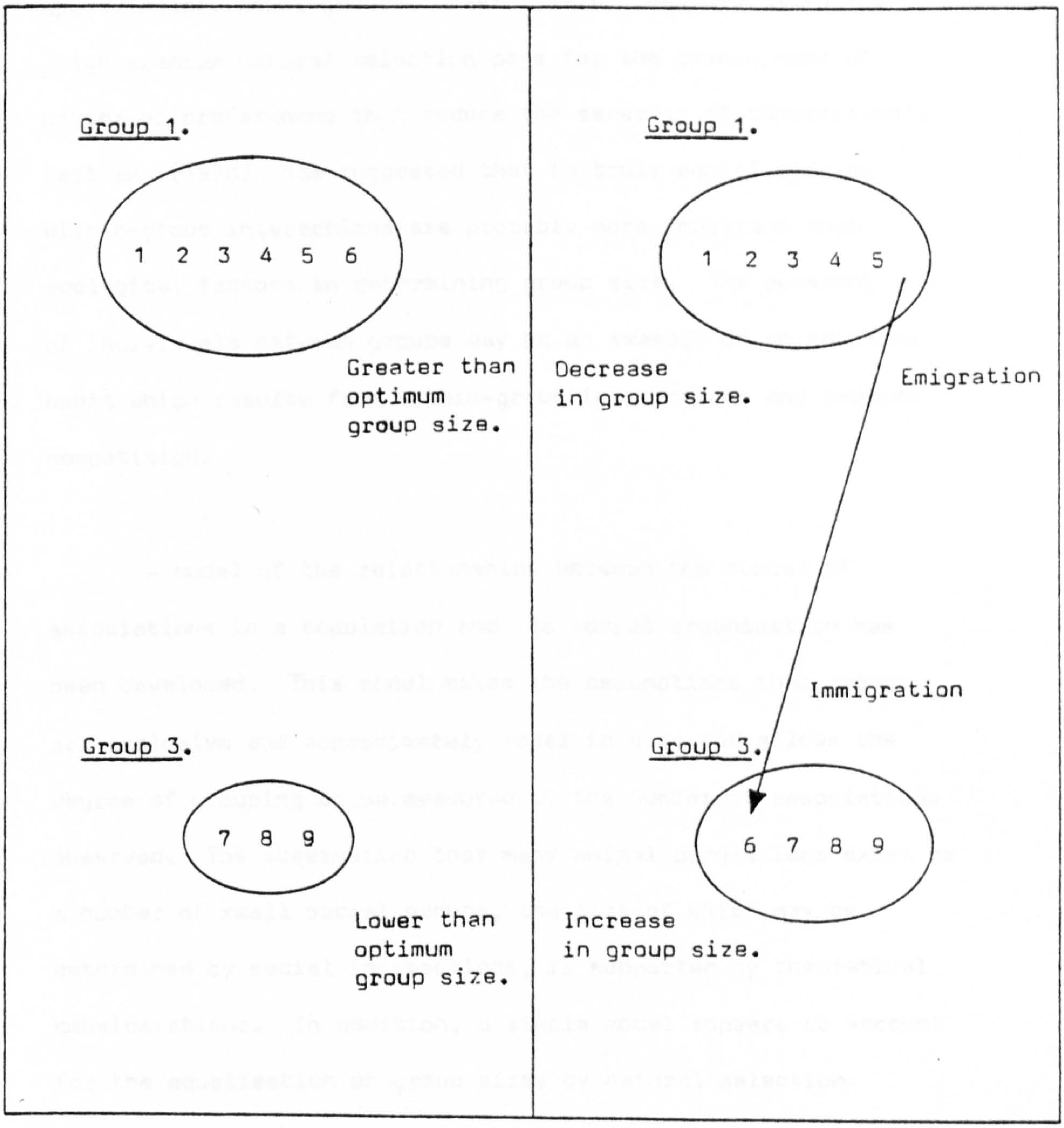



**Fig. 11.12. The possible selective value of migration of an animal from group 1 to group 3 (see Fig. 11.11.). The numbers represent individual animals.**

the tendency of this population to exist as a number of approximately equal groups. Mayr (1970) has discussed the 'high premium natural selection pays for the development of habits or preferences that reduce the severity of competition'. Bertram (1978) has suggested that in truly social species within-group interactions are probably more important than ecological factors in determining group size. The movement of individuals between groups may be an example of an adaptive habit which results from within-group interactions and reduces competition.

A model of the relationships between the number of associations in a population and its social organisation has been developed. This model makes the assumptions that groups are exclusive and approximately equal in size and allows the degree of grouping to be measured by the number of associations observed. The observation that many animal populations exist as a number of small social groups, the size of which may be determined by social interactions, is supported by theoretical considerations. In addition, a simple model appears to account for the equalisation of group sizes by natural selection.

## 11.2. RECORDING ASSOCIATIONS

The definition of an association between two animals and the method used to record associations are important in the interpretation of any calculations based upon the theoretical considerations described above.

All cats observed together in a single zone at the same time were considered to be associating. No account was taken of the relative distance between individuals because often these distances changed continuously due to movements. Cats less than six months old were excluded from the record of associations because many such animals disappeared at an early age and their inclusion would have produced many short-lived associations.

Each recording took the following form:

| Visit number | Time | Zone | Total No. of cats | Individual cat numbers |
|---|---|---|---|---|
| 127 , | 11.45 , | A , | 3 , | 14 , 19 , 53 |

The number of associations observed in a group of $n$ animals seen together is given by equation 11.4.

$$A_g = \frac{n(n-1)}{2}$$

In the example above,

$$A_g = \frac{3(3-1)}{2} = 3.$$

and the actual associations are:

(14, 19), (14 , 53), and (19, 53).

When the number of animals in a recording is small the individual associations are easily listed. However, when $n$ is large the problem of listing associations becomes much greater, (for example when $n = 10$, $A_g = 45$). Problems arise when $n$ is large. The manual listing of all associations is tedious and error prone. Also, when the total population is large the number of possible associations ($A_{max}$) is so great that a cumulative record of the number of times each association was observed would be difficult to construct, (for example if $p = 40$, $A_{max} = 780$).

For these reasons the associations presented below were generated by a computer from raw data in the form indicated above. The data were analysed at the end of the study period thereby removing the need for continually updating cumulative totals of associations for each pair of animals. The data were analysed separately for each year and for quarterly periods : July to September, October to December, January to March and April to June. Animals which were less than six months old during any of these three-monthly periods were excluded from the analysis until the period at the beginning of which they were first more than six months old. Depending upon the month of birth some individuals may have been as much as nine months old before they were included in the analysis. Only nine cats were added due to maturation in year 1 so this probably had little effect on the analysis.

No attempt was made to examine associations of more than two individuals because this would have produced a great increase in the number of calculations. The usefulness of such calculations is uncertain.

The total number of times each association was observed was recorded for each quarterly period and each year of the study. For each pair of animals the degree of association was examined using the association index,

$$I_{AB} = \frac{2J}{nA + nB} \qquad (11.15.)$$

where $J$ is the number of joint occurrences of animal A and animal B, and $nA$ and $nB$ are the number of individual occurrences of animal A and animal B respectively. Values of $I_{AB}$ range from zero (when A is never seen with B) to 1.0 (when A is always seen with B).

Schaller (1972) used this index to examine the degree of association between female lions in two separate prides. He considered animals showing an association index of 0.4 or more to be 'companions'. Southwood (1968) has presented a t - test for the significance of associations:

$$t = \left[\frac{(nA + nB)(2J - 1)}{2.\ nA.\ nB.} - 1\right] \left[\sqrt{nA + nB - 1}\right] \qquad (11.16)$$

This is useful because the association index does not take account

Table 11.3.

The effect of the number of observations on the statistical significance of the association index ($I_{AB}$).

| nA | nB | J | $I_{AB}$ | t | p |
|---|---|---|---|---|---|
| 1 | 1 | 1 | 1.0 | 0 | 0.500 |
| 2 | 2 | 2 | 1.0 | 0.866 | 0.193 |
| 3 | 3 | 3 | 1.0 | 1.491 | 0.068 |
| 4 | 4 | 4 | 1.0 | 1.984 | 0.024* |
| 5 | 5 | 5 | 1.0 | 2.400 | 0.008** |
| 6 | 6 | 6 | 1.0 | 2.764 | 0.003** |

* significant at 5% level

** significant at 1% level

of the effects of small samples, for example if $nA = 1$, $nB = 1$ and $J = 1$, $I_{AB} = 1.0$ . The t - test has been used to examine the significance of all the association indices calculated, at the 5% level. Table 11.3. shows how the significance of the t value increases with sample size when the association index is 1.0 .

The importance of an association may not be the same for each animal in the association. For example, if $nA = 19$, $nB = 16$ and $J = 12$, $I_{AB} = 0.685$, $\underline{t} = 1.889$ and $\underline{P} = 0.03$. This suggests that the association is highly statistically significant. However, 75.0% of the times that B was seen it was associating with A, but on only 63.2% of the times that A was seen was it associating with B. This suggests that the association does not have the same importance to both animals. The association index used here does not take account of this.

## 11.3. ASSOCIATIONS AND SOCIAL GROUPS

### 11.3.1. The social groups

A total of 961 recordings were made of cats seen associating together and cats seen alone during this study, excluding kittens (453 in year 1; 508 in year 2). From these recordings 2911 separate associations between pairs of cats were generated by computer (1581 in year 1; 1330 in year 2). The pairs of cats recorded together and the number of times each pair was observed together are presented for each

Table 11.4.

Summary of the number of cats recorded associating together during each three-month period of the study and the number of associations observed.

| Period | No. of cats observed* | No. of groups of associating cats* | No. of different pairs of associating cats | Total no. of individual associations |
|---|---|---|---|---|
| 1. July - Sept 1978 | 22 | 113 | 67 | 481 |
| 2. Oct - Dec 1978 | 26 | 93 | 77 | 176 |
| 3. Jan - Mar 1979 | 29 | 128 | 118 | 553 |
| 4. Apr - June 1979 | 32 | 119 | 98 | 371 |
| 5. July - Sept 1979 | 34 | 111 | 80 | 377 |
| 6. Oct - Dec 1979 | 27 | 116 | 60 | 334 |
| 7. Jan - Mar 1980 | 21 | 90 | 29 | 153 |
| 8. Apr - June 1980 | 28 | 191 | 68 | 466 |

* Including cats seen alone.

three - month period in Appendix II , along with values for the association index. Some of this data is summarised in Table 11.4. The individual cats which were present during each year of the study are listed in Table 6.1.

Four social groups of cats were present in the colony throughout the study (groups A, D, F and R) and a fifth group (group AN) was discovered during the trapping operation. Group AN was strictly speaking outside the study area and individuals from this group were only recorded when they appeared in zones within the study area, in periods 5 and 6 (see Section 6.3.).

All of the individual adult cats which were considered to be resident in each of the social groups at any time during the first or second year of the study are listed in Table 11.5. Immigrant cats and nomads are also listed. The dynamics of the groups have been analysed by examining the social structure of the colony in each three - month period of the study. The results of this analysis are presented as a series of network diagrams (Fig. 11.14 and 11.15). In these diagrams a line links each pair of cats seen together.

A number of problems arise in the construction and interpretation of these network diagrams. The locations of the groups in the network diagrams do not correspond to their geographical positions within the hospital (c.f. Fig. 6.4.).

Table 11.5.

Adult members of the social groups and nomadic cats present in year 1 and year 2.

| | Year 1 | | Year 2 | |
|---|---|---|---|---|
| | Females | Males | Females | Males |
| Group A | 13+ | 1+ | 14 | 53 |
| | 14 | 11+ | 19 | |
| | 16+ | 53I | | |
| | 19 | | | |
| | 25+ | | | |
| Group D | 8+ | 27 | 10 | 28 |
| | 10 | 28 | 21 | 44 |
| | 21b | 29* | 43 | 49 |
| | 43b | 44I? | 62 | |
| | 47b+ | 49b | 121I | |
| | 62b | 60TI+ | | |
| | | 64TI | | |
| | | 67TI+ | | |
| Group F | 32 | 7+ | 32 | 88 |
| | 33 | 88 | 33 | 100 |
| | 38b | 97 | 38 | 101 |
| | | (100b) | | |
| | | (101b) | | |
| Group R | 51 | 50 | 51 | 50 |
| | 54 | 65*b | 54+ | 68 |
| | 66b | 68b | 66 | |
| | 86 | | 86 | |
| Group AN | (114) | (117b) | 114 | 117 |
| | (118b) | | 118 | |
| Nomads | 9 | 23* | 9 | 23* |
| | 17 | 24+ | 17 | 27 |
| | | 26+ | | 29* |
| | | 34 | | 34 |
| | | 39 | | 39 |
| | | 52I? | | 52 |
| | | 63I? | | 63 |
| | | 69I? | | 65* |
| | | (105TI) | | 69+ |
| | | (107TI) | | 105TI+ |
| | | | | 107TI |

\+ Died / disappeared in year indicated
b Born in year indicated
* Control male
I Permanent immigrant
TI Temporary immigrant
( ) Present but not recorded
? Status uncertain

In the network diagrams the social groups are arranged as indicated in Fig. 11.13 .

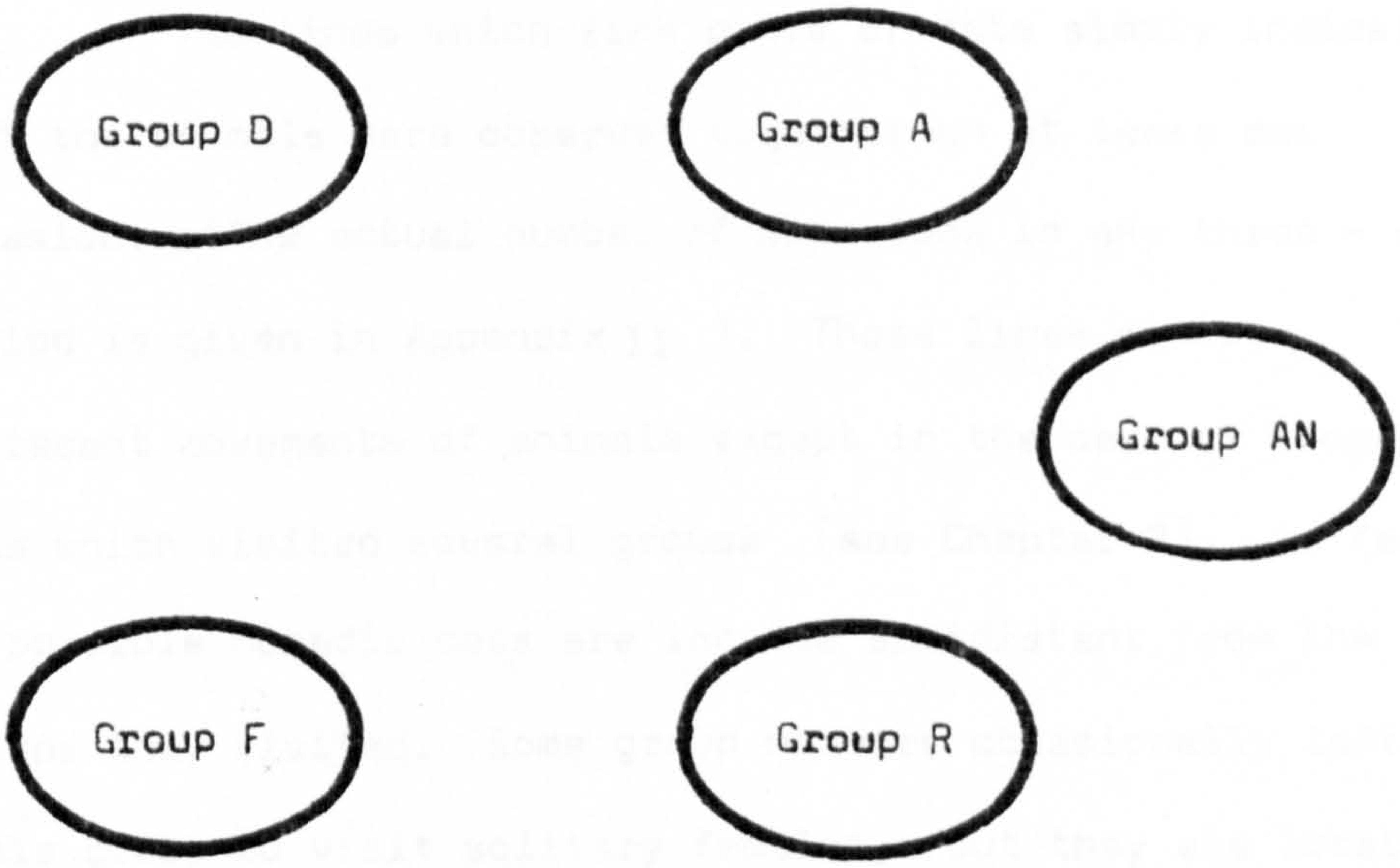



Fig. 11.13. Location of the social groups in the network diagrams.

Cats were assigned to particular social groups on the basis of their associations with other cats but the home range of each animal was also taken into account. The division of the colony into distinct social groups was a rather subjective process and depended to a great extent upon personal knowledge of the colony. It would be extremely difficult to identify the groups shown in Fig. 11.13 . from the data on associations presented in Appendix II alone. The dynamic nature of each of the social groups is evident from the number of births, deaths and immigrants indicated in Table 11. 5 . especially in year 1. The presence of an individual animal in a particular group in any three - month period does not necessarily mean that it was present throughout this period. The precise times of appearance and disappearance of individual animals is given in Fig. 6.6..

The lines which link pairs of cats simply indicate that the animals were observed together on at least one occasion. (The actual number of occasions in any three - month period is given in Appendix II ). These lines do not represent movements of animals except in the case of nomadic cats which visited several groups (see Chapter 7). As far as possible nomadic cats are located equidistant from the groups they visited. Some group members occasionally left their group to visit solitary females, but they are located within their respective groups. The location of individual cats in different diagrams does not remain constant due to changes in group sizes and associations.

Cats which were solitary in any three - month period have been excluded from Fig. 11.14 but are included in Fig. 11.15 (open circles) which also indicates associations which were statistically significant ($\underline{P} < 0.05$). The sex of individual cats is only indicated in Fig. 11.15 .

### 11.3.2. Associations and groups in period 1 (July - September 1978)

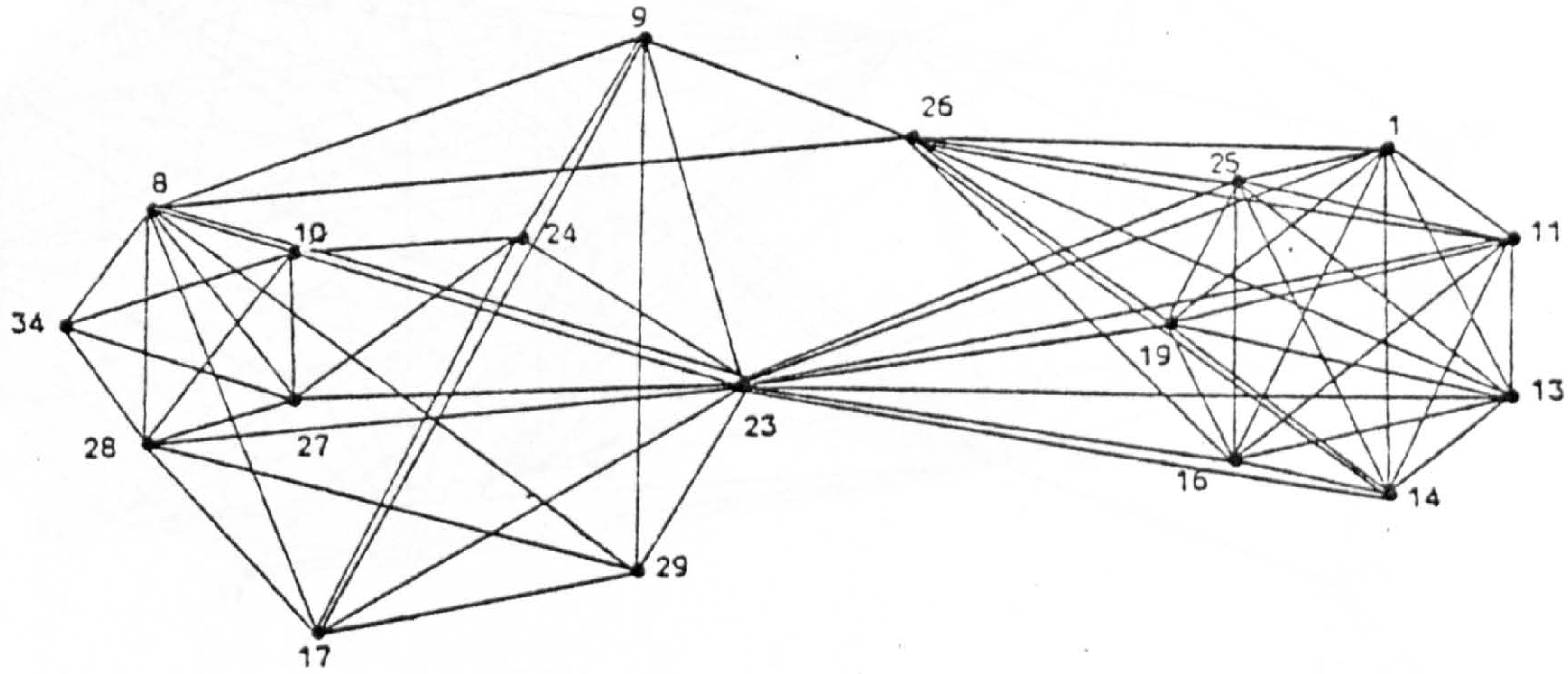
In the early stages of the study the colony was thought to consist of only two social groups (A and D)

Fig. 11.14. Network diagrams illustrating all associations observed between adult cats recorded in the colony. Each three - month period of the study is shown separately:

| | | | |
|---|---|---|---|
| Year 1 | (a) | Period 1 | July - September 1978 |
| | (b) | Period 2 | October - December 1978 |
| | (c) | Period 3 | January - March 1979 |
| | (d) | Period 4 | April - June 1979 |
| Year 2 | (e) | Period 5 | July - September 1979 |
| | (f) | Period 6 | October - December 1979 |
| | (g) | Period 7 | January - March 1980 |
| | (h) | Period 8 | April - June 1980 |

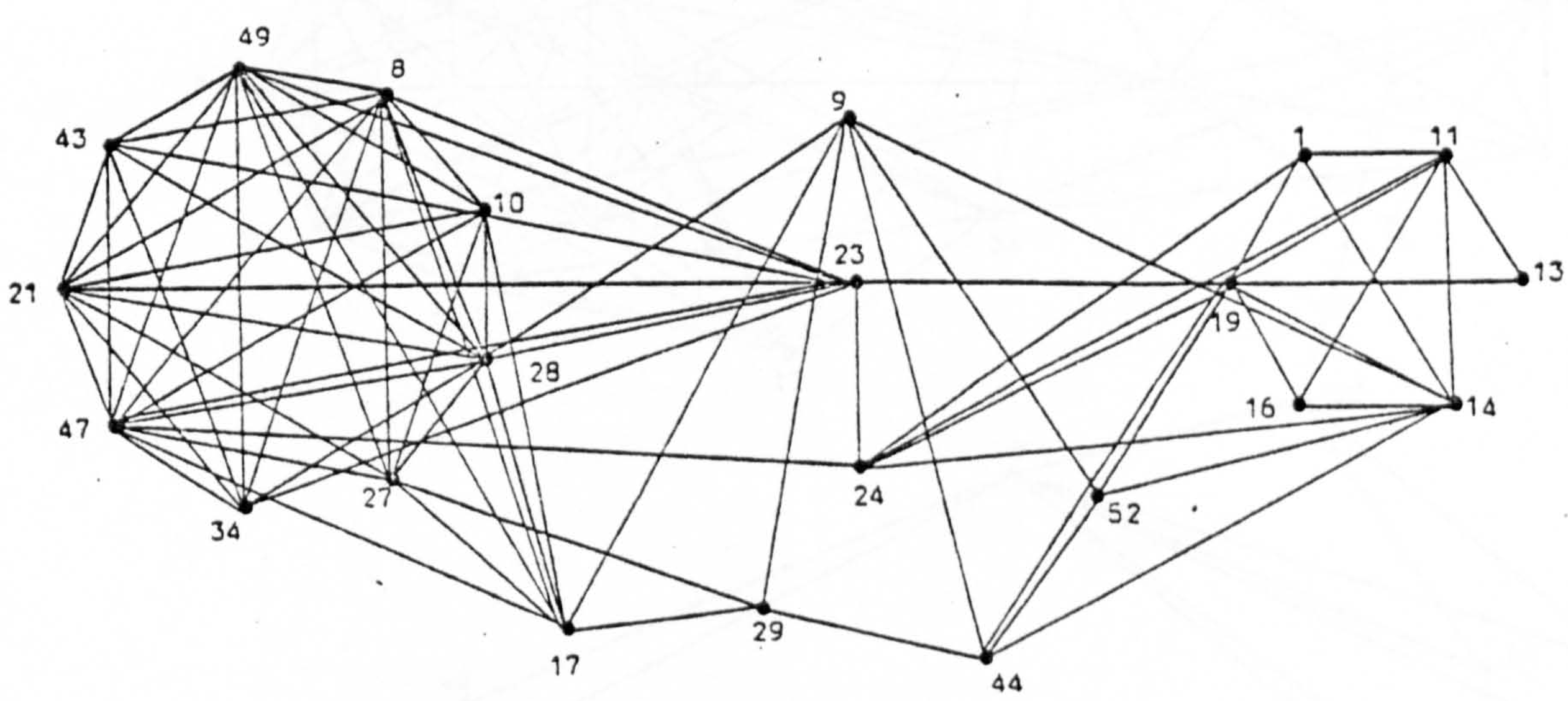
The sex of each cat and individuals which were only ever seen alone in any three - month period are indicated in Fig. 11.15.

(a)



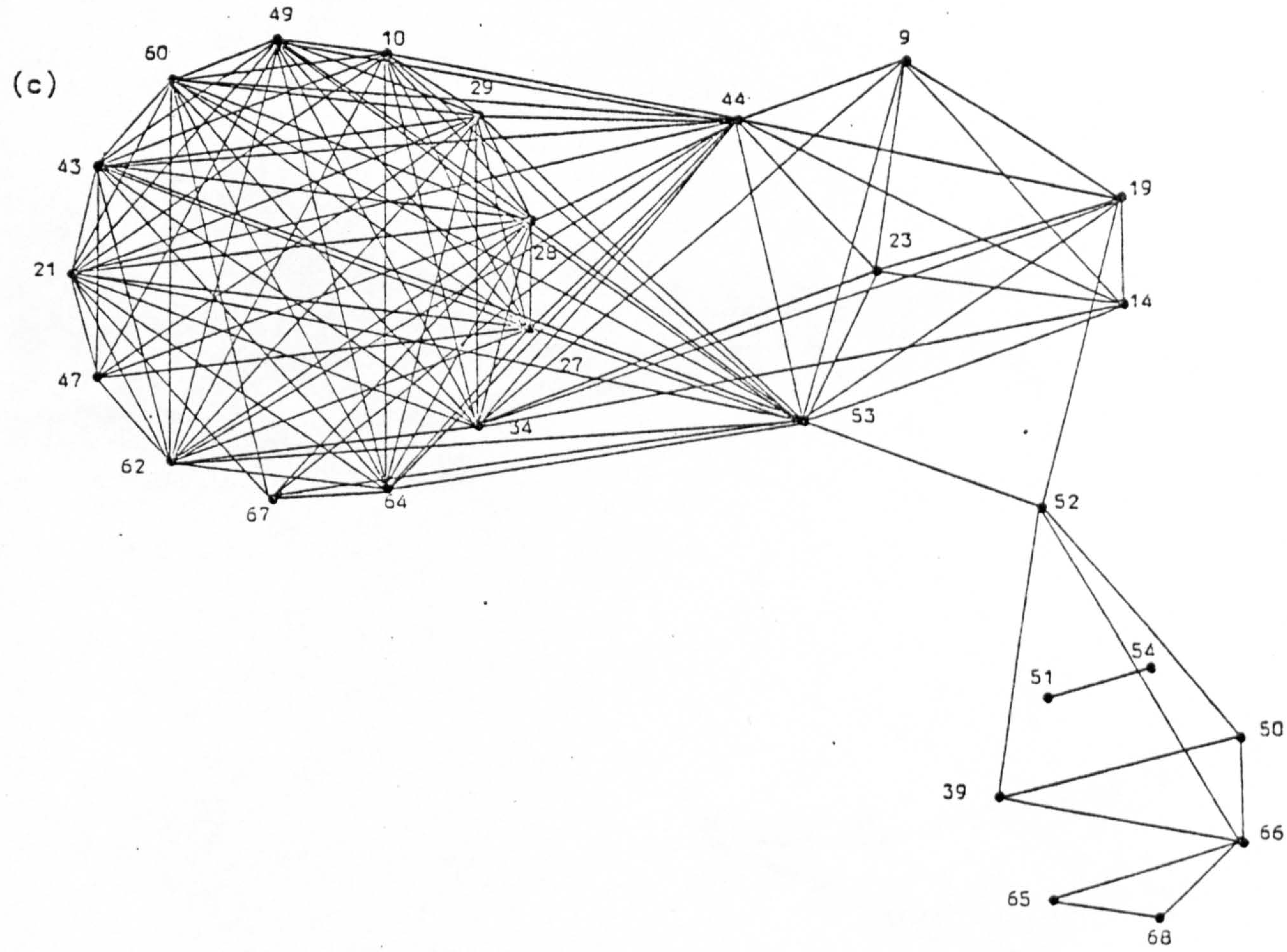

Period 1 (July - September 1978)

(b)



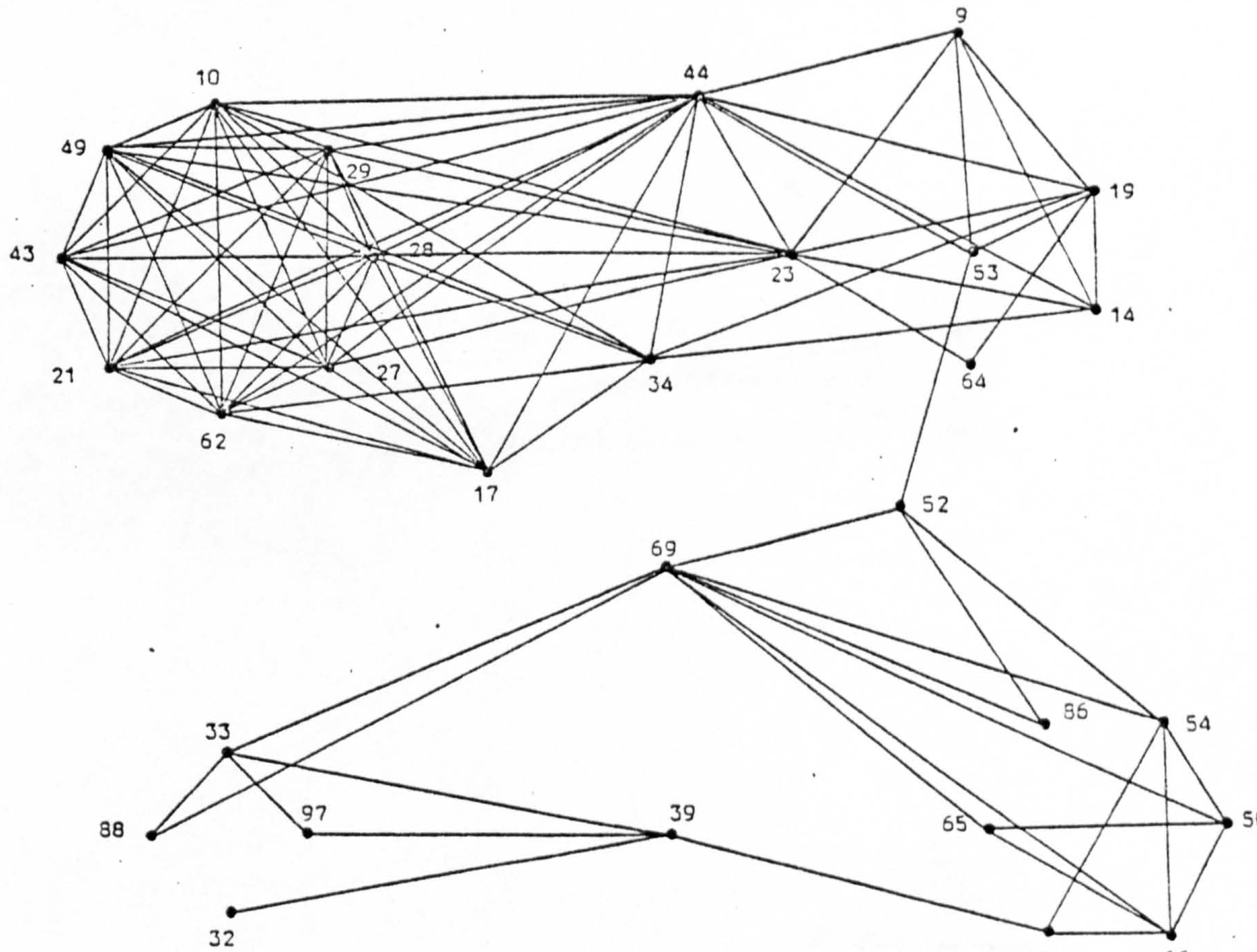

Period 2 (October - December 1978)

(c)



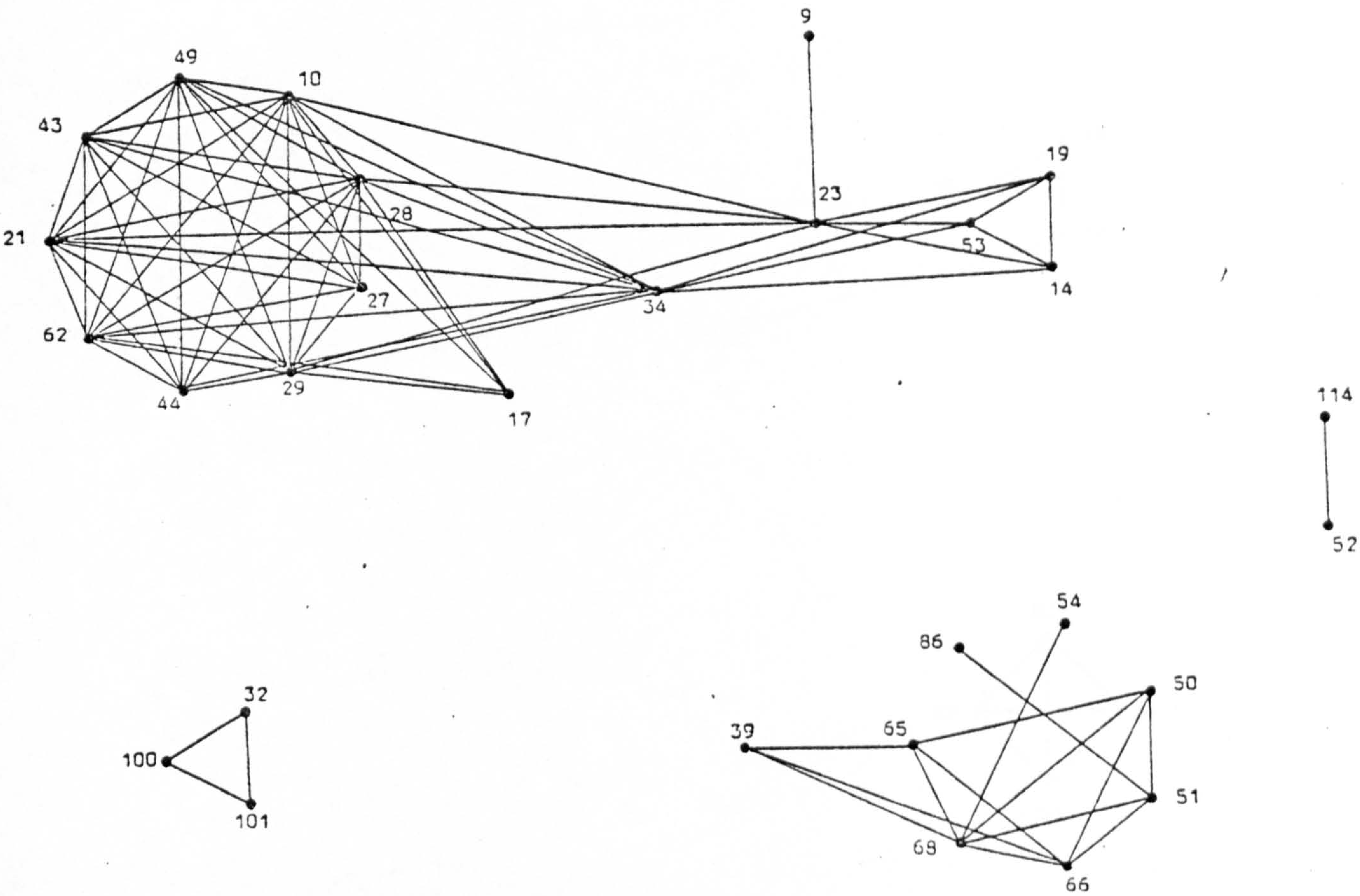

Period 3 (January - March 1979)

(d)



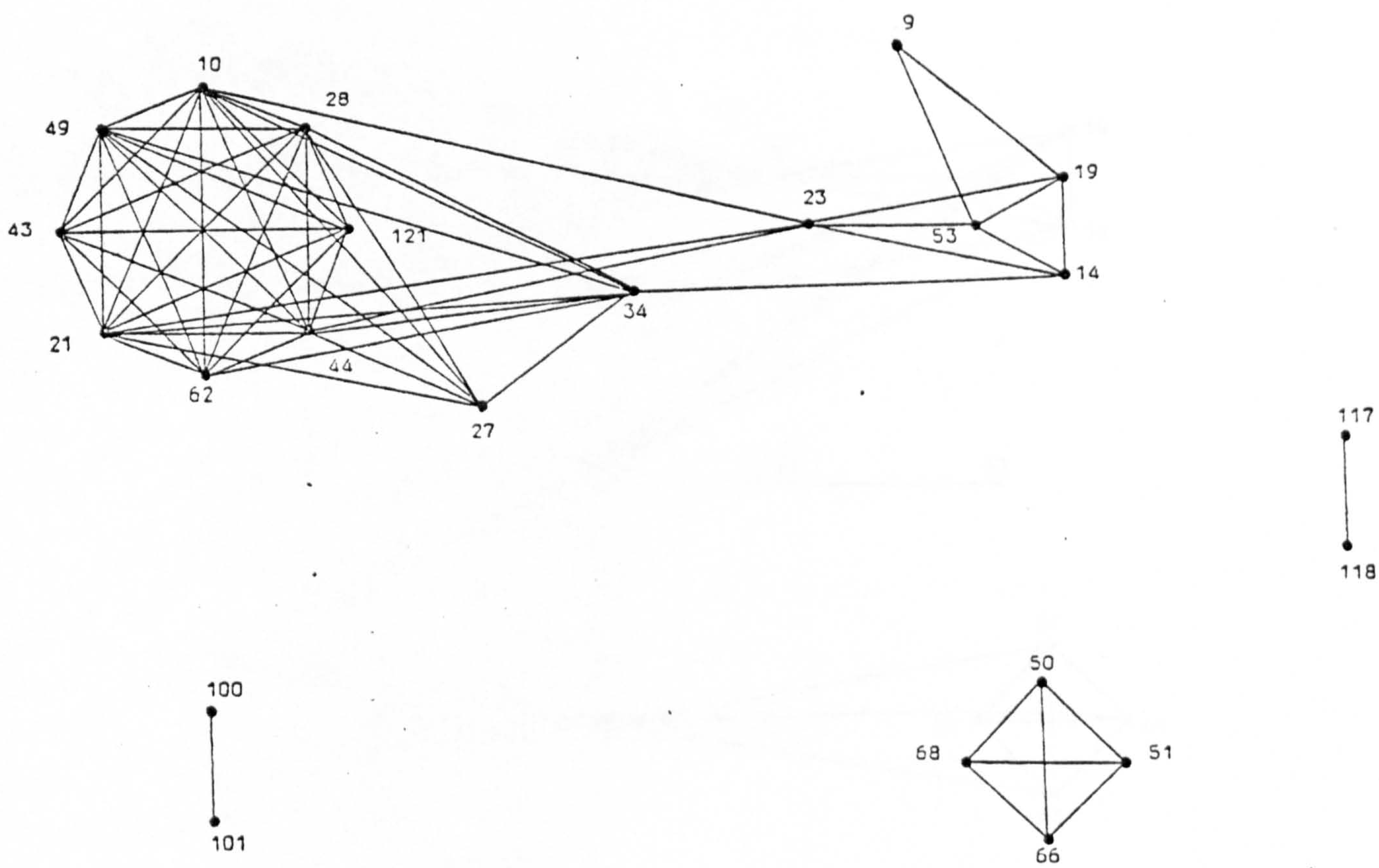

Period 4 (April - June 1979)

(e)



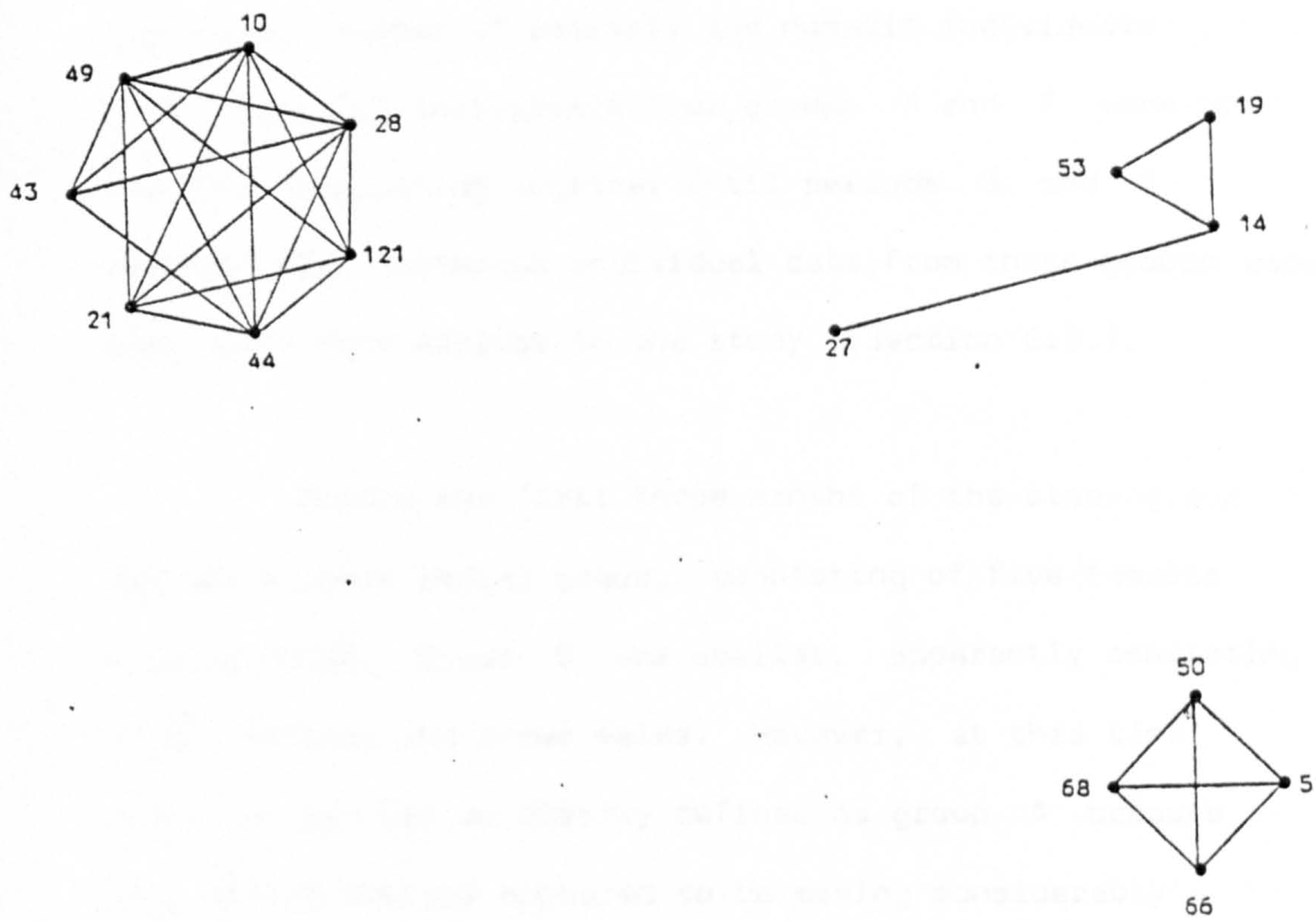

Period 5 (July - September 1979)

(f)



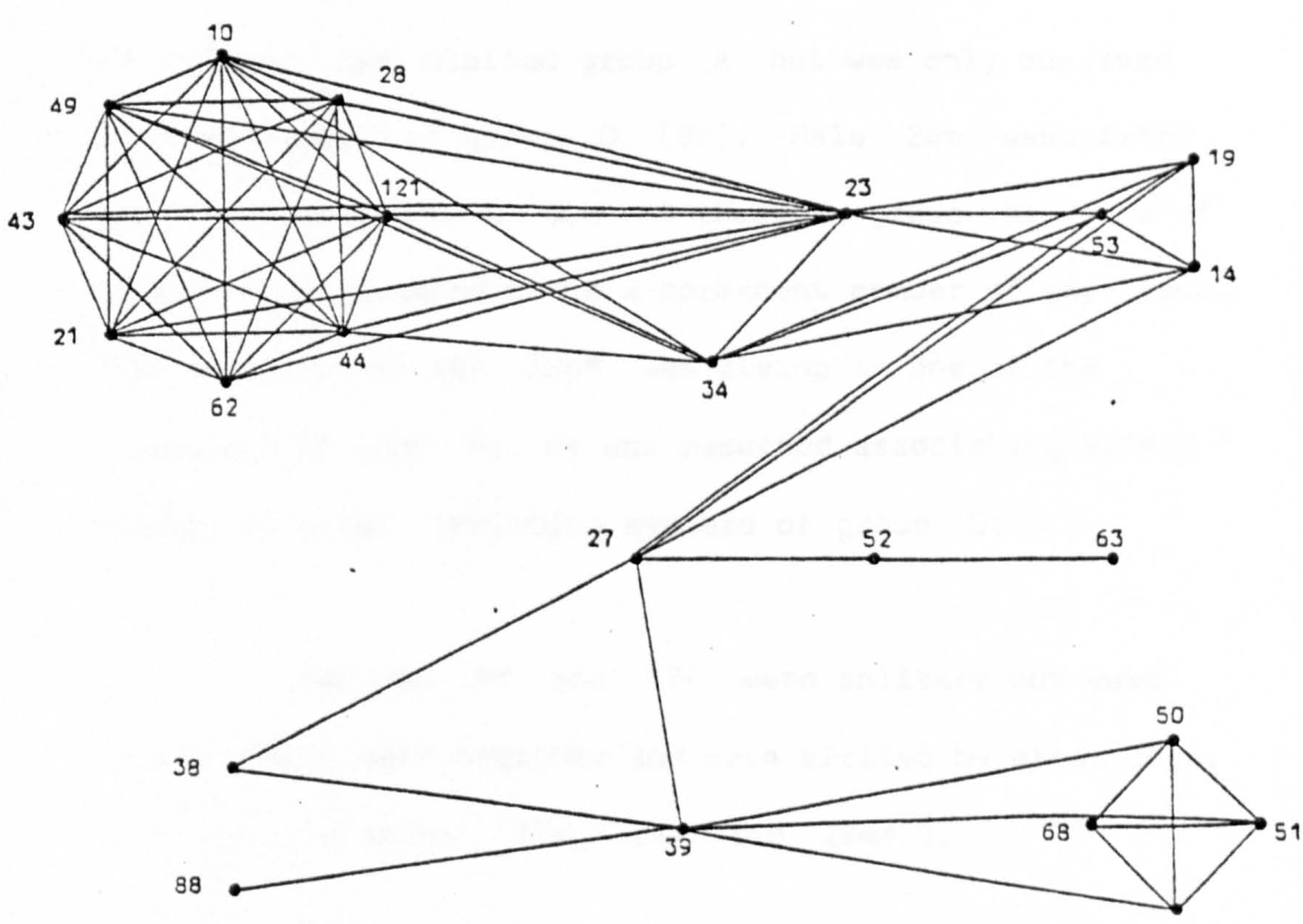

Period 6 (October - December 1979)

(g)




Period 7 (January - March 1980)

(h)




Period 8 (April - June 1980)

and a small number of solitary and nomadic individuals (Fig. 11.14.(a)). Individuals from groups R and F were not recorded associating together until periods 3 and 4 respectively, although individual cats from these groups **were seen** alone much earlier in the study (Section 6.3.).

During the first three months of the study group A was the largest social group, consisting of five females and two males. Group D was smaller, apparently consisting of two females and three males. However, at this time group D was not as clearly defined as group A because some of its members appeared to be moving considerably between zones, possibly due to the presence of several feeding places.

Male 23m* visited groups A and D during this period and 26m visited group A but was only observed with one member of group D (8f). Male 24m associated with cats in group D but not those in group A. None of these males appeared to be a permanent member of any group. The neutered pet cat 29m* was living in one of the buildings in zone B. He was recorded associating with a number of cats, including members of group D.

Females 9f and 17f were solitary but were occasionally seen together and were visited by other cats, particularly males (23m, 24m and 29m* ).

11.3.3. Associations and groups in period 2 (October - December 1978)

At the beginning of this period there was little change in group A except that 25f had disappeared in September 1978 (period 1). Male 26m disappeared in July 1978 (period 1) and was therefore no longer visiting group A in period 2, but male 24m was observed associating with some members of this group. (Previously he had not been seen with group A ).

By October 1979 group A had been reduced to only two cats (14f and 19f). Two new males began visiting this group, 52m and 44m (only after the resident males 1m and 11m had disappeared from the group). These two males also visited 9f. Male 52m had not been recorded in period 1, but had probably been living at the edge of the colony. Male 44m had previously been seen once, in zone G. During this period a total of four males visited group A at some time (23m* , 24m, 44m and 52m). The reasons for the decline of group A have been discussed in Section 6.9.4.

In contrast to the changes which occurred in group A, group D increased in size. This was due to the maturation of 43f which was born in group D and the movement of 21f, 47f and 49m into the group. Female 21f was the daughter of 10f but had previously been seen only in zone C. Female 47f and 49m were thought to have been the kittens of 9f.

Female 9f remained solitary but visited group A after the decline in the size of this group. The other solitary female, 17f, was recorded in association with a number of cats from group D, and also with 9f and 29m*.

By the end of period 2 it was apparent that there were four social groups in the colony, although associations between individuals within groups R and F had not been observed.

11.3.4. Associations and groups in period 3 (January - March 1979)

Throughout this period group A consisted of only two females, 14f and 19f. Males 23m* , 44m and 52m continued to visit this group and two additional males began visiting: 34m, which was originally only recorded with cats in group D and 53m, an immigrant which had not previously been recorded in the colony. Male 53m also visited group D. Female 9f began visiting group A more frequently. She had not been recorded here when the group was much larger.

Group D showed a further increase in size. Female 62f matured (she was born in group D) and 29m* moved into the group. Three males immigrated into group D for a short time (60m, 64m and 67m) temporarily bringing the total number of adults in the group to 13, excluding the visiting males 44m and 53m. Male 23m* did not appear to visit group D in period 3. The pattern of associations between individuals in group D appears extremely complex during this period. It must, however, be remembered that the three immigrant males were only present for a short time and the 13 cats shown in the group were never all seen together.

Group R was defined by a pattern of associations for the first time during this period. However, relatively few of the total number of possible associations within this group were actually observed. This was partly due to the difficulty of finding these cats and their shyness. At this time the group appeared to consist of two females (50f and 54f) and two males (39m and 50m) however 39m also spent time in zone G and may therefore have been associating with individuals from group F. In addition 54f's three kittens (65m*, 66f and 68m) matured during this period and entered the adult class. Male 52m was recorded associating with some members of group R.

Female 17f was not recorded in the colony during this period. She had moved outside the study area.

11.3.5. Associations and grouos in period 4 (April - June 1979)

For the first time all four social groups could be defined in terms of observed associations between cats in this period. There is little doubt that all four groups existed throughout the first year of the study.

By the end of this period 53m appeared to be resident in group A increasing the size of this group to three individuals. He did not visit group D at any time during this period, but he was observed in zone S (near group R). Males 23m* , 34m and 44m continued to visit group A and the immigrant 64m was observed with 19f. Female 9f was also seen in group A but was not resident in the group.

Group D decreased in size to only eight cats. The three immigrants 60m, 64m and 67m left the group. Males 60m and 67m were not seen again. Males 23m*, 34m and 44m all visited group D and some individuals from the group were also recorded associating with 17f. She returned to the colony in period 4 and visited group D temporarily.

Group R was still poorly defined in period 4. Another adult female (86f) was recorded for the first time but she was probably present throughout the study. The group was visited by 52m and by a new male (69m) which appeared to be an immigrant. Male 39m was observed associating with one cat in group D and also with individuals in group F.

Group F appeared to consist of four cats (two of each sex) although others were known to live in the same area. In addition to 39m this group was also visited by 69m.

At the end of year 1 the colony appeared to consist of four social groups each containing males and females. It seemed likely that most of the individuals within any group were related but some kittens of both sexes appeared to migrate from their natal groups to other groups. Dards (1979) observed that most male feral cats in Portsmouth dockyard migrated from their natal groups when aged between one and two years. The Winwick Hospital colony was much smaller than the population in the dockyard and consequently only a relatively small number of cats were observed to leave their natal group.

Many kittens were born into the four social groups during the study (Fig. 6.7.) but most did not survive for more than a few months. However, four of the eight cats present in group D at the end of year 1 had been born during the study.

All of the cats present at the end of year 1 were captured and neutered except 29m*, which was already neutered, 23m*, 65m*, 117m and 118f which could not be captured (Section 6.5.). During the trapping operation a fifth social group (group AN) was discovered at the boundary of the study area. After neutering the cats were returned to the areas where they were captured (see Chapter 12.).

11.3.6. Associations and groups in period 5 (July - September 1979)

In this period group A consisted of three cats (14f, 19f and 53m). Male 53m stayed with this group for the remainder of the study.

Group D remained the same as in period 4 apart from the addition of 44m. He became a permanent resident in this group and did not visit group A again. Female 17f was observed associating with some members of this group but remained solitary.

The nomadic males 23m* and 34m continued to visit groups A and D. Male 23m* was also observed associating with 9f. This solitary female did not associate with members of group A during period 5.

No change was observed in group R apart from the absence of visits by males 52m and 69m. Male 39m continued visiting group R but was not resident here. Individuals in group F were not recorded together except 32f was seen associating with two young males, 100m and 101m. These males were both kittens when recorded in year 1.

It is interesting that only two animals were observed moving between groups in this period (23m* and 34m), one of which was not neutered (23m*). The social groups appeared to be much more discrete than at any time during year 1. Group AN was recorded for the first time during this period: 52m was observed in association with 114f.

11.3.7. Associations and groups in period 6 (October - December 1979)

Group A remained the same as in the previous three - month period. Males 23m* and 34m continued to visit the group and 9f was also observed with 14f and 19f.

Group D decreased slightly in period 6. Male 29m* left the group permanently and was not recorded in the colony during this period. Male 27m appeared to leave the group but was observed associating with some of its members. Although 27m was considered to have been neutered it was later discovered that only one testicle had been removed (see Section 7.5.4. ). Female 121f appeared to immigrate into the colony from outside. She settled in group D and remained here for the remainder of year 2. Males 23m* and 34m continued to visit group D.

Group R appeared to consist of only four cats during this period, but each cat clearly associated with all the others. Other members of the group were still present in the colony but were not recorded, except for 54f which was seen alone. The entire male 65m* appeared to have left the colony, (He was recorded alone in period 7).

In group F only two males (100m and 101m) were observed associating. In group AN 117m was observed with 118f. Once again, only 23m and 34m were observed moving between groups A and D. The other groups appeared to be isolated.

## 11.3.8. Associations and groups in period 7 (January - March 1980)

In this period only three groups were apparent within the colony (groups A, D and R). Groups F and AN undoubtedly still existed but none of the cats from group F were observed and only 117m was seen from group AN.

Group A remained unchanged but was visited only by 27m. This male had not been recorded in group A before. Groups D and R also remained the same as in period 6 except that 62f was not recorded in group D. Neither of these groups appeared to be visited by nomadic males, and the groups were much more discrete than at any time during the study.

## 11.3.9. Associations and groups in period 8 (April - June 1980)

The pattern of associations became more complex in the final three months of the study with the reappearance of nomadic males which moved between the social groups.

Group A consisted of 14f, 19f and 53m, but was once again visited by 23m* and 34m. This group was also visited by 27m. Group D consisted of the same individuals that were present in period 6, and was also visited by 23m* and 34m.

Group R remained the same as in periods 6 and 7 but was visited by 39m. This male also associated with individuals from group F.

Male 27m associated with 38f, a member of group F, but no associations were observed between individual members of this group. A number of associations were observed between nomadic males which had not been seen together at any other time.

### 11.3.10. The statistical significance of associations

The number of associations which were statistically significant ($\underline{P} < 0.05$) in each three - month period of the study was small, except in period 1 when approximately 28% of the associations were significant (Table 11.6 ). The animals present in group A in period 1 appeared highly social. They were often seen together and relatively easy to observe due to the lack of thick vegetation in zone A. As a

Table 11.6.

The number of statistically significant associations recorded in each three-month period of the study.

| Period | No. of different pairs of associating cats | No. of statistically significant associations $P<0.05$ | Percentage of all associations which were significant |
|---|---|---|---|
| 1 | 67 | 19 | 28.4 |
| 2 | 77 | 1 | 1.3 |
| 3 | 118 | 2 | 1.7 |
| 4 | 98 | 3 | 3.1 |
| 5 | 80 | 6 | 7.5 |
| 6 | 60 | 4 | 6.7 |
| 7 | 29 | 6 | 20.7 |
| 8 | 68 | 6 | 8.8 |

The actual associations to which these figures refer are indicated in Fig. 11.15.

result of this all of the associations between members of the group were statistically significant except those between the two resident males (1m and 11m). The only other significant association was between 10f and 28m in group D (Fig. 11.15(a)). Many of the members of group A disappeared at the beginning of period 2 (see Fig. 6.6.) and the total number of statistically significant associations was low in the remaining three periods in year 1 (Table 11.6).

In period 2 the only statistically significant association was between 17f and the neutered pet cat 29m*. In periods 3 and 4 the only significant associations were between some members of group D.

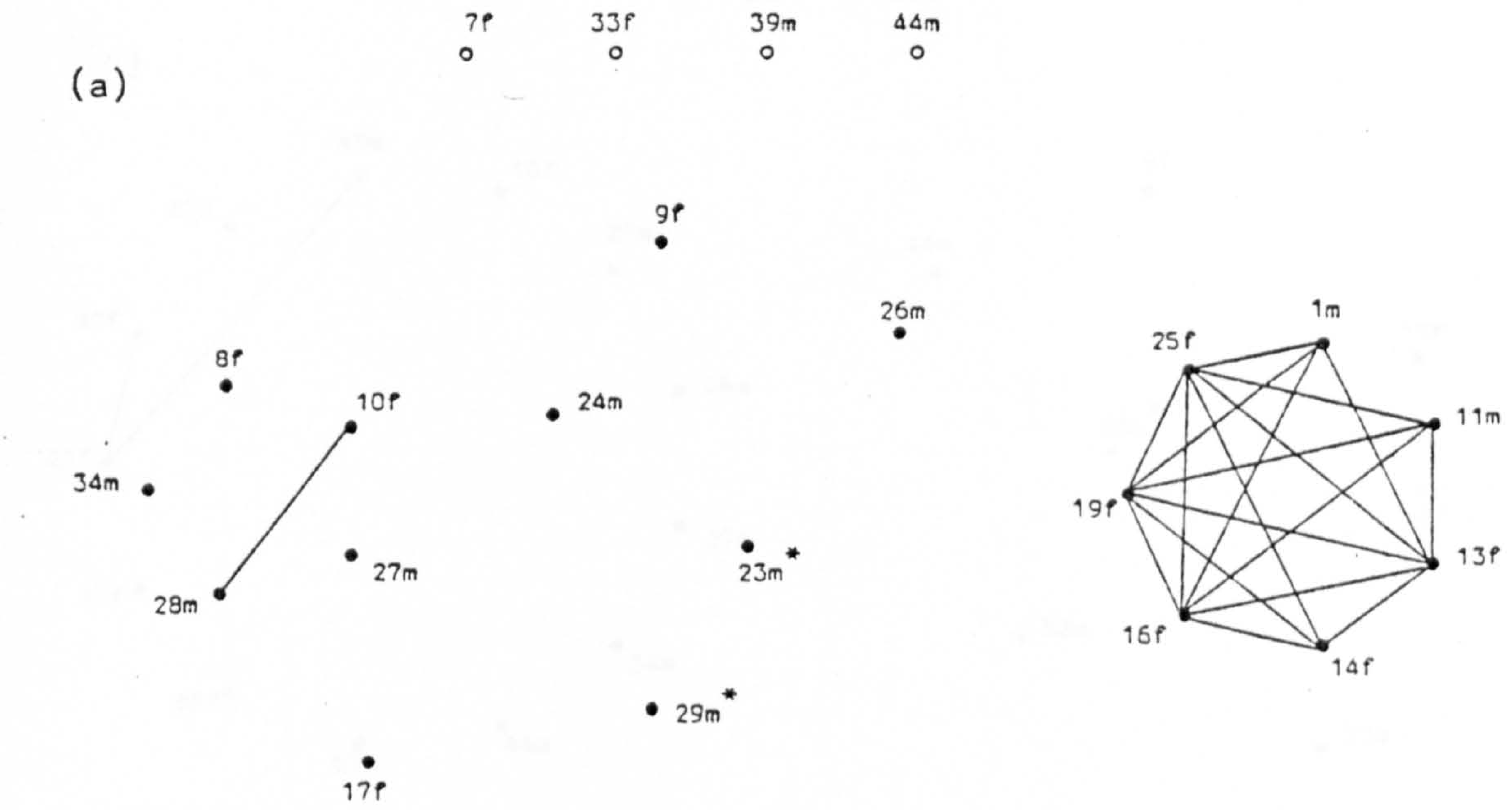
In year 2 a greater number of significant associations were recorded in each period than in any period in year 1, excluding period 1 (Fig. 11.15(a)-(h)). These significant associations represent a higher percentage of the total number of associations recorded compared with year 1 (except in period 1 ). Most of the statistically significant associations were between individuals within group A and between individuals within group D. A small number of significant associations were observed in group R.

All of the significant associations in both years of the study were between individuals which were living in the same social group (except the association between 17f, a solitary

Fig. 11.15. Network diagrams illustrating only statistically significant associations between adult cats ( $P < 0.05$). Cats which were only ever seen alone are indicated as open circles. Each three - month period of the study is shown separately:

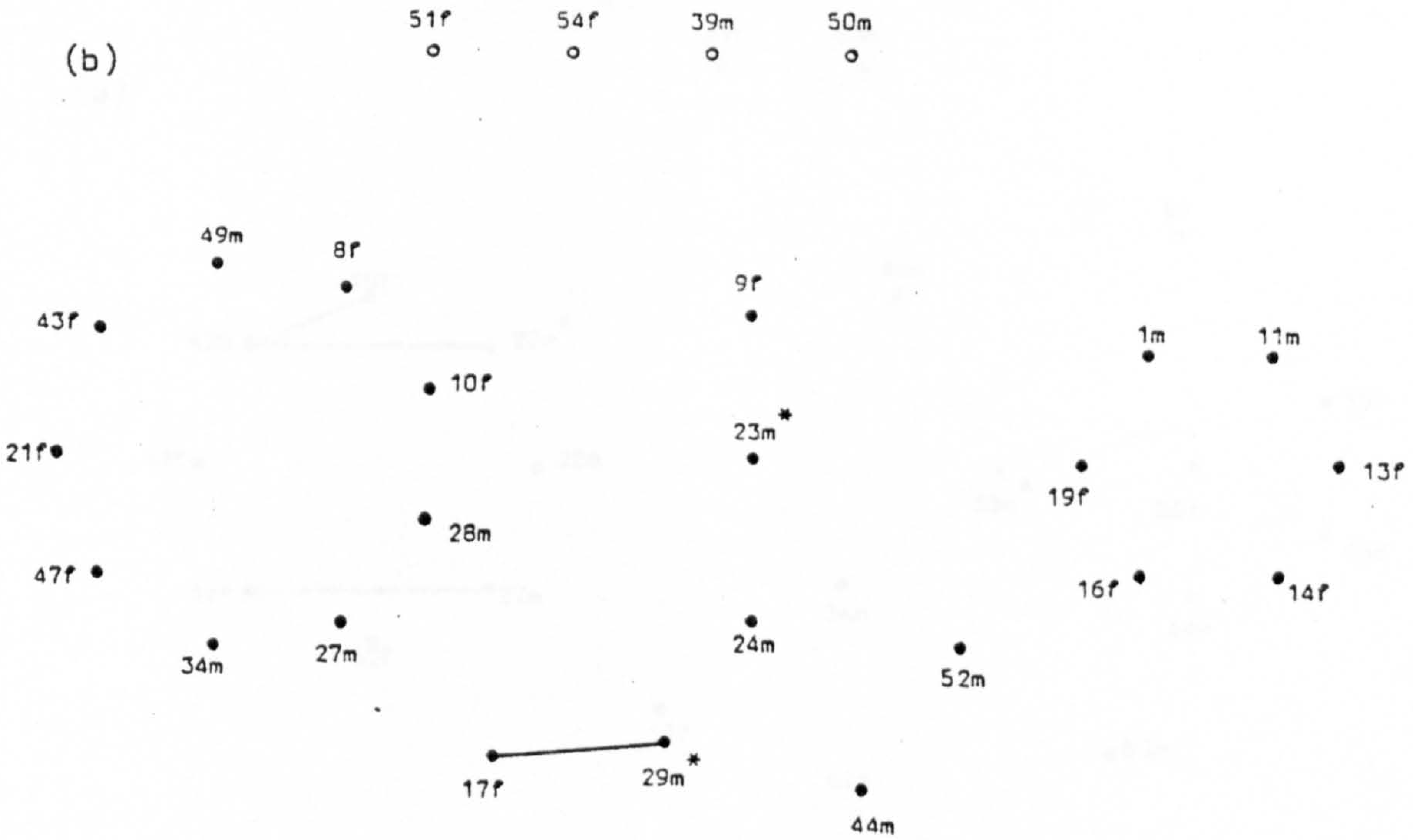
| | | | |
|---|---|---|---|
| Year 1 | (a) | Period 1 | July - September 1978 |
| | (b) | Period 2 | October - December 1978 |
| | (c) | Period 3 | January - March 1979 |
| | (d) | Period 4 | April - June 1979 |
| Year 2 | (e) | Period 5 | July - September 1979 |
| | (f) | Period 6 | October - December 1979 |
| | (g) | Period 7 | January - March 1980 |
| | (h) | Period 8 | April - June 1980 |

(a)

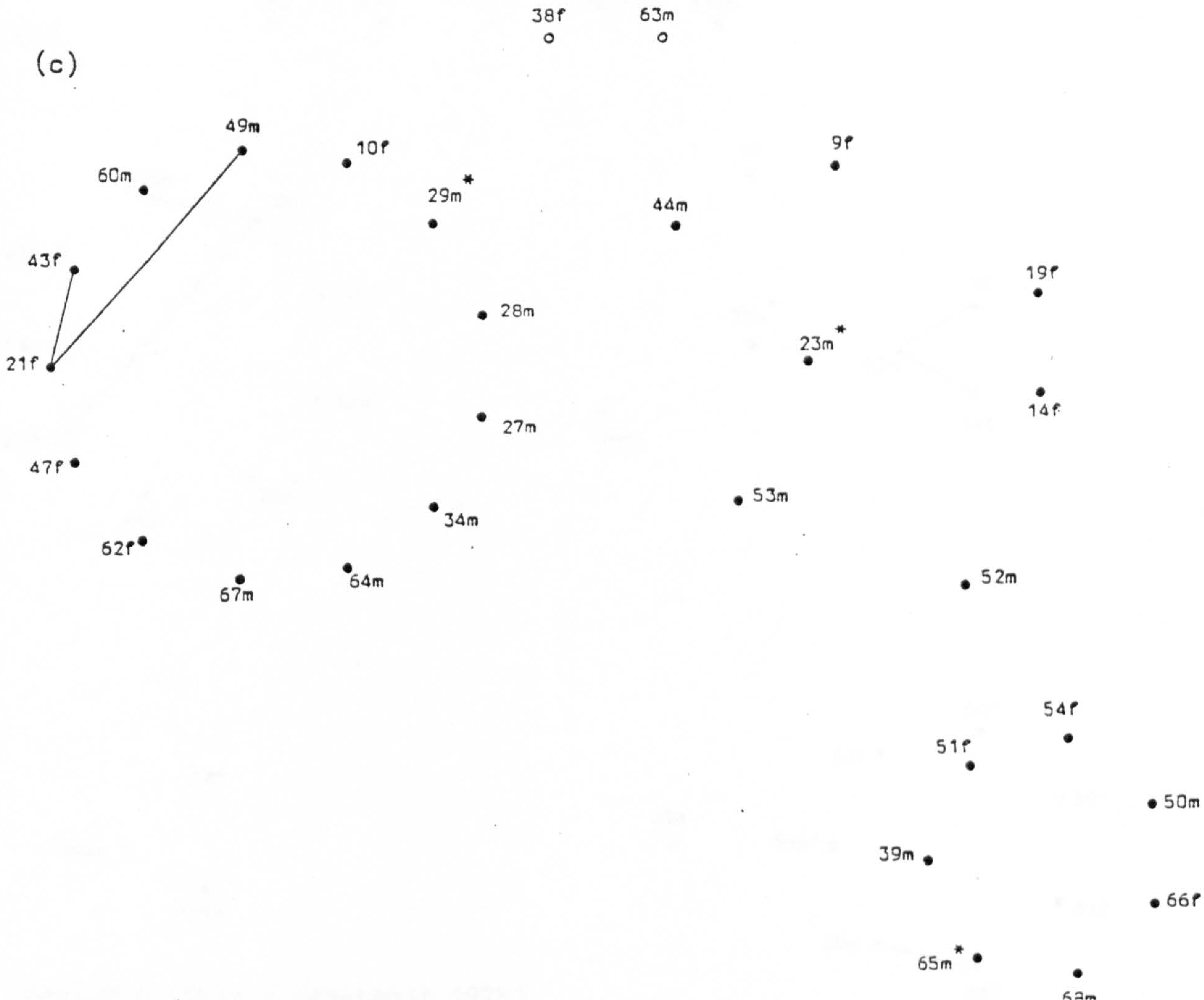



Period 1 (July - September 1978)

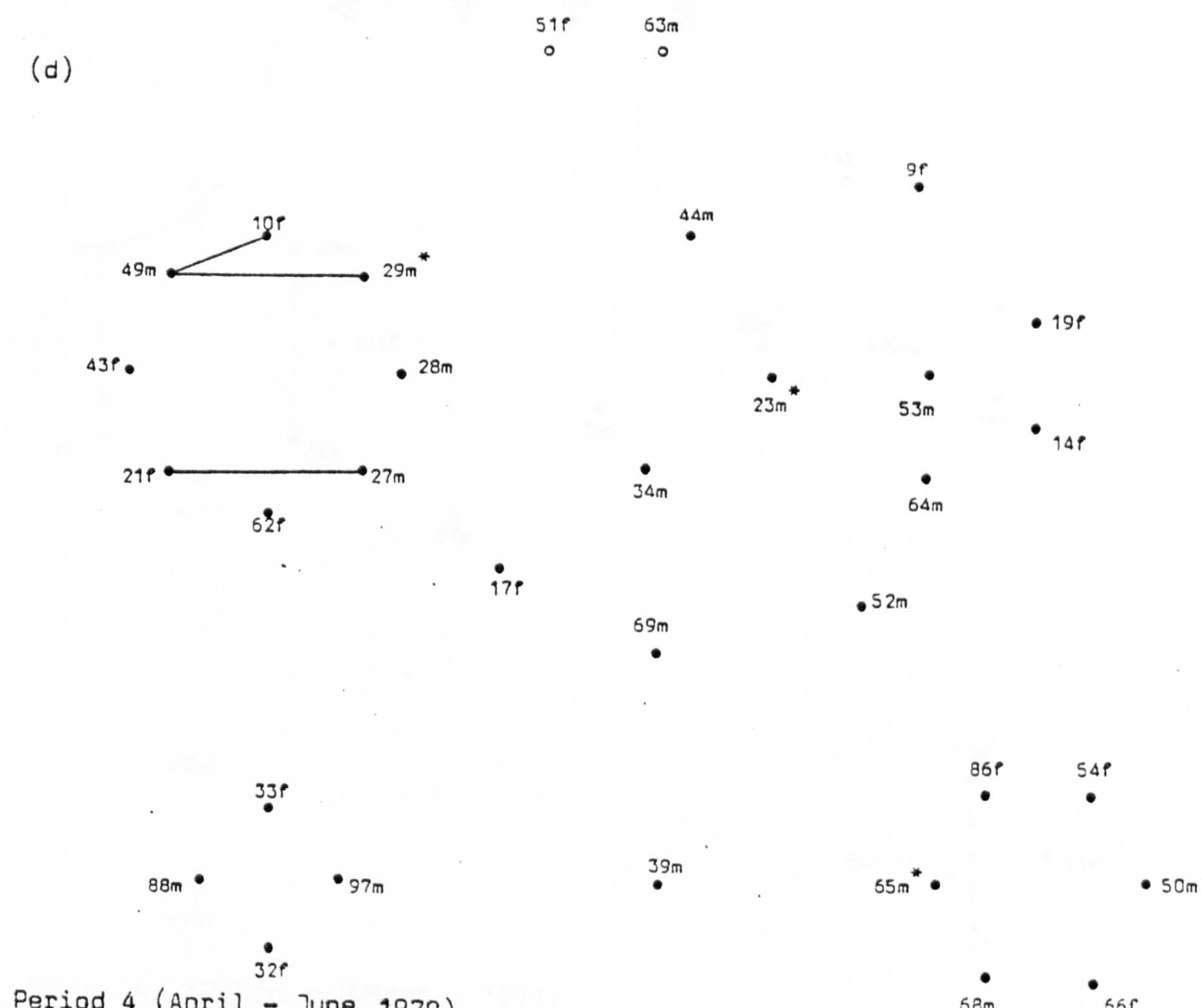
(b)




Period 2 (October - December 1978)

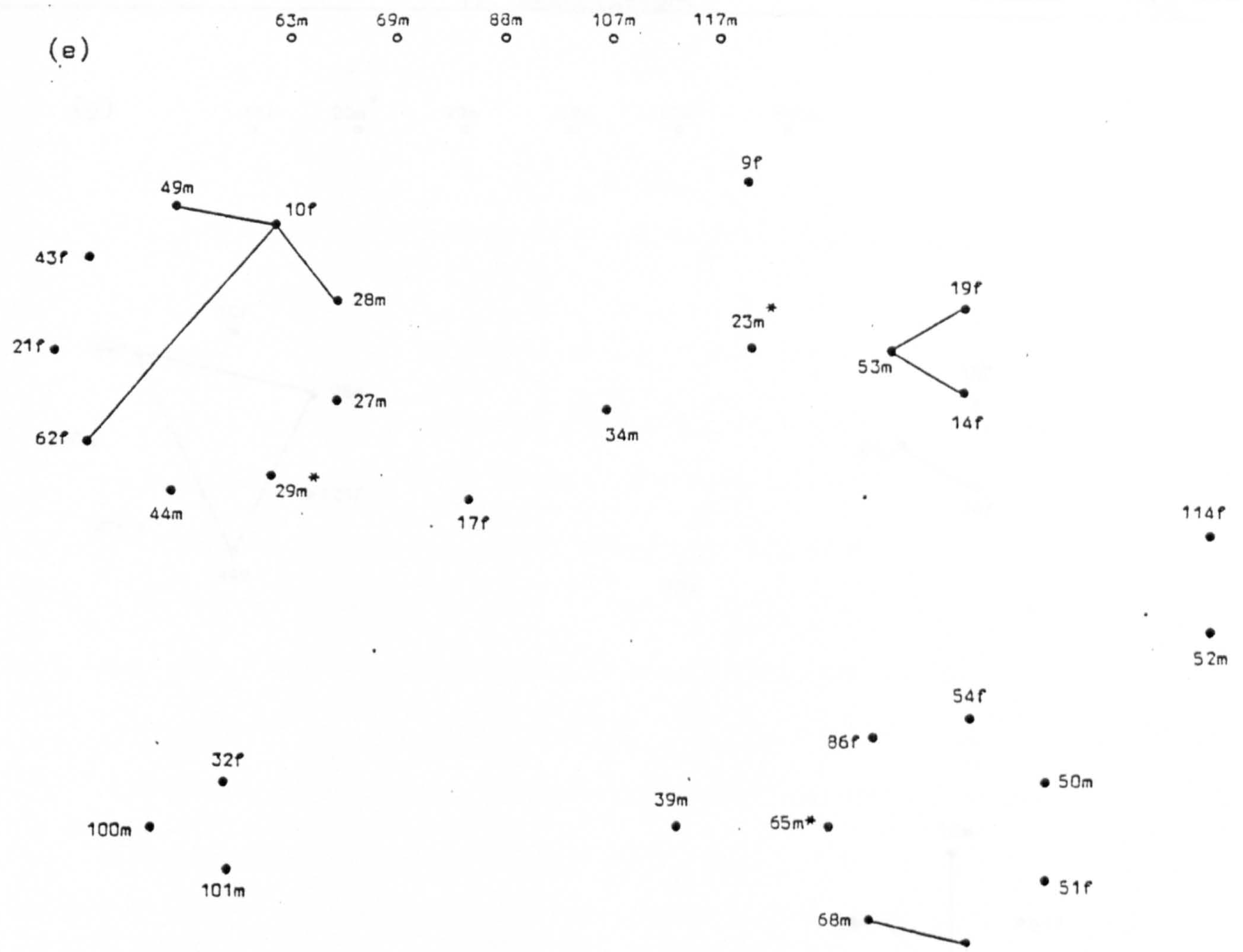



Period 3 (January - March 1979)



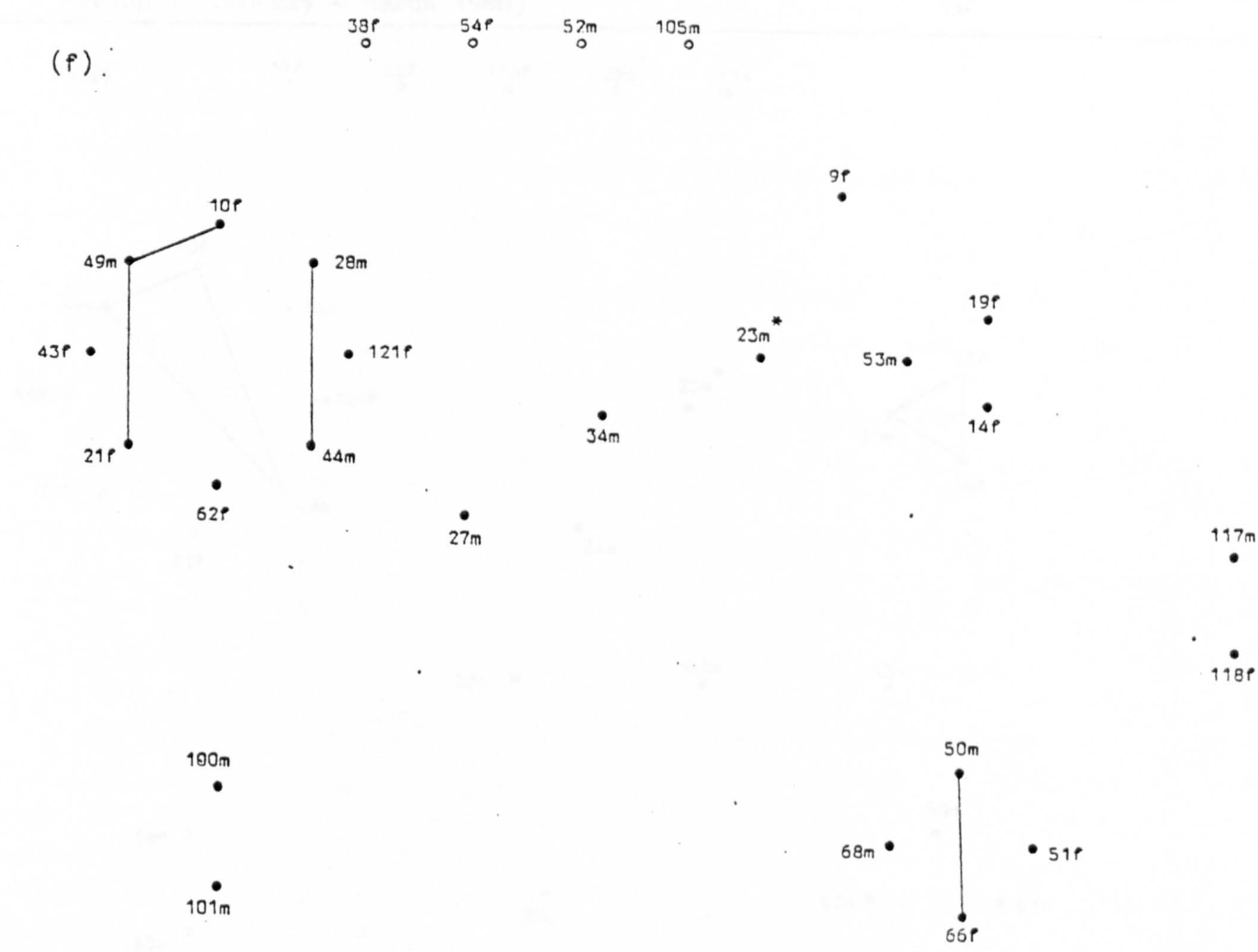

Period 4 (April - June 1979)

(e)

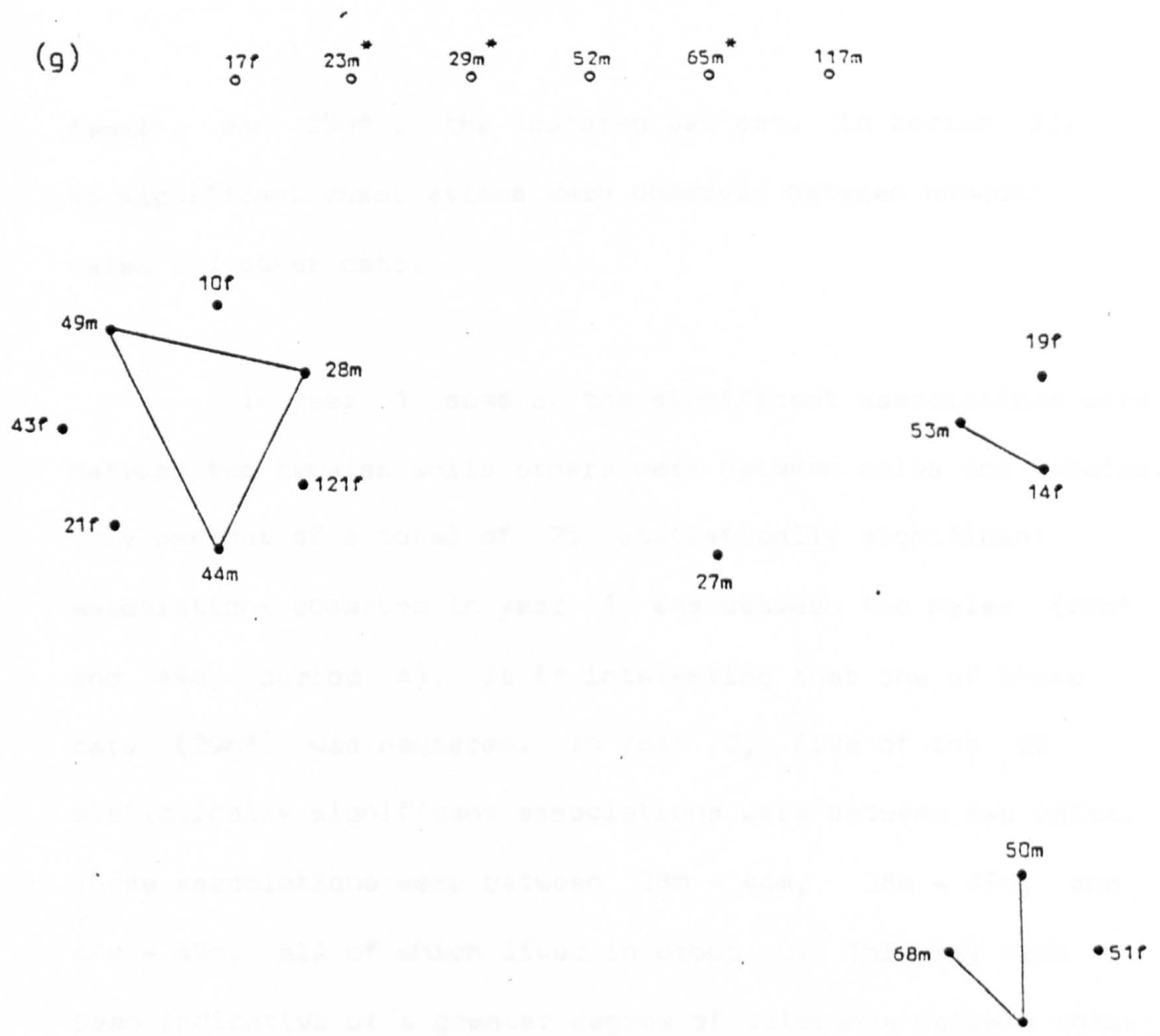



Period 5 (July - September 1979)

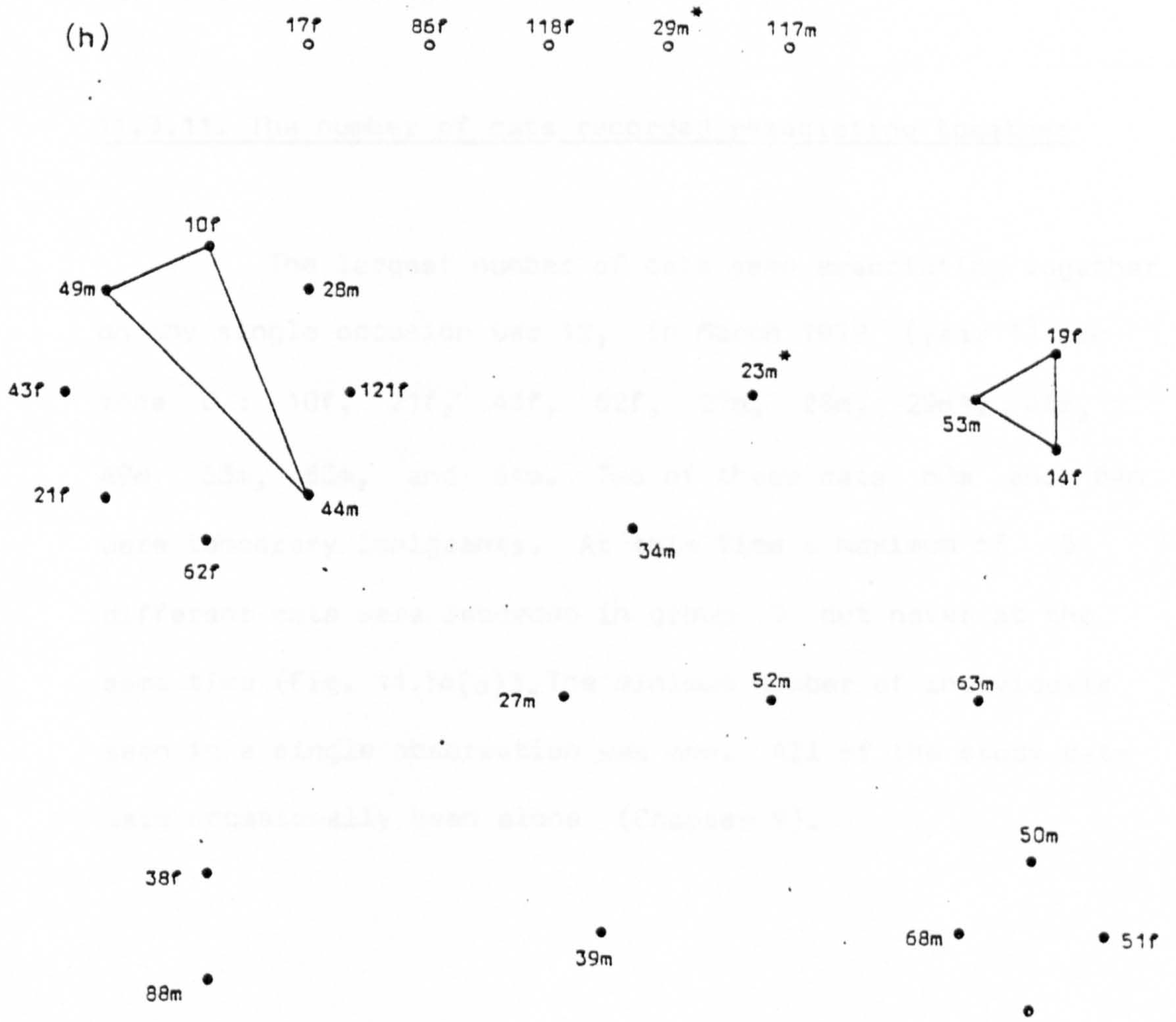
(f)




Period 6 (October - December 1979)




Period 7 (January - March 1980)




Period 8 (April - June 1980)

female, and 29m* , the neutered pet cat, in period 2). No significant associations were observed between nomadic males and other cats.

In year 1 some of the significant associations were between two females while others were between males and females. Only one out of a total of 25 statistically significant associations observed in year 1 was between two males (29m* and 49m, period 4). It is interesting that one of these cats (29m*) was neutered. In year 2, five of the 22 statistically significant associations were between two males. These associations were between 28m - 44m, 28m - 49m, and 44m - 49m, all of which lived in group D. This may have been indicative of a greater degree of tolerance between these cats after neutering.

## 11.3.11. The number of cats recorded associating together

The largest number of cats seen associating together on any single occasion was 12, in March 1979 (year 1) in zone D : 10f, 21f, 43f, 62f, 27m, 28m, 29m*, 44m, 49m, 53m, 60m, and 64m. Two of these cats 60m and 64m were temporary immigrants. At this time a maximum of 13 different cats were recorded in group D but never at the same time (Fig. 11.14(c)). The minimum number of individuals seen in a single observation was one. All of the study cats were occasionally seen alone (Chapter 9).

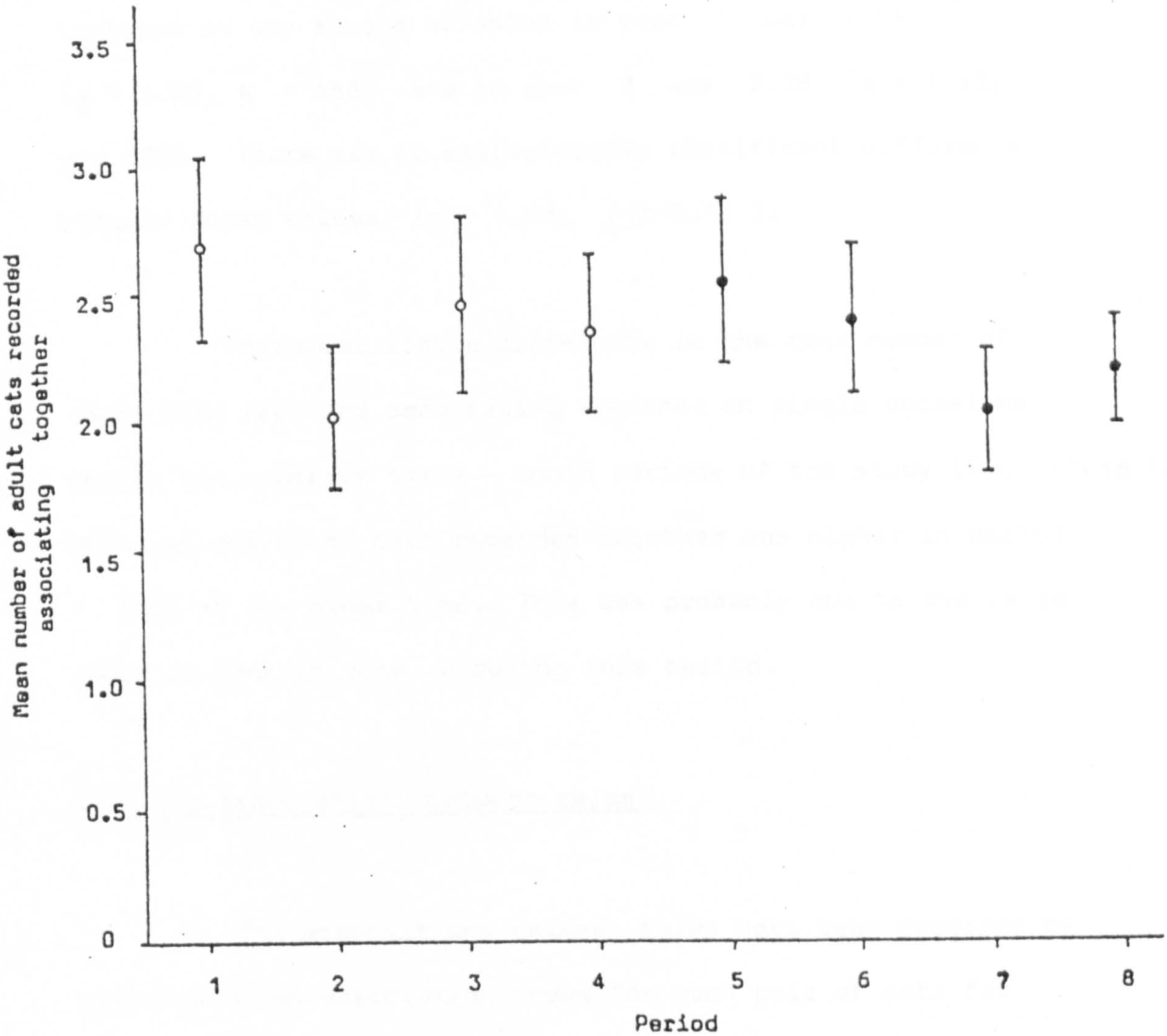



Fig. 11. 16. Mean number of cats recorded associating together and 95% confidence limits, during each three - month period of the study, (year 1 o ; year 2 ●).

The mean number of adult cats recorded associating together on any single occasion in year 1 was 2.39 ($\underline{s}$ = 1.85, $\underline{N}$ = 453) and in year 2 was 2.28 ($\underline{s}$ = 1.52, $\underline{N}$ = 508). There was no statistically significant difference between these values ($\underline{d}$ = 1.02, $\underline{P} > 0.10$ ).

There was little difference in the mean number of adult cats recorded associating together on single occasions during the separate three - month periods of the study (Fig. 11.16 ). The mean number of cats recorded together was higher in period 1 than at any other time. This was probably due to the large group of cats in zone A during this period.

11.3.12. Associations between males

The associations between males have been examined by calculating an association index for each pair of cats for the two study years (Table 11. 7 ). Only the 12 study males were considered.

The highest association index calculated in year 1 was between 27m and 28m (0.41) which lived in group D. Four males from this group (27m, 28m, 29m* and 49m) all exhibited quite high degrees of association with each other. The study males did not all associate together. Some males associated regularly with others but some individuals never met. The two males which were nomadic in both years of the study were

Table 11.7.

The number of associations observed between males in year 1 (a) and year 2 (b). The **value** of the association index is given in parentheses.

(a)

Year 1

| Cat | 27 | 28 | 34 | 44 | 50 | 52 | 53 | 49 | 68 | 23 | 29 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 28 | 22 (·41) | | | | | | | | | | |
| 34 | 5 (·12) | 11 (·26) | | | | | | | | | |
| 44 | 4 (·09) | 10 (·21) | 6 (·17) | | | | | | | | |
| 50 | - | - | - | - | | | | | | | |
| 52 | - | - | - | 3 (·10) | 2 (·11) | | | | | | |
| 53 | 3 (·08) | 5 (·12) | - | 5 (·15) | - | 2 (·09) | | | | | |
| 49 | 19 (·32) | 21 (·34) | 8 (·16) | 12 (·22) | - | - | 6 (·13) | | | | |
| 68 | - | - | - | - | - | - | - | - | | | |
| 23 | 2 (·05) | 3 (·07) | 2 (·06) | 4 (·11) | - | - | 1 (·03) | 4 (·08) | - | | |
| 29 | 15 (·31) | 11 (·22) | 2 (·05) | 5 (·12) | - | - | 5 (·14) | 19 (·34) | - | 3 (·08) | |
| 65 | - | - | - | - | 1 (·08) | - | - | - | 1 (·15) | - | - |

(b)

Year 2

| Cat | 27 | 28 | 34 | 44 | 50 | 52 | 53 | 49 | 68 | 23 | 29 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 28 | 3 (·06) | | | | | | | | | | |
| 34 | 1 (·05) | 7 (·12) | | | | | | | | | |
| 44 | 1 (·02) | 60 (·66) | 10 (·18) | | | | | | | | |
| 50 | - | - | - | - | | | | | | | |
| 52 | 1 (·04) | - | - | - | - | | | | | | |
| 53 | 2 (·04) | - | 4 (·07) | - | - | - | | | | | |
| 49 | 4 (·08) | 54 (·60) | 8 (·14) | 54 (·61) | - | - | - | | | | |
| 68 | - | - | - | - | 27 (·59) | - | - | - | | | |
| 23 | - | 6 (·09) | 1 (·03) | 6 (·09) | - | - | 11 (·16) | 4 (·06) | - | | |
| 29 | 1 (·07) | 6 (·11) | 3 (·16) | 3 (·06) | - | - | - | 5 (·10) | - | 1 (·04) | |
| 65 | - | - | - | - | 2 (·08) | - | - | - | 1 (·04) | - | - |

rarely seen together even though they both visited groups A and D. They were seen together on two occasions in year 1 and only once in year 2 (when 34m was neutered). Males 23m* and 34m showed a low degree of association with a number of males in both years.

Higher degrees of association between the males in group D were observed in year 2 compared with year 1. Association indices calculated between 28m, 44m and 49m were all $\geqslant$ 0.60. A high degree of association was also observed between 50m and 68m in group R (association index = 0.59).

In both years of the study the males could be divided into nomads and residents (Chapter 10). The number of males which were resident in specific groups increased in year 2 because some males which were nomadic in year 1 became resident in the second year of the study. The total number of pairs of associating males decreased from 32 in year 1 to 27 in year 2 as a result of these changes in behaviour. While the strength of associations between some males tended to increase in year 2 compared with year 1, the total number of males with which any single male associated tended to decrease (Table 11.8.). These changes may have been indicative of a greater degree of tolerance between males after neutering, as suggested in Section 11.3.10.

Table 11.8.

The number of male associates of each of the study males in year 1 and year 2 of the study.

| Male Number | Number of male associates (study males only) | |
|---|---|---|
| | Year 1 | Year 2 |
| 27 | 7 | 7 |
| 28 | 7 | 6 |
| 34 | 6 | 7 |
| 44 | 8 | 6 |
| 50 | 2 | 2 |
| 52 | 3 | 1 |
| 53 | 7 | 3 |
| 49 | 7 | 6 |
| 68 | 1 | 2 |
| 23* | 7 | 6 |
| 29* | 7 | 6 |
| 65* | 2 | 2 |

## 11.4. GROUPING OF CATS

### 11.4.1. The degree of grouping

The actual number of associations observed between different pairs of cats in the colony ($A_{obs}$) was much lower than the maximum number of associations which would have been observed if all individuals had associated together ($A_{max}$), in any single three - month period of the study (Table 11.9.). ($A_{max}$ has been calculated including and excluding cats seen alone). This was because the colony was divided into a number of social groups and individual cats tended to associate with relatively few other cats.

Linear regression analysis has been used to examine the relationship between the number of cats recorded in each three - month period and the number of associations observed between pairs of cats (Fig. 11.17. ). A linear relationship has been assumed for simplicity. In both years of the study the observed number of associations ($A_{obs}$) was much lower than the expected number if all cats associated together ($A_{max}$). The number of associations observed in the colony in year 1 was higher than that observed in year 2 when a similar number of cats were present. This suggests that the social groups were more discrete in year 2. In the two years the rate of increase in the number of associations due to an increase in the number of animals observed was almost identical (approximately 4.0 ) and much lower than would be expected if all cats

Table 11.9.

A comparison of values of $A_{max}$ with $A_{obs}$ (calculated by including and excluding cats seen alone ) for each three-month period of the study.

| Period | $A_{obs}$ | Including cats seen alone | | Excluding cats seen alone | |
|---|---|---|---|---|---|
| | | p | $A_{max}$ | p | $A_{max}$ |
| 1 | 67 | 22 | 231 | 18 | 153 |
| 2 | 77 | 26 | 325 | 22 | 231 |
| 3 | 118 | 29 | 406 | 27 | 351 |
| 4 | 98 | 32 | 496 | 30 | 435 |
| 5 | 80 | 34 | 561 | 29 | 406 |
| 6 | 60 | 27 | 351 | 23 | 253 |
| 7 | 29 | 21 | 210 | 15 | 105 |
| 8 | 68 | 28 | 378 | 23 | 253 |

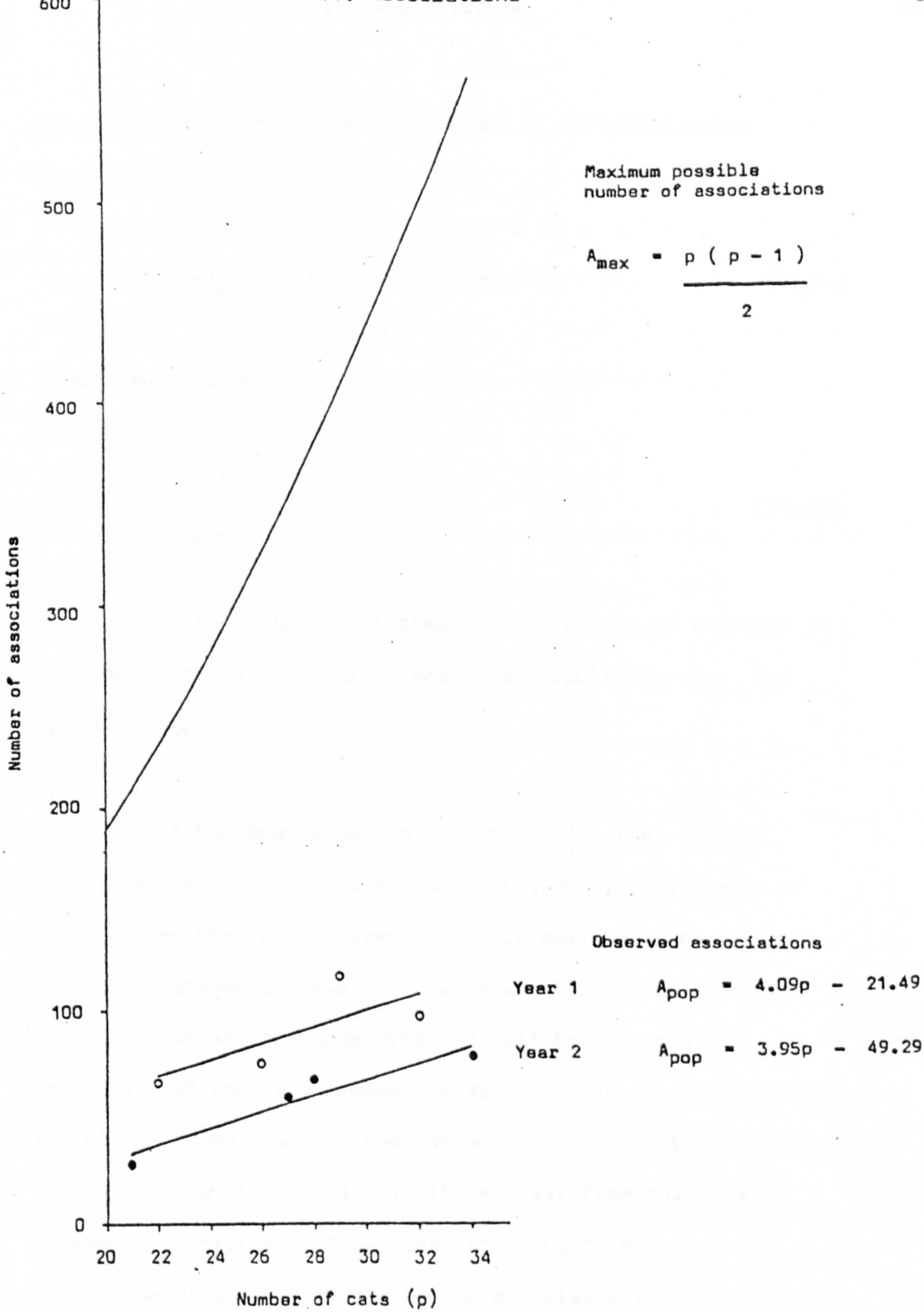



Fig. 11.17. A comparison of the relationship between the number of cats observed and the number of associations observed in year 1 (o) and year 2 (●) and the number of associations which would be expected if the population was not divided into groups ($A_{max}$). Cats seen alone are included in p.

associated together. This is obtained by differentiating equation 11.5:

$$A_{max} = \frac{p\,(p - 1)}{2} \qquad (11.5.)$$

Differentiating,

$$\frac{d\,A_{max}}{d\,p} = p - \tfrac{1}{2} \qquad (11.16)$$

In this case it is clear that the rate of increase in the number of associations increases as population size (p) becomes larger.

It has been shown in Section 11.1. that if any population is divided into a number of groups, the number of associations possible between the individuals will be reduced. When these groups are small and approximately equal in size the number of associations observed will be only a small percentage of the total number of associations possible between all of the animals in the population. This percentage has been called m (equation 11.10.). It is clear from the data presented in Section 11.3. that the Winwick Hospital cat colony was divided up into a number of relatively small groups of animals.

In order to study changes in the extent to which the cats tended to form groups values of $m$ have been calculated for each three - month period of the study (Fig. 11. 18 ). Low values of $m$ indicate the presence of a population divided into discrete groups between which few cats migrate; high values of $m$ indicate a tendency for the groups to be less discrete with individual cats associating with others in several groups.

The highest values of $m$ were recorded in period 1 when the only associations recorded were between members of groups A and D and the cats which moved between these groups. Later in year 1 the value of $m$ tended to decrease as members of the other groups were identified and observed associating together. This trend was apparent when solitary cats were included in the population and when they were not. (The exclusion of solitary cats reduces $p$ in equation 11.10. thereby reducing $A_{max}$ and causing an increase in $m$ ).

In year 2 the values of $m$ were generally lower than in year 1. The mean value of $m$ for the four three - month periods in year 1 was 33.3 ($\underline{s}$ = 8.7) compared with 24.5 ($\underline{s}$ = 3.6) in year 2, excluding cats which were seen alone in these periods. If these solitary cats are included the mean values of $m$ are reduced but a similar decrease in year 2 is apparent (year 1, $\bar{x}$ = 25.4, $\underline{s}$ = 4.5; year 2, $\bar{x}$ = 15.8, $\underline{s}$ = 2.1 ).

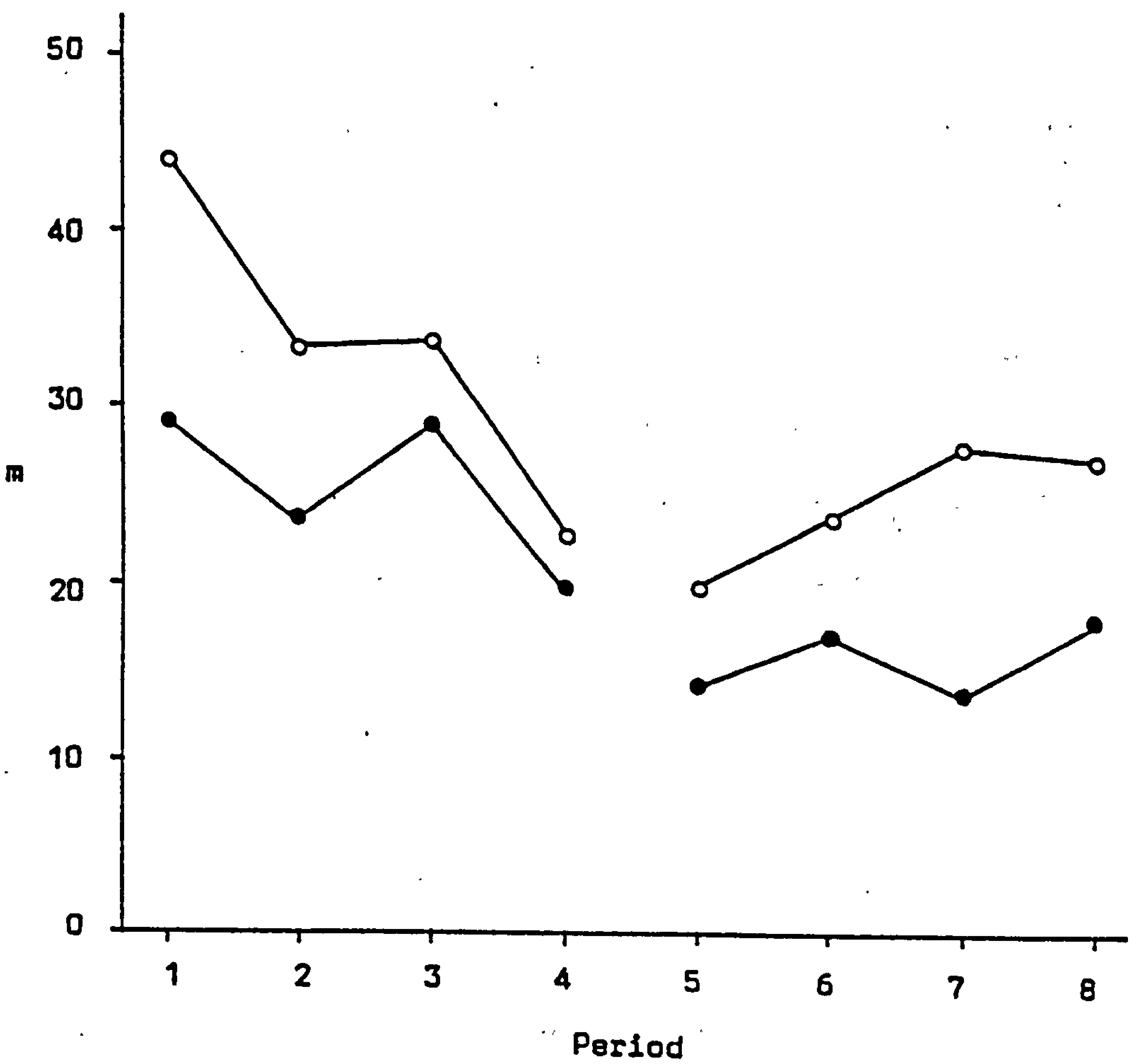



Fig. 11.18. Changes in the value of m during the study. m has been calculated excluding (o) and including (•) cats seen alone.

This decrease in m during year 2 could be due to a number of different types of changes in the population. It has been shown in Section 11.1. that m will decrease if a population of fixed size divides into a larger number of smaller groups. It has also been shown that m will decrease if the number of groups remains the same but the individual animals become more evenly distributed between these groups. A reduction in the movements of nomadic cats or an increase in the number of solitary cats would have a similar effect on m. Examination of Fig. 11. 14. suggests that m decreased in year 2 as a result of the tendency of the groups to be smaller, more stable in size and more discrete, with fewer animals moving between the groups than in year 1. It is also possible that the late identification of some cats in year 1 may have affected calculations of m.

It is possible that the number of visits made to the colony in each three - month period could have affected the number of different cats recorded and therefore the number of associations observed between pairs of cats. However, no statistically significant correlation was found between the number of visits and the number of cats recorded, including solitary animals (correlation coefficient($r$) = 0.44 , $t$ = 1.20, $p$ = 0.86, $d.f.$ = 6).

Table 11.10.

A comparison of estimates of g (the number of groups in the colony) calculated from equations 11.9 and 11.13.

| Period | | Estimate of g | | | |
|---|---|---|---|---|---|
| | | Including cats seen alone | | Exlcuding cats seen alone | |
| | Eq. | 11.9 | 11.13 | 11.9 | 11.13 |
| 1 | | 3.1 | 3.4 | 2.1 | 2.3 |
| 2 | | 3.8 | 4.2 | 2.8 | 3.0 |
| 3 | | 3.2 | 3.4 | 2.8 | 3.0 |
| 4 | | 4.5 | 5.1 | 4.0 | 4.4 |
| 5 | | 6.0 | 7.0 | 4.4 | 5.1 |
| 6 | | 5.0 | 5.8 | 3.7 | 4.2 |
| 7 | | 5.6 | 7.2 | 3.1 | 3.6 |
| 8 | | 4.8 | 5.6 | 3.3 | 3.7 |

Equation 11.9. $$g = \frac{p^2}{2 . A_{pop} + p}$$

Equation 11.13 $$g \approx \frac{100}{m}$$

## 11.4.2. Estimating the number of groups

Estimates of the number of groups present in the colony have been calculated for each three - month period of the study using equations 11.9. and 11.13. (Table11.10). In each case the estimate obtained from equation 11.13 is higher than that obtained from equation 11.9.

The data presented in Fig. 11.14 suggests four social groups were present in the colony (five in year 2 if group AN is included, but few associations were observed between members of this group). Both equations gave acceptable estimates of the number of groups in the colony although equation 11.9 gave rather low estimates in periods 1 - 3 when solitary cats were excluded, and equation 11.13 gave some high estimates in year 2 when solitary cats were included in the calculations. These equations give some indication of the extent to which a population is divided into social groups, but the precise number of groups suggested is not very accurate since the equations do not take into account movements of animals between groups. Nevertheless, the equations can be used to supplement information on grouping obtained by calculating values of m.

## 11.5. DISCUSSION

The feral cat colony in Winwick Hospital was divided into a number of relatively small social groups. These groups were approximately the same size and the effect of this grouping was to reduce the number of associations observed between pairs of cats compared with the number expected if all cats associated together.

The large groups of cats observed in year 1 appeared to be unstable. Initially, group A was the largest social group in year 1. The productivity of the females in this group appeared to be high yet no kittens survived to become adults (Section 6.8.1.) and many of the adults disappeared shortly after the beginning of the study. Group D was small at the beginning of year 1, increased in size in periods 2 and 3, but had decreased in size by the end of the year. Group R began as a small group but increased in size due to the survival of three kittens (all from the same litter).

The tendency for social groups to stay small and approximately equal in size may be due to a number of factors. There is some evidence that survival of kittens is greater in small groups, causing these groups to increase in size. Dards (1979) suggested that conception may be inhibited or early abortion stimulated in the larger groups of female cats in Portsmouth dockyard. Small groups may be increased in size and large groups reduced by the movement of cats, particularly males. It is also possible that cats tend to be more likely to be removed from the larger, more noticeable groups. It is possible that cats were removed from group A when it was large (Section 6.9.3.). Man may be an important ecological factor especially if he removes cats in a density - dependent fashion. The distribution and availability of food may also influence the size and location of social groups. The division of the colony into a number of relatively small groups may allow the animals to make the most efficient use of the available food. It is also possible that the separation of the population into groups is in part a result of social interactions between the animals. This may be particularly important in males. Dards (1979) observed agonistic encounters between mature and immature males more frequently than amicable interactions, especially when the young males appeared to be reaching puberty. She describes the migration of toms from their natal group presumably as a result of this aggression.

Neutering appeared to stabilise the size and composition of the social groups in the Winwick Hospital colony. Fewer movements of males between groups were recorded after neutering and no immigrant males joined the groups. There also appeared to be a greater degree of tolerance between males (although aggressive encounters were not observed in either year of the study). It is likely that this increase in stability would be welcomed on many premises inhabited by feral cats. The cats could be confined to relatively small areas and the possibility of the transmission of disease between groups would be reduced.

There are many similarities between the social organisation of the feral cat colony in Winwick Hospital during the first year of the study, the cats studied by Dards (1979) in Portsmouth dockyard, and the lions studied by Schaller (1972). Schaller examined the associations between members of a pride of lions in the Serengeti, but excluded males. He calculated values for the association index ranging from zero to 0.89. Schaller noted that no two animals remained together all the time but some showed values of 0.4 or more, and these were considered to be 'companions'. Schaller observed that companionships had no influence on pride composition. No matter how widely females were scattered or how frequently they met other pride members, they still constituted a closed social unit which strange lionesses were not allowed to join.

Dards (1979) made similar calculations for the cats in the dockyard. Her values for the association index ranged from zero to 0.6. Like Schaller (1972) she only calculated association indices between members of the same social group and excluded males. Consequently the values obtained by Dards and Schaller are not directly comparable with those calculated for the cats in Winwick Hospital, which include males and were calculated for all the cats in the population.

Dards (1979) noted that in the Portsmouth dockyard cats 'companions' were often close relatives or from litters born at the same time. She found that the size of the values of the association index varied between social groups, reflecting individual differences in the degrees of sociability. A similar situation is seen in the Winwick cat colony where some groups contain cats between which there are many statistically significant associations while in other groups there may be no significant associations. Neither Dards (1979) nor Schaller (1972) tested the statistical significance of the associations they observed and both appear to have ignored the effect of the number of observations on the value given by the index of association.

Dards and Schaller give no data on the total number of associations recorded in the populations they studied. Nevertheless, if the groups they describe contain animals which only associate with others in the same group the total number of associations may be estimated using equation 11.6. This equation also assumes that each animal associates with <u>all</u> the others in the same group.

Dards (1979) excluded males in her consideration of social group composition. The mean group size recorded in the Portsmouth dockyard population was 4.4 in 1976, 4.9 and 4.8 in the following two years. In the first two years there were 23 groups and in 1978 this number increased to 26. These groups accounted for over three - quarters of the females in the population. The remaining females were solitary. In 1976 a total of 102 females were observed in groups ranging in size from two to nine individuals.

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Using equation 11.6. an estimate of 226 associations is obtained for the individuals in the 23 groups described by Dards (1979). This represents approximately 4.4% of the maximum number of associations possible between 102 individuals (equation 11.5.). If the 31 solitary females observed by Dards are included in this calculation, and assumed not to associate with the social females, the value of m falls to 2.6% .

The 12 lion prides described by Schaller (1972) in the Serengeti ranged in size from four to 13 individuals (including only adult males and females). For this population of 103 adults (excluding solitary animals) m = 8.3% , assuming that animals only associate with others in their group.

The values of m calculated for the populations studied by Dards (1979) and Schaller (1972) are lower than those calculated for the Winwick Hospital cat population. There may be a number of reasons for this. The estimates calculated for Dards' and Schaller's data are not based on observed associations and assume that no animals moved between groups. Also the Winwick Hospital cat population was smaller than the populations with which it has been compared.

The mathematics developed in this chapter could be used to investigate social organisation in animal populations using computer simulation models. Dynamic models simulating the movements of individuals between groups, natality and mortality within groups and immigration and emigration could be used to examine the effect of various factors upon the total number of associations within a population.

A logical development of the method used here which describes group structure in the form of network diagrams would be the removal of the subjectivity involved in defining these groups. This could be achieved using a computer program capable of examining all of the associations, comparing the association indices and assigning animals to particular groups on the basis of their degree of association . There would, however, still be a certain amount of subjectivity involved in selecting the degree of association required for group formation and membership. If home range is also considered when defining groups the analysis would be complicated further. Dards (1979) defined groups of cats on the basis of overlapping home ranges. This may be misleading if associations are not considered because animals may use the same areas at different times.

The writing of computer programs to analyse and simulate social organisation in animal populations is an extremely complex task. It requires a biological understanding of the factors which are important in defining social groups; the mathematical expertise to express these in the form of an efficient algorithm; and the ability to write an effective program.

In the past the study of social organisation has been largely descriptive in nature. An increase in the development and use of mathematical techniques will improve biologists' ability to describe social organisation in a quantitative fashion.

# PART IV

# TRAPPING

# AND

# VETERINARY EXAMINATION

# OF THE CATS

# 12. TRAPPING OPERATION

## 12.1. INTRODUCTION

A number of techniques have been used to capture mammals alive. These have ranged from automatically operated traps for many small mammals (e.g. Delany, 1974) to immobilising drugs for large mammals (e.g. Gray & Nettashinghe,1970). Feral cats have been trapped, apparently successfully, for many years (Hammond, 1981; Jackson, M., 1981; Remfry, 1981) but little has been published on the methods used and no attempt appears to have been made to describe a complete trapping operation. Van Aarde (1978) trapped 52 cats on Marion Island using traps fitted with remote signalling devices (Condy et al, 1975), but has not described his trapping methods in detail.

It was necessary during this study to trap all the cats living in Winwick Hospital so that they could be neutered. Two experienced cat trappers provided their services for this purpose. They were Miss Celia Hammond (R.S.P.C.A.) and Mr. Michael Jackson (Jackson & Booth Services Ltd., Wandsworth Common, London).

## 12.2. METHODS

### 12.2.1. Trapping

In the week before the trapping operation began a notice was circulated to each ward of the hospital to inform the staff of the proposed trapping activities and to assure those concerned that the cats would be returned neutered and otherwise unharmed.

The trapping operation began in the early hours of 1st. July 1979 and ended on 12th. July. For convenience this period has been divided into twelve 24-hour days numbered consecutively from 1st. July and beginning at midnight on 30th. June.

A total of five persons were involved in the trapping operation, including Miss Hammond and Mr. Jackson. Four were engaged in trapping at the hospital for the first three days. Thereafter only Miss Hammond continued trapping. Two vans were used at different times during the trapping operation to transport cats and equipment around the grounds of Winwick Hospital. A third van was used almost exclusively (by the author) to transport cats to the University Veterinary Hospital in Liverpool, a distance of some 30 km. This journey was made on ten occasions.

Three types of traps were used : a standard R.S.P.C.A. automatic single cat trap (see Appendix III) and two manually operated traps specially designed by Jackson & Booth Services Ltd., for single and multiple captures (Fig. 12.1.) During the first three days of the trapping operation up to ten traps were in use at any time. Most of these were Mr. Jackson's traps. The traps were set during the late evening and throughout the night until dawn. Traps were set only rarely during the daylight hours in

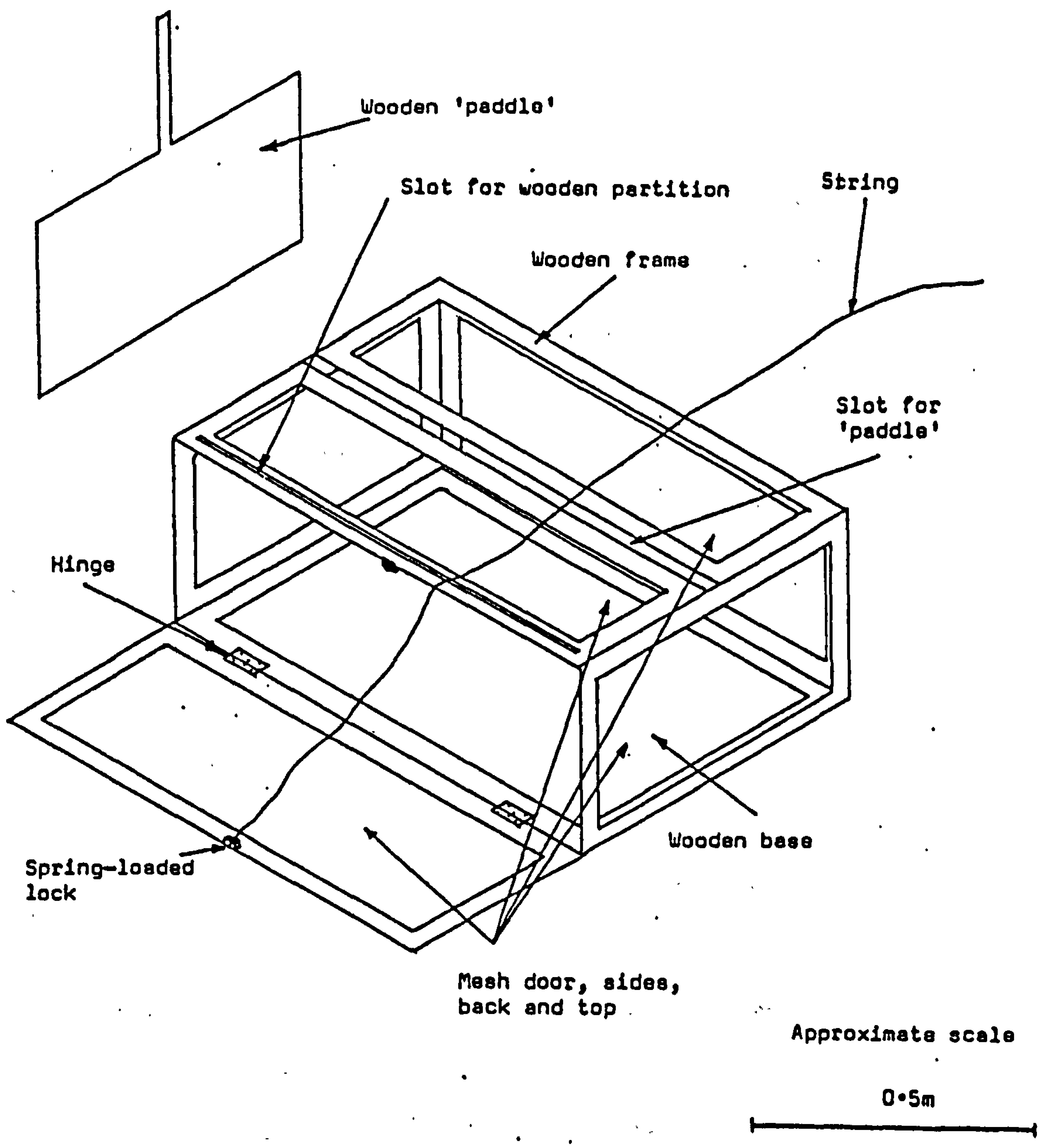



Fig. 12.1. Manually operated cat trap designed and used by Jackson & Booth Services Ltd.

order to minimise possible interference by patients and hospital staff. Automatic R.S.P.C.A. traps were set in inaccessible areas such as the derelict sheds in zone A (Plate 15) basements and underground ducts.

The number of traps used varied throughout the trapping operation. At the end of day 3 Mr. Jackson left the hospital and his traps were not available thereafter. Some of the captured cats were transferred from traps to wire cat baskets, but during the first three days of the operation so many cats were captured that some had to remain in the traps, thereby reducing the number of traps available for further trapping. From day 4 onwards one R.S.P.C.A. trap was used manually for much of the time, with a small number of automatic traps left unattended.

Traps were set at a large number of locations throughout the trapping operation but the trapping effort was concentrated in zones A, D, F, G, R and Y . When cats were discovered or reported from outside the study area, but still within the hospital grounds, traps were set in the areas where these cats had been seen. The presence of the trappers in the grounds continuously for 12 days prompted many unsolicited reports of cats from hospital staff which assisted the location of some animals.

The trapping effort was greatest during the first three days of the operation. Mr. Jackson's manual traps were placed at a number of locations in the study area, as indicated above, and two vans were used to drive between the traps so that they could be inspected in turn throughout the night. The use of vans was essential for carrying equipment and because the traps were widely separated. Each van was usually occupied by two trappers. Commercial cat food, fish and pieces of fried chicken were used as bait. It was necessary to bait traps throughout each night since it was often removed from the traps while the trappers were absent. The removal of bait was a useful indicator of the presence of cats and the trappers used this information in deciding which traps to watch. If a cat was seen near any trap it was observed from the van once this had been positioned so that one of the trappers could reach the string that operated the trap's door. This string extended to a distance of some 20 - 30 metres from the trap, but this varied. While waiting for the cat to enter the trap it was possible to use the vehicle's headlamps to illuminate the area. Cats appeared undisturbed by this. Since the hospital grounds were poorly lit at night the use of headlamps was important in helping the trappers to determine the appropriate time to operate the trap. As the trap door was hinged at the bottom, when the trap was operated the door flew upwards. If the cat was standing on the door this had the effect of throwing the animal inside the trap without harming it. Serious injury would have been sustained by any cat which had not entered the trap far enough when the trap was operated so it was very important that the trapper should be able to see the cat's position clearly. The problem of determining the position of the cat within the trap was made more difficult because the trap was operated from behind so that the trappers' view of the door was obscured by the trap itself.

When a multiple trap was used and two cats were available for capture at the same time care was taken to trap both cats together rather than catch one cat and scare the other away. No attempt was made to capture single cats if a group was present for the same reason.

Once a cat had entered the trap it was generally allowed to feed on the bait inside for a moment before any attempt was made to close the trap's door. As the cat gained confidence it would normally move further into the trap, clear of the door. Mr. Jackson normally spent some time at any trapping site allowing cats to become accustomed to entering traps for food before attempting to catch them. This approach was not possible at Winwick Hospital because Mr. Jackson was only available for three days and it was considered essential to begin trapping as early as possible. Details of his usual trapping strategy are given in Jackson, M., (1981).

To operate Jackson's manual trap the string attached to the door was pulled sharply causing the door to close and a small spring-loaded lock to fasten the door to the front of the trap. This lock alone was too weak to secure the door so the string was kept taut by one person holding the door closed, while a second person secured the door with two bolts located on the frame of the trap. Whenever possible the trapped cat was then transferred to a wire cat basket which was just large enough for the animal to turn around. Care had to be taken at this stage to ensure that the cat did not escape. A sliding wooden partition was placed behind the door of the trap so that this door could be opened without the cat being able to escape. A 'paddle' was then inserted into the trap and used to restrict the cat to one end of this trap. A wire basket was placed with its open side against the wooden partition in the trap, opposite the cat, and the partition was removed. The cat was persuaded into the basket and then the sliding door of the basket was replaced. This transfer of cats to wire baskets was usually done inside a vehicle to reduce the possibility of escape.

Wherever possible the reaction of cats to being trapped and any injuries sustained during trapping were recorded. The zone and time of capture were also recorded. This information was not available for every cat because trapping was usually taking place at several locations at the same time and only one recorder was present. After capture cats were contained within either wire baskets or traps depending upon availability. A label was attached to each of these containers indicating the identification number of the cat inside. Cats which had not been previously seen ('unknown' cats) were assigned a number.

While awaiting transportation to the veterinary hospital the cats were housed in two unused outbuildings within the hospital grounds, where they were fed, given water and their traps and baskets were cleaned as far as possible. The veterinary hospital was not open at weekends so it was not possible for its staff to receive the first of the captured cats until day 2 , and visits to the hospital were not possible on days 7 and 8. It was therefore necessary to keep some cats in captivity for several days.

12.2.2. Veterinary treatment and release

The objective of the trapping operation was to capture all of the cats in Winwick Hospital, neuter and return all the adults and remove the kittens which were too young to neuter. Badly diseased kittens were humanely destroyed by Mr. Jackson using chloroform as soon as they were captured. Healthy kittens were taken for re-homing by Miss Hammond. Diseased kittens which may have responded to treatment were taken to the veterinary hospital, but most were eventually destroyed since the veterinary surgeons considered them unsuitable for re-homing in view of the large number of healthy unwanted kittens generally available.

All of the adult cats captured and three male kittens considered old enough for the operation were neutered at the veterinary hospital with the exception of 29m* who was already neutered and 119m who was captured late on day 12 and was neutered by a veterinary surgeon in Warrington. At the veterinary hospital two veterinary surgeons and a team of veterinary nurses performed the operations using the procedures outlined below under anaesthetic.

Males An incision was made along the posterior surface of each scrotum. Each testis was removed by pulling it away from the scrotal sac thus severing the _plexus pampiniformis_ and the _vas deferens_.

_Females_. A single incision was made in the flank. Both ovaries and oviducts were removed but the body of the uterus was left intact.

Soluble sutures were used to repair all skin incisions since it would not have been possible to return the cats at a later date for the removal of sutures.

Each of the adult cats (except 119m who was not taken to the veterinary hospital ) was examined for parasites, disease and physical damage (see Chapter 13). While under anaesthetic each cat was vaccinated against feline infectious enteritis and sprayed with dichlorvos ('Nuvan Top' - Ciba Geigy) to destroy fleas.

Each cat was temporarily marked by shaving a 5cm square of hair from each flank. In addition an experimental freeze branding tool was used to destroy hair follicles on the cat's back with the intention of producing a permanent mark several centimetres long. Two parallel white lines of hairs should have been produced by this tool but several months later it was evident that the tool had not produced the desired effect. The cats which were neutered in the early part of the trapping operation had to be released back into the colony as soon as possible because accomodation and feeding problems made it impossible to confine these cats while the remaining animals were being trapped. This caused problems of identification since neutered and entire cats were present in the colony from day 3 onwards. To aid identification further a waterproof ink marker was used to put a red line on the face of each neutered cat, between its eyes. This wore off with time but the unfortunate choice of colour lead to concern from some hospital staff who thought the animals were bleeding.

Each cat was released as soon as possible after the neutering operation. Before release it was given food and water either at the veterinary hospital or at Winwick Hospital. The cats were released one at a time, each in the zone in which it was captured. A record of the time of release was made and the behaviour of the cat during and immediately after release was recorded.

## 12.3. NUMBER OF CATS CAPTURED

During the 12 day trapping operation 66 cats were captured alive comprising 23 males (including six 'unknown'), 18 females (including three 'unknown'), and 25 kittens. The fate of all of the animals present during the trapping operation has been examined earlier (Section 6.5.).

Calculation of the cumulative total of all the 'known' adult cats captured by the end of each successive day of the trapping operation indicates a progressive decrease in trapping success (Fig. 12.2.). 'Unknown' cats have been excluded since

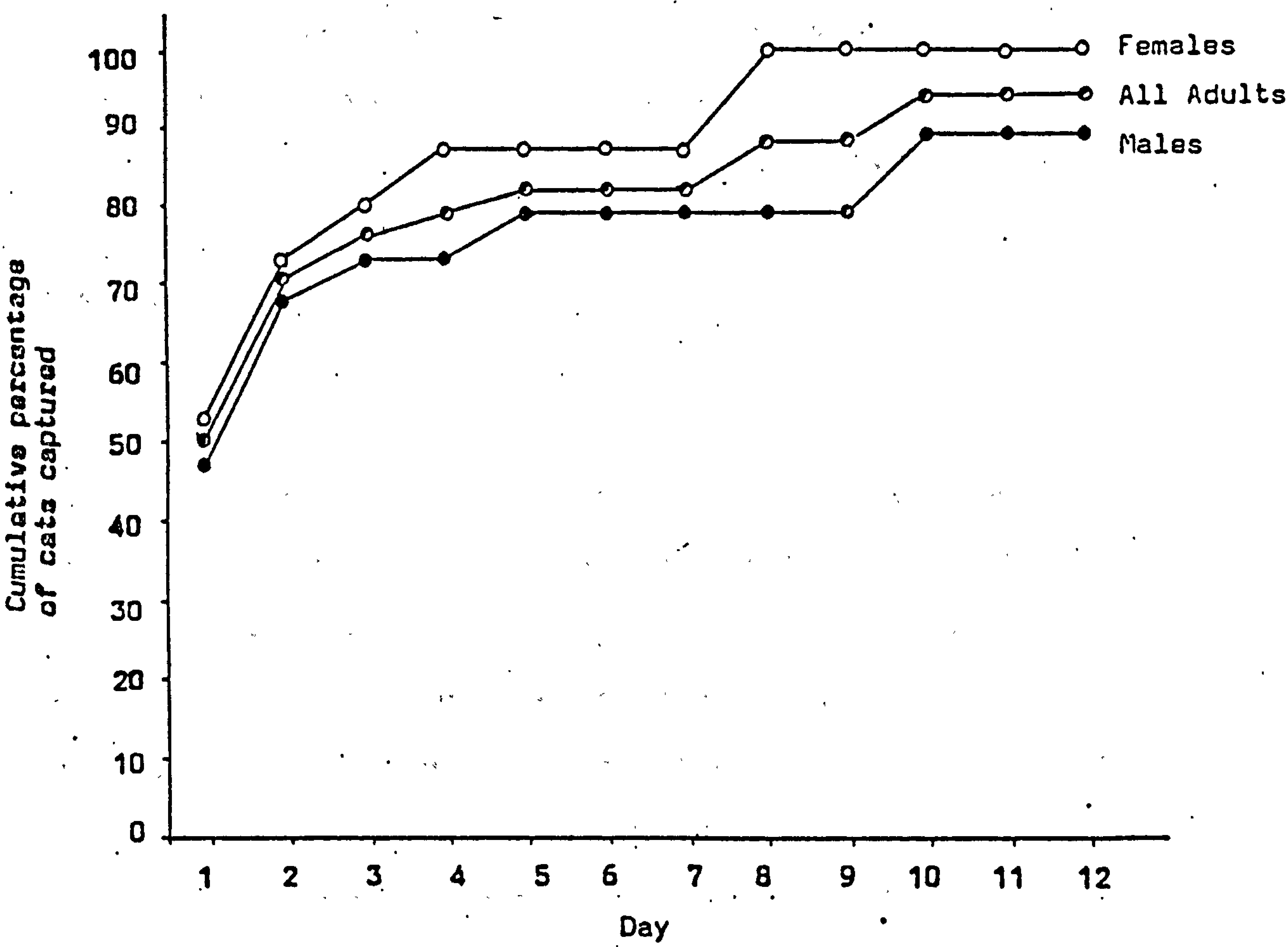



Fig. 12.2. Cumulative total of 'known' adult cats captured by the end of each successive day of the trapping operation, expressed as per cent.

they may not have been present in the colony and available for capture throughout the operation. Females appear to have been easier to capture than males, possibly because most females utilised a relatively small home range whereas many males ranged over much larger areas and some undoubtedly spent time outside the study area. All of the females had been captured by day 8, but by day 12 two males still remained at large and were never captured. Both of these cats were nomadic and it was difficult to know where to set traps for them.

The reduced trapping effort after day 3 may have been partly responsible for the reduction in the number of cats captured on subsequent days. However, even during the first three days of the trapping operation, when trapping effort remained relatively constant, trapping success decreased with time. Kristensen (1981) has reported that in neutering projects undertaken in Denmark the majority of the cats were trapped at the start of the project. This phenomenen is not surprising since more wary animals are likely to take longer to catch. A questionnaire survey conducted by Remfry (1981) of 38 different sites where feral cats were trapped showed that 87% (of 121 adults) were successfully captured. This agrees well with the percentage of the total number of 'known' adult cats captured in this study (Fig. 12.2.).

## 12.4. AMOUNT OF TIME SPENT IN CAPTIVITY

The practical problems of housing, feeding and cleaning a large number of feral cats necessitated the speedy return of neutered cats to the colony as soon as they were considered well enough to be released. By the end of day 1, 19 adult cats had been captured (Fig. 12.3.). None of these cats could be transported to the veterinary hospital until day 2. On day 3 cats captured on day 2 were transported to the veterinary hospital and neutered cats from the previous day were returned to Winwick Hospital. Neutered cats then had to be released to make room for those which were being captured. Ideally all of the neutered cats should have been held in captivity until all the remaining entire cats had been trapped. This would have avoided the problem of having a mixed colony of neutered and entire cats and the possibility of recapturing neutered animals. This was not possible because of the large number of cats in the colony. Many of the adult females had young kittens which put further pressure on accommodation.

The amount of time spent in captivity, from the time of capture to the time of release, was recorded for 21 cats, (including 29m* who was already neutered). This ranged from 2.49 to 4.44 days with a mean of 3.26 days ($\underline{s}$ = 0.53). It hasbeen suggested that males should be allowed to convalesce for 24 hours and females for two days before release (Anon., 1981). Kristensen (1981) suggests 1 - 2 days for males and 2 - 4 days for females. No necessity was seen during this study to treat the sexes differently ( males: $\bar{\underline{x}}$ = 3.15 days, $\underline{s}$ = 0.43, $\underline{N}$ = 12; females: $\bar{\underline{x}}$ = 3.39 days, $\underline{s}$ = 0.68, $\underline{N}$ = 8) but individuals which were slow to recover from the anaesthetic or reluctant to take food were generally

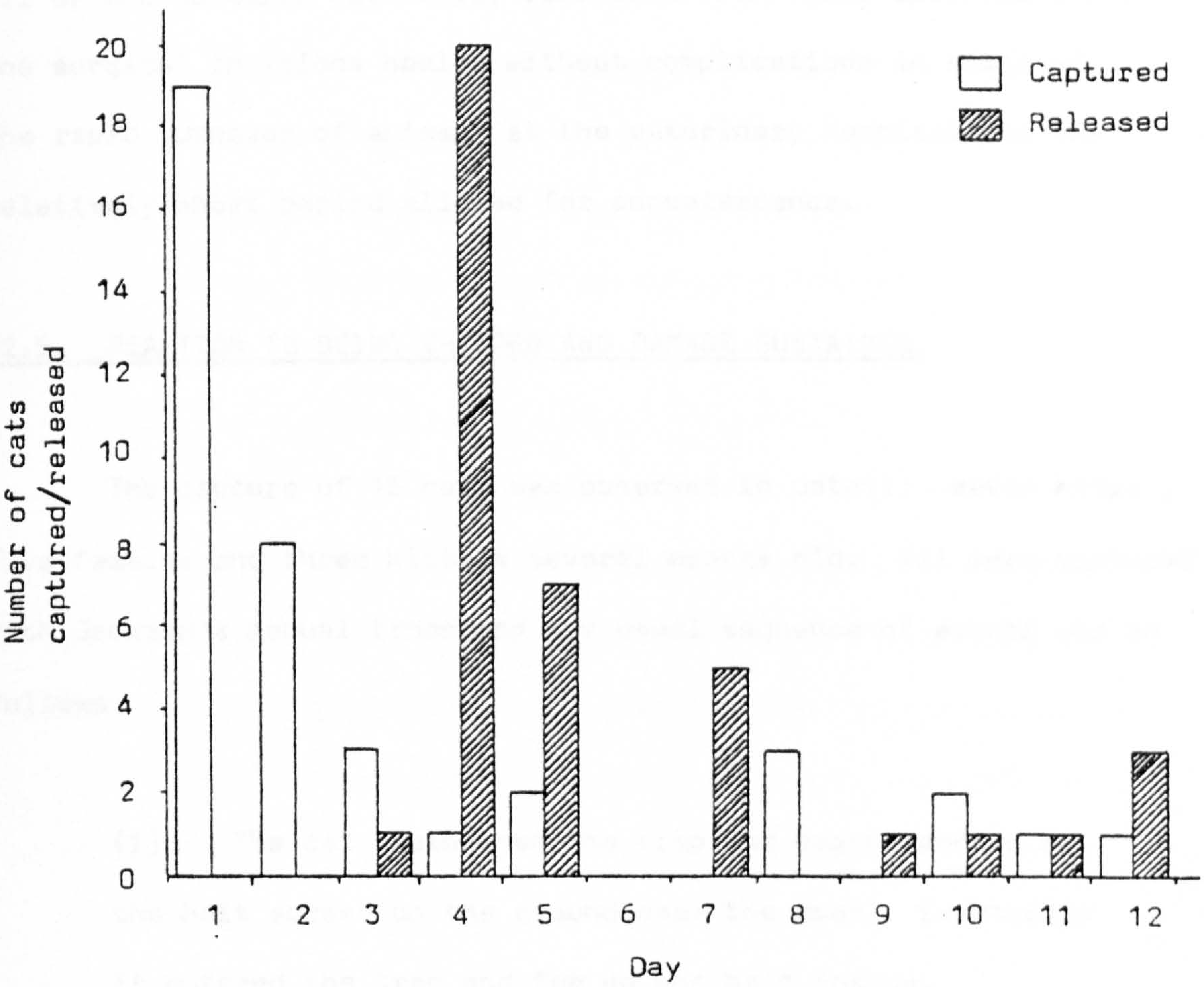



Fig. 12.3. Number of adult cats captured and released on each day of the trapping operation. These data include all 'unknown' cats. The day on which 52m was captured was not recorded so he has been excluded from the total captured. Female 99f was rehomed. Male 119m was captured late on day 12 and released after the end of the period to which this figure relates.

confined until considered fit for release.

As far as could be ascertained from field observation alone all of the neutered cats fully recovered from their operations and the surgical incisions healed without complications in spite of the rapid turnover of animals at the veterinary hospital and the relatively short period allowed for convalescence.

## 12.5. REACTION TO BEING TRAPPED AND DAMAGE SUSTAINED

The capture of 15 cats was observed in detail: seven males, five females and three kittens several months old. All were captured with Jackson's manual traps and the usual sequence of events was as follows:

(i) The cat approached the trap and began feeding on the bait spread on the ground near the door. Eventually it entered the trap and fed on the bait inside.

(ii) When the cat was clear of the door the string was pulled sharply closing the door and often moving the trap slightly. The cat was startled and, if standing on the door, thrown inside the trap.

(iii) While the door was being secured the cat ran at the door and the back of the trap and pushed at the mesh with its fore feet. It then ran at the ends of the trap and pushed at the mesh here and at the top of the trap. Some cats scratched at the base of the trap's sides and other parts of the structure and some bit the mesh.

(iv) The cat was transferred to a wire basket or small trap as described in Section 12.2.1. The basket was just large enough for an adult cat to turn around in and this confinement had the effect of subduing the animal. Generally no further attempt was made to escape and the cat remained relatively calm.

All of the adult cats captured were observed while confined in wire baskets or small traps except 119m which was captured after the author had left the hospital. Most remained silent and showed very little activity except the neutered male ward cat 29m* which called continuously. None of the cats showed any outward signs of stress while confined.

Four of the seven males examined immediately after capture had bleeding noses which appeared to have been sustained during trapping probably by hitting the head against the sides of the trap. Damage to the nose during trapping has also been reported by Tabor (1981). Blood of unknown origin was found in the trap used to capture one of the other males. None of the five females or three kittens observed immediately after capture appeared to have sustained any damage.

## 12.6. ESCAPE OF CATS FROM TRAPS

Three adult cats escaped from Jackson's manual traps. Male 28m was captured at 01.55 hrs. on day 1 but escaped when the string operating the trap's door snapped and the door fell open. He was captured successfully 17 minutes later in the same trap in the same place, after the trap had been repaired. Female 21f was captured at 22.45 hrs. on day 1 but escaped when the string snapped. She was captured again after 55 minutes in the same trap and in the same place. Female 9f was first captured on day 3 . She was released by a patient from the hospital before the trap could be secured. An attempt was made to capture this cat by hand on day 7 when she was discovered asleep but this failed. Miss Hammond eventually captured her on day 8 by hand, five days after she was first trapped, and very near the location of the original trap.

Other cats appeared to be springing automatic R.S.P.C.A. traps left in inaccessible places throughout the operation, without becoming trapped. In many cases the bait from inside the trap had been taken so that there was no doubt that a cat had entered the trap. It must therefore be assumed that the cats escaped due to either a faulty door mechanism or obstruction of the falling door by a second cat blocking the entrance, thus allowing the escape of both animals. Unfortunately it was not possible to observe cats making their escape.

On day 3, 33f was released in zone F at 19.30 hrs. She ran to shelter in the underground ducting system and was recaptured accidentally in zone AG2 approximately 15 minutes later.

## 12.7. LOCATIONS WHERE ADULT CATS WERE CAPTURED

Sixteen of the 28 captured 'known' adult cats were trapped in the zone in which they had been recorded most frequently in year 1 of the study (Table 12.1.). Four of the remaining cats (10f, 54f, 66f and 69m ) were known to use the zone in which they were trapped and this was often adjacent to or very near the zone where they were most frequently seen. Nomadic cats, for example 9f and 44m, were more likely to be captured in areas where they were rarely or never seen than cats which utilised a very small number of zones, for example 14f.

Information about the zones utilised by each cat in year 1 has been given earlier (Chapter 7) except for 32f, 33f, 38f, 54f, 86f, 39m, 63m, 64m, 69m, 88m, and 97m. Little was known about the home ranges of these cats because none was recorded on more tham eleven occasions and most were seen on less than four occasions. Consequently the relationship between their ranges and places of capture was unclear. The precise number of times each cat was recorded during year 1 is given in Table 6.1.

It is interesting that in spite of intensive trapping activity

Table 12.1.

Zones in which the 'known' cats were captured during the trapping operation.

| Zone | Cats captured | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| A | 14f | 19f | 53m | 64m | | | | |
| D | 21f | 43f | 62f | 27m | 28m | 34m | 49m | 29m* |
| F | 32f | 33f | 38f | 44m | 88m | | | |
| G | 39m | 63m | | | | | | |
| Q | 10f | | | | | | | |
| R | 66f | 86f | 50m | | | | | |
| Y | 54f | 69m | 97m | | | | | |
| AH | 51f | | | | | | | |
| AL | 9f | | | | | | | |

Female 17f was captured outside the study area. Records are not available for the zones of capture of 52m, 68m, and 107m. Cat numbers which are underlined indicate individuals which were captured in the zone in which they were most frequently recorded in year 1.

Table 12.2.

Zones and locations outside the study area where 'unknown' adult cats were captured during the trapping operation.

| Cat | | Zone / location |
|---|---|---|
| 98m | | AH |
| 105m | | AB |
| 106m | | AJ |
| 113m | | E ? |
| 115m | (ward pet) | Female admissions ward * |
| 119m | | Gardens * |
| 99f | | D |
| 109f | | Greenhouses / gardens * |
| 114f | | AN (behind Nurses' Home) * |

? Precise location unknown

* Outside study area

in the same zones day after day cats remained in the areas where they normally lived, even though many must have been present when their associates from the same social group were trapped. On two occasions different cats were captured in the same trap used at exactly the same location with only a very short time interval between the captures. In the most heavily utilised zone, D, 49m and 43f were trapped at 06.20 hrs. and 06.35 hrs. respectively on day 1. Later the same day, in the same place, 21f and 34m were trapped at 23.40 hrs. and 23.50 hrs. respectively.

Nine 'unknown' adult cats were captured during the trapping operation. The possible origins of these animals have been discussed in Chapter 6. Most were captured either near or outside the perimeter of the study area (Table 12.2.).

## 12.8. BEHAVIOUR OF CATS ON RELEASE

When the neutered cats were released in Winwick Hospital a record was kept for each animal indicating whether it ran or walked out of the trap or cat basket in which it had been confined, and whether or not it sought shelter after release (Table 12.3.).

Approximately 65% of 'known' adult males and 71% of 'known' adult females ran out of their traps or baskets when opened. All of the animals immediately sought shelter in their

Table 12.3.

Behaviour of cats when released.

| | | Cat Number | Behaviour when released from trap or basket: Ran away | Walked away | Sought shelter | Did not seek shelter |
|---|---|---|---|---|---|---|
| Known | Males | 27 | X | | X | |
| Known | Males | 28 | | X | | X |
| Known | Males | 29 | | X | | X |
| Known | Males | 34 | | X | | X |
| Known | Males | 39 | X | | X | |
| Known | Males | 44 | X | | X | |
| Known | Males | 49 | | X | | X |
| Known | Males | 50 | X | | X | |
| Known | Males | 52 | X | | X | |
| Known | Males | 53 | | X | W | |
| Known | Males | 63 | X p | | X | |
| Known | Males | 64 | | X | W | |
| Known | Males | 68 | X | | X | |
| Known | Males | 69 | X | | X | |
| Known | Males | 88 | X | | X | |
| Known | Males | 97 | X | | X | |
| Known | Males | 107 | X | | X | |
| Known | Females | 9 | X | | X | |
| Known | Females | 10 | | X | | X |
| Known | Females | 14 | | X | W | |
| Known | Females | 17 * | | | | |
| Known | Females | 19 | X | | X | |
| Known | Females | 21 | | X | W | |
| Known | Females | 32 | X p | | X | |
| Known | Females | 33 | X | | X r | |
| Known | Females | 38 | X | | X | |
| Known | Females | 43 | | X | W | |
| Known | Females | 51 | X | | X ** | |
| Known | Females | 54 | X | | X | |
| Known | Females | 62 | X | | X | |
| Known | Females | 66 | X | | X | |
| Known | Females | 86 | X | | X | |
| Known | Kittens | 100 | X | | X | |
| Known | Kittens | 101 | X | | X | |
| Known | Kittens | 112 * | | | | |
| Unknown | Males | 98 | | X | | X ** |
| Unknown | Males | 105 | X | | X ** | |
| Unknown | Males | 106 | | X | | X ** |
| Unknown | Males | 113 | | X p | W | |
| Unknown | Males | 115 + | | | | |
| Unknown | Males | 119 * | | | | |
| Unknown | Females | 99 | | X | | X ++ |
| Unknown | Females | 109 | X | | X | |
| Unknown | Females | 114 | X | | X | |

W Walked or walked quickly to a sheltering place
p Needed to be persuaded to leave trap/basket
r Recaptured accidentally approximately 15 minutes after release
* Observer not present when released
** Ran or walked out of study area after release
\+ Pet cat returned to ward
++ Appeared lost when released and was later rehomed

X Response(s) of cat

normal hiding places and most quickly disappeared from view. Some cats hid in vegetation while others entered buildings or parts of the underground duct system. The remaining 'known' adults walked out of the trap or basket. Some of these cats walked away from the trap or basket and into a hiding place, but four males (including 29m*, who had been neutered on a previous occasion) and one female made no attempt to find cover. One male, 28m, walked about four metres from his trap and sat down before eventually wandering into the nearby bushes. Including those 'known' adult cats which walked out of their trap or basket, as well as those that ran, a total of 76% of 'known' males and 93% of 'known' females sought shelter and / or disappeared after release. The two male kittens which were observed on being released (together) ran out of their trap and disappeared down a hole in the underground duct system from which they had appeared during the trapping operation.

The behaviour of the 'unknown' adult cats when released was interesting. Male 119m was not observed and 115m was a ward cat. Of the remaining four males which had not been seen in the colony prior to the trapping operation one ran and two walked away from the study area after being released where, they were captured within the study area. This lends further support to the earlier suggestion that these animals were immigrants (Chapter 6). Only one other cat, 51f, showed a similar behaviour but she was known to be a member of the colony and ran into vegetation on the periphery of the study area in an attempt to avoid the observers.

The 'unknown' female 99f was released at 08.10 hrs. on day 3 in zone D, where she had been captured on day 1. She was very tame and appeared disorientated: she called frequently and walked slowly around zone D , but did not sit or walk in any of the areas normally used by the cats in group D. She appeared as if she was exploring the area for the first time. The cat was put back in a basket by hand, fed and then released again in zone D at 08.50 hrs. She again appeared disorientated and wandered through the area while calling. Eventually 99f was recaptured by hand and it was decided that she should be re-homed. She was lactating when examined at the veterinary hospital and it seemed likely that she had either strayed into the colony or had been abandoned possibly with her kittens, although they were not identified among the kittens discovered.

Female 109f was returned to the gardens, outside the study area, where she was captured and did not subsequently appear to enter the study area. She also had kittens when she was captured and was presumably either a stray or had been abandoned. Female 114f was returned to zone AN where she had been discovered living in the garden at the rear of the Nurses' Home. She was a very timid cat and immediately sought refuge in the bushes here.

Most of the cats were released without difficulty but three of the adults needed to be persuaded to leave their open trap or basket by shaking or tipping it up. Once disturbed they were successfully released.

## 12.9. DISCUSSION

Variation in the behaviour of individual animals towards traps and 'trap shyness' have been recorded in mammals (Delany, 1974). It was thought that the feral cats at Winwick Hospital may have exhibited 'trap shyness' since the colony had been subjected to trapping on several occasions before this study began. However, although some cats were more difficult to catch than others most of the cats present in the colony were successfully captured in 12 days including those that had escaped from traps during the trapping operation. It was also interesting that in spite of intensive trapping in certain areas of the hospital the resident cats from these areas were not dispersed.

Difficulties in trapping and handling feral cats have been reported. The Naval Undersea Center at San Diego, California sponsored a feral cat removal programme on San Clemente Island for three - and - a - half months in 1974 ( Anon.b ,1976). Researchers from San Diego University found that trapping efficiency diminished more rapidly than would have been expected due to the successive reduction in the population size alone. They attributed this to the developement of a 'shyness' towards the traps and also suspected that the trap size and baits used may have been inadequate. Trapped cats were to be transported to the University of California Medical School to test for background levels of various viral diseases. However, this transfer was abandoned 'due to the inability of the examiners to deal with the extreme ferocity of the animals'.

If a decline in trapping success with time is experienced by pest control operators attempting to eradicate feral cat colonies it is not surprising that few colonies are completely removed by trapping (except perhaps those that are very small) since the operation is unlikely to be cost - effective after the first few days. If trapping is abandoned before all the cats are captured it is possible that man's trapping efforts may have a selective influence on the colony, allowing the more wary animals to survive and reproduce thus making future trapping attempts more difficult.

It is likely that the trapping success achieved in cat colonies depends largely upon the expertise and persistence of the trappers, especially when manually operated traps are used. The success of the trapping operation at Winwick Hospital was undoubtedly due to two factors. First, more than 12 months of previous study of the colony identified the adult cats which were present in the colony (apart from immigrants) and determined their distribution and sheltering places. Second, the use of specially designed manual traps operated by experienced professional feral cat trappers.

It is difficult to see how complete trapping of a feral cat colony could be achieved in colonies where each individual animal has not been previously identified since the trappers could never be certain that they had captured all of the cats. The problem of identification in unfamiliar colonies makes it possible that pet cats could be accidentally captured. Jackson, M.(1981) normally distributes leaflets to local residents advising them to confine their pet cats when he is trapping but less prudent operators could take a considerable number of pets unintentionally. The number of 'unknown' adult cats captured at Winwick Hospital, particularly males, is indicative of the size of this problem.

The time of year when trapping is undertaken must affect the efficiency of a trapping operation. If it is undertaken when young kittens are present, as in this study, these kittens must be taken but are often difficult to find, especially when very young. During Winter young kittens will be rarer but adult cats will probably be more difficult to find in poor weather conditions (see Chapter 8).

The stress caused to the cats trapped at Winwick Hospital appeared to be negligible apart from during the time spent in the trap between capture and transfer to the cat basket. This was, however, of very limited duration. The damage sustained by the cats during trapping was slight and probably self-inflicted during attempts to escape from the traps. This could probably be reduced by decreasing the size of Jackson's manual traps so that the cat could not run at its sides. However, it seems likely that cats would be more reluctant to enter smaller traps and there would be greater danger of the animals being trapped in the door.

The automatic R.S.P.C.A. traps used in the trapping operation were small and difficult to use because the door-releasing mechanism tended to be inefficient. This trap is widely used to capture cats because it is readily available, but its small size, noisy operation and unreliability make it unsuitable. What is probably required is a large automatic trap which is tall, so that the cat can walk erect through the door instead of having to lower its head (c.f. R.S.P.C.A. trap), and deep so that the cat can be attracted to the back of the trap with bait before the door closes. Metal traps like that produced by the R.S.P.C.A. tend to be unreliable because they are easily twisted during use and transportation, rendering the door-operating mechanism useless. Several R.S.P.C.A. traps had to be repaired and modified while trapping at Winwick Hospital and some new R.S.P.C.A. traps were found to be so poorly constructed that they would not operate correctly. Cat traps would probably be better constructed with a frame of wood or some other non-malleable material, and the door-operating mechanism should be as simple as possible. Jackson's traps were large and well constructed, but unfortunately the manually-operated door required the continual presence of the trapper. If trapping is to be undertaken on a large scale for the purpose of neutering a new, efficient and easy-to-use trap is required which can be operated automatically and used by an inexperienced person.

The trapping methods used by Jackson & Booth Services Ltd., and Miss Celia Hammond are successful, and appear to be humane and cause little disturbance to the colony. Unfortunately, however, the need for special traps and the labour-intensive nature of manual trapping would make the neutering of feral cat colonies on a large scale extremely expensive.

# 13. PARASITES, DISEASE AND PHYSICAL DAMAGE.

## 13.1. INTRODUCTION

The incidence of disease within any animal population is difficult to investigate without capturing a large number of individuals so that they may be examined. Little information can be obtained by direct field observation unless the animals are approachable and the symptoms of disease are easy to recognise. Almost all of the feral cats at Winwick Hospital were captured for neutering and this opportunity was taken for the veterinary staff at the Liverpool Veterinary Hospital to examine the animals for symptoms of disease, parasites and physical damage.

Dards (1979) was able to obtain some information on disease and parasites from the colony in Portsmouth dockyard but since few corpses were found and cats were not captured no systematic attempt could be made to examine the population.

The nature and extent of disease within feral cat colonies is of interest for a number of reasons. It is biologically interesting because disease may contribute to mortality and thereby influence population dynamics. From a practical point of view public acceptance of and support for neutered colonies may depend on the demonstration that the cats are healthy and that they do not act as an important reservoir of disease which could be transmitted to the domestic cat population.

Concern has also been shown at the possibility that cats may transmit various diseases to man (Southam, 1981; Nicholson, 1981). If feral cats are to be accepted by our society it is important that they should not represent a health hazard to man or his domestic animals.

## 13.2. EXAMINATION FOR PARASITES, DISEASE AND PHYSICAL DAMAGE.

Each cat was examined under anaesthetic for the presence of parasites, signs of disease, bites and other physical damage by the veterinary staff. A record sheet (Fig. 13.1.), provided by Miss C. Hammond, was completed for each cat by a veterinary nurse. This recorded the animal's identification number, confirmation of its sex, a drawing of its coat colour pattern ( to confirm its identity), notes on its condition and, if female, whether it was pregnant or lactating (see Section 6.8.2.). This examination was superficial because of the time constraints imposed by the large number of cats involved. Parasites were recorded only if they could be seen on the cat's body. No faecal analysis was performed.

## 13.3. VIRAL DISEASES

### 13.3.1. The nature of viral disease in cats

There are five widely distributed viral diseases of domestic

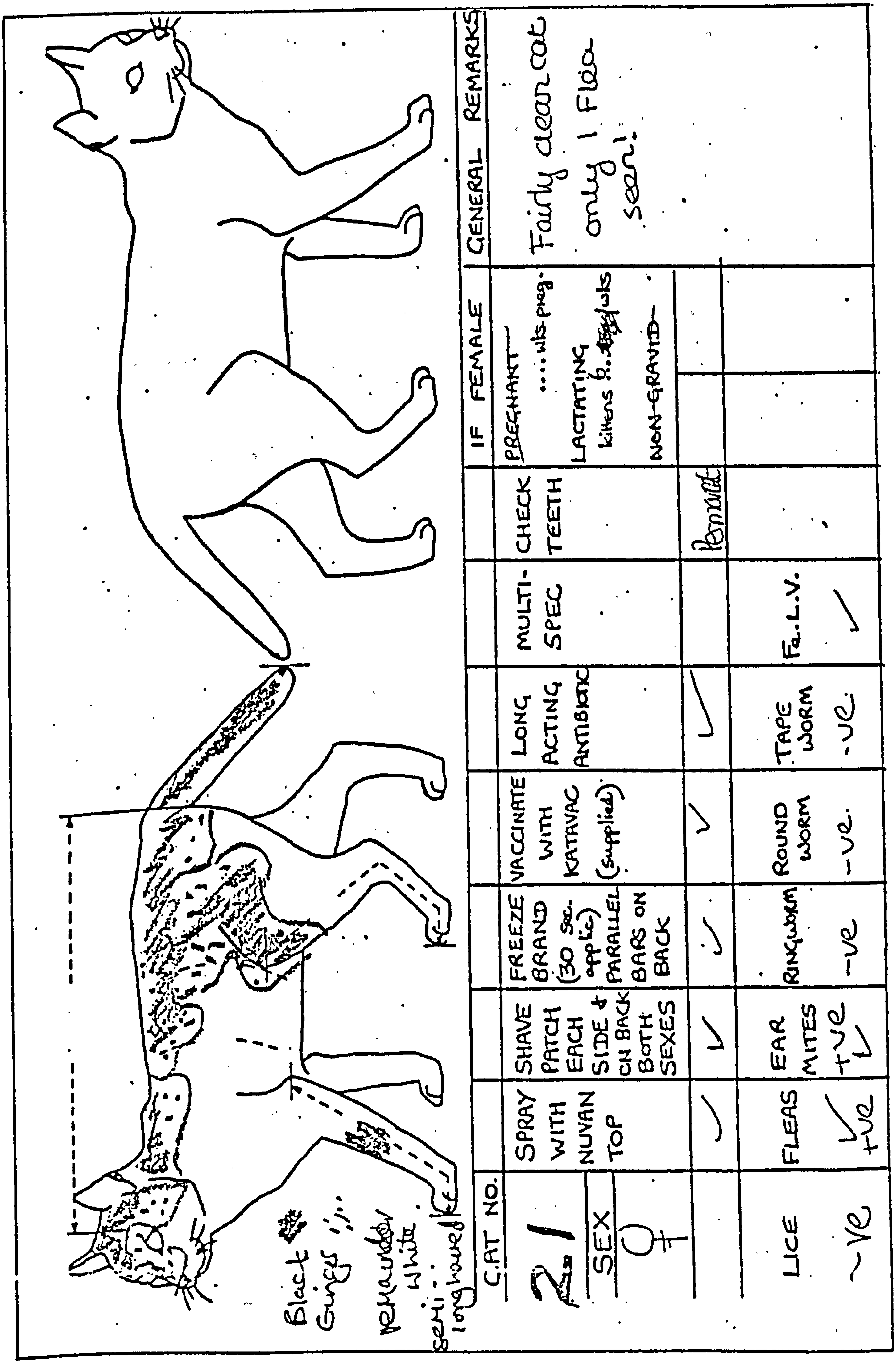



Fig. 13.1. Record sheet used for recording the results of the veterinary examination.

cats. Feline panleukopaenia virus causes panleukopaenia (infectious enteritis); feline herpesvirus (F.H.V.) and feline calicivirus (F.C.V.) are responsible for upper respiratory tract diseases; a virus causes feline infectious peritonitis, and feline leukaemia virus (Fe.L.V.) causes diseases of the haemopoetic system. Fe.L.V. is probably the most important infectious cause of fatal disease in cats. F.H.V. causes about 50% of all cat 'flu epidemics and the remainder are caused by F.C.V.

The immuno-suppressive system of mammals produces specific virus-neutralising antibodies in response to invasion by viruses. Once the disease has been defeated antigen (viral material) and antibody may remain in the blood. Antigen is removed from the body very quickly, but antibody may remain for many years conferring immunity to the disease (Guttman, 1971). If a particular animal is not susceptible to a disease it may become a carrier, harbouring the virus and producing antibodies, without exhibiting disease symptoms. Tests designed to detect antibody only cannot be used to distinguish between immune animals and carriers.

### 13.3.2. Examination for evidence of exposure to viral diseases

Blood samples were taken from the cats at the Liverpool Veterinary Hospital. Professor Oswald Jarrett, of the Department of Veterinary Pathology, University of Glasgow, examined these samples for the presence of virus-neutralising antibodies to Fe.L.V., F.C.V. and F.H.V. Additional tests were performed for Fe.L.V. virus and antigen. Tests for F.C.V. (virus) and F.H.V. (virus) could not be made because it is necessary to take throat swabs from the animals in order to isolate virus.

## 13.4. THE CONDITION OF 'KNOWN' CATS

### 13.4.1. Parasites

Fleas (probably Ctenocephalides felis (Bouché)) were observed on approximately 94% of the 'known' adult males and 87% of the 'known' adult females. Mites (Scarcoptes sp.) were observed on approximately 71% and 40% of 'known' adult males and females respectively. The cats were only examined superficially for ectoparasites so some of the individuals which appeared to be free of parasites may have had a low degree of infestation. Before examination at the veterinary hospital the cats had been kept in close proximity to each other and it is possible that some transmission of parasites, particularly fleas, could have occured while they were in captivity.

Tapeworm segments (probably Taenia sp.) were found in the coat of one 'known' adult male cat. As no faecal examinations were made the nature and abundance of endoparasites in the colony could not be determined.

### 13.4.2. Diseases and disorders

Teeth were missing, broken or both in approximately 53% of the 'known' adult males and 33% of the 'known' adult females. Poor quality food scraps, particularly bones, were available to the cats and may have contributed to the damage to their dentition. Dards

(1979) found evidence of bones in 91% of the faecal samples examined from cats in Portsmouth dockyard.

Gingivitis (inflammation of the gums) was observed in two 'known' adult females, probably caused by infection. Halitosis (bad breath) was reported from two 'known' adult male cats. While this may be a symptom of various diseases of the respiratory tract or the upper alimentary canal, some of them chronic, it may also be due to a minor infection or even the presence of decaying food in the mouth. Both animals appeared otherwise healthy though there was evidence of the presence of tapeworm in 69m.

Ocular discharge was observed in approximately 29% of 'known' adult males and 20% of 'known' adult females. One female, 10f. had a noticeable ocular discharge periodically throughout the study period but no other symptoms of disease were observed. One 'known' female had an eye ulcer and one 'known' adult of each sex showed nystagmus (involuntary eye movements) which may have been a symptom of nervous disease or due to a defect of vision.

Four 'known' adult male cats had respiratory disorders either coughing or congested lungs. Influenza was diagnosed in one 'known' adult male.

The coats of most of the 'known' cats were in good condition except for two which were patchy and one cat had miliary eczema.

One male, 27m, was thought to have had only one testicle when he was neutered. This testicle was removed at the veterinary hospital. When Miss Hammond revisited Winwick Hospital in March 1981 it was discovered that 27m still possessed a testicle and it appears that at the time of neutering only one testicle had descended.

Most of the 'known' cats were in good health but only one, a kitten (112m), had no parasites, disease or physical damage. No diseases or disorders were recorded in the cats which were born during the study, and were therefore no more than 16 months old, (49m, 68m, 21f, 38f, 43f, 62f, and 66f), or the captured kittens which were born in 1979 (100m, 101m and 112m). However, diseased kittens present during the trapping operation were destroyed and no definitive veterinary examination was made. The condition of each cat is shown in Table 13.1.

## 13.5. THE CONDITION OF 'UNKNOWN' CATS

All of the 'unknown' cats had fleas, one of each sex had mites, one male had lice (probably Order Mallophaga) and another male had a tick (Order Acarina). Apart from the presence of parasites and one case of influenza the nine 'unknown' adult cats had only a small number of minor conditions. This reflects the presence of one hospital ward cat in this group and supports the view expressed earlier (Chapter 6) that most of these animals did not belong to the colony and some may have been pets or strays.

Table 13.1.

Parasites and disorders present in the captured cats.

| | | Cat Number | Parasites/Disorders: Fleas | Mites | Lice | Tapeworm | Tick | Teeth missing/broken | Gingivitis | Halitosis | Ocular discharge | Eye ulcer | Nystagmus | Respiratory disorder | Influenza | Miliary eczema | Patchy coat | Testicle missing | Constipation | Bites/wounds/scars |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Known | Males | 27 | x | x | | | | | | | | | | | | | | x | | |
| | | 28 | x | | | | | x | | | x | | | | | | | | | |
| | | 29 | | | | | | x | | | | | | | | | | | | x |
| | | 34 | x | x | | | | x | | | | | | x | | | | | | |
| | | 39 | x | x | | | | | | | x | | | | x | | | | | x |
| | | 44 | x | x | | | | x | | | | | | | | | x | | | |
| | | 49 | x | x | | | | | | | | | | | | | | | | |
| | | 50 | x | | | | | | | | | | | x | | | | | | |
| | | 52 | x | x | | | | x | | | | | | | | | | | | x |
| | | 53 | x | x | | | | | | | | | | | | | x | | | x |
| | | 63 | x | x | | | | x | | | | | | | | | | | | x |
| | | 64 | x | | | | | x | | | x | | | x | | | | | | |
| | | 68 | x | x | | | | | | | | | | | | | | | | |
| | | 69 | x | x | | x | | x | | x | x | | | | | | | | | x |
| | | 88 | x | x | | | | | | | | | | | | | | | | |
| | | 97 | x | x | | | | x | | | | | x | | | | | | | x |
| | | 107 | x | | | | | | | x | x | | | | | | | | | |
| | Females | 9 | | | | | | x | | | | | | | | | | | | |
| | | 10 | x | | | | | | | | x | | | | | | | | | |
| | | 14 | x | | | | | | | | | | | | | | | | | |
| | | 17 | | | | | | x | | | x | | | x | | | | | | |
| | | 19 | x | x | | | | | x | | | | | | | | | | | |
| | | 21 | x | x | | | | | | | | | | | | | | | | |
| | | 32 | x | | | | | | | | x | | x | | | | | | | |
| | | 33 | x | x | | | | | | | | | | | | | | | | x |
| | | 38 | x | x | | | | | | | | | | | | | | | | |
| | | 43 | x | | | | | | | | | | | | | | | | | |
| | | 51 | x | x | | | | x | | | | | | | | | | | | |
| | | 54 | x | | | | | x | | | | | | | | x | | | | |
| | | 62 | x | | | | | | | | | | | | | | | | | |
| | | 66 | x | | | | | | | | | | | | | | | | | |
| | | 86 | x | x | | | | x | x | | | x | | | | | | | | |
| | Kittens | 100 | x | x | | | | | | | | | | | | | | | | |
| | | 101 | | x | | | | | | | | | | | | | | | | x |
| | | 112 | | | | | | | | | | | | | | | | | | |
| Unknown | Males | 98 | x | | | | | | | | | | | | | | | | | |
| | | 105 | x | | | | | | | | | | | | | | | | | |
| | | 106 | x | x | | | x | | | | | | | | | | | | | x |
| | | 113 | x | | x | | | | | | | | | | | | | | | |
| | | 115 | x | | | | | | | | | | | | | | | | | |
| | Females | 99 | x | x | | | | | | | | | | x | | | | | x | x |
| | | 109 | x | | | | | | | | | | | | | | | | | |
| | | 114 | x | | | | | x | | | | | | | | x | | | | |

## 13.6. EVIDENCE OF FIGHTING

Wounds, scars and bites (all assumed to be cat bites) were found on 41.2 % of the 'known' adult males but only on 6.7% of 'known' adult females. This difference between the sexes is statistically significant at the 10% level but not at the 5% level ($\chi^2 = 3.39$, with Yates' correction, d.f. = 1, P = 0.07) suggesting that fighting more frequently involves males than females ( Table 13.2).

Table 13.2.

The number of 'known'cats with and without bites when captured during the trapping operation.

| | Number of cats with | | |
|---|---|---|---|
| | Bites | No bites | Total |
| Males | 7 | 10 | 17 |
| Females | 1 | 14 | 15 |
| Total | 8 | 24 | 32 |

It is interesting that neither of the young males ( 49m and 68m) had bites and only one male kitten had been bitten. No fighting was observed at any time during the study.

Kristensen (1981) found that 66% of all male cats but no females had bite wounds in a neutering operation undertaken in Amager, near Copenhagen. Dards (1979) reported few fights from the feral cat population in Portsmouth dockyard and suggested that this was due to a hierarchy established among males though she found little evidence of this.

In a colony of one male and three related adult females Macdonald (1981) recorded only 14 instances of spontaneous aggression out of approximately 1200 interactions. The only serious aggressive interactions observed comprised attacks by the colony on a stray male. Tabor (1981) has reported similar behaviour from a colony in London. It may be that fighting occurs between colony members and interlopers rather than between cats in the same colony. Evidence from bite wounds alone cannot be used to confirm or refute this hypothesis, but on one occasion a male cat at Winwick hospital was observed chasing an unidentified male at the periphery of the study area, and it has been shown earlier that immigrant cats entered the colony during this study (see Chapter 6).

It has been suggested that neutering reduces and even eliminates fighting in feral cat colonies ( Hammond, 1981; Remfry, 1981). No quantitative evidence of this has been provided, and since few fights have been observed in scientific studies of entire colonies it is difficult to see how a reduction in fighting could be detected. Unfortunately it was not possible to examine the cats in this study for bites after neutering since it was impractical to trap them a second time and bites could not often be seen by direct observation in the field.

## 13.7. CHANGES IN PHYSICAL CONDITION AFTER NEUTERING

Remfry (1981) has reported that cats became fatter and sleeker after neutering from the results obtained from a questionnaire survey of persons involved in feral cat control schemes. These features of a cat's physical appearance are difficult to quantify and assessments made by persons who support neutering as a control measure may not be objective. The physical appearance of the cats at Winwick Hospital was observed before and after neutering and only one cat, 28m, changed noticeably after neutering. When entire he was a long-haired adult male. After neutering he appeared to increase in weight so that his body looked disproportionately large and his legs disproportionately short. The extent to which this change in appearance was due to an increase in weight could not be determined since the cats were not weighed before and after neutering.

## 13.8. EVIDENCE OF EXPOSURE OF THE COLONY TO VIRAL DISEASES

Blood samples were tested for 34 adult cats from the colony, (Table 13.3). These animals represent 85% of all the adults captured and 87.5% of the 'known' adults captured.

Table 13.3.

Cats from which blood samples were taken and the antibodies present.

Each sample was tested for the presence of antibodies to feline leukaemia virus (Fe.L.V.), feline calicivirus (F.C.V.) and feline herpesvirus (F.H.V.).

| | | Cat Number | Sample Taken | Antibody FeLV | Antibody FCV | Antibody FHV |
|---|---|---|---|---|---|---|
| Known | Males | 27 | x | - | + | + |
| | | 28 | x | - | + | + |
| | | 29 | ? | | | |
| | | 34 | x | - | + | + |
| | | 39 | x | - | + | + |
| | | 44 | x | - | + | + |
| | | 49 | x | - | + | + |
| | | 50 | ? | | | |
| | | 52 | * | | | |
| | | 53 | x | - | + | + |
| | | 63 | x | - | + | + |
| | | 64 | x | - | + | + |
| | | 68 | x | - | + | + |
| | | 69 | x | - | + | + |
| | | 88 | x | - | + | + |
| | | 97 | x | - | + | + |
| | | 107 | x | - | + | + |
| | Females | 9 | x | - | + | + |
| | | 10 | x | - | + | + |
| | | 14 | x | - | + | + |
| | | 17 | ? | | | |
| | | 19 | x | - | + | + |
| | | 21 | x | - | + | + |
| | | 32 | x | - | + | + |
| | | 33 | x | - | + | - |
| | | 38 | x | - | + | - |
| | | 43 | x | - | + | + |
| | | 51 | x | - | + | + |
| | | 54 | x | - | + | + |
| | | 62 | x | - | + | + |
| | | 66 | x | - | + | + |
| | | 86 | x | - | + | + |
| | Kittens | 100 | 0 | | | |
| | | 101 | ? | | | |
| | | 112 | ? | | | |
| Unknown | Males | 98 | x | - | + | - |
| | | 105 | x | - | + | + |
| | | 106 | x | - | + | + |
| | | 113 | x | - | + | + |
| | | 115 | 0 | | | |
| | Females | 99 | ? | | | |
| | | 109 | x | - | + | - |
| | | 114 | x | - | + | + |

x Sample taken and tested
* Sample taken but not tested
? No record of sample being taken
0 Sample not taken
\+ Antibody present
\- Antibody absent

At the time the blood examples were examined no antibodies were detected for Fe.L.V. However, in two of the samples Fe.L.V. antigen, but not virus, was found. These results are incompatible. From the absence of antibody it appears that the colony had not been exposed to Fe.L.V. However, the presence of two cats with antigen make it likely that these two had been in contact with Fe.L.V. , but they were not carriers since no infectious virus could be detected. Further tests would be necessary to clarify the status of the colony regarding Fe.L.V. but unfortunately it was not possible to perform these tests.

All of the cats tested had been exposed to F .C.V. All except four had also been exposed to F.H.V. but only two of these were members of the colony, (33f, and 38f) and they were both from group F. Without conducting further tests it is not possible to determine whether the animals whose blood contained antibodies to F.C.V. and F.H.V. were carriers of the diseases caused by these viruses or whether they were immune.

## 13.9. DISCUSSION

Apart from occasional reports of badly diseased or injured cats ( Dards, 1979) most of the adult cats living in the feral cat colonies which have been studied appear to have been in good condition ( Dards, 1979; Remfry, 1981) and reports from persons who regularly work with feral cats tend to confirm this ( Jackson, M., 1981). However, since dead adults are rarely found it is difficult to assess the importance of disease in adult mortality. Only nine out of a total of 135 adult cats which disappeared from the Portsmouth dockyard population were known to have died due to disease ( Dards, 1979 ). A further 26 cats appeared to have been ill prior to disappearance. Dards considered disease as a cause of death to be well represented in her analysis of the fate of adult cats which were lost from her population because the diseases from which adults suffer tend to be more protracted than those which kill kittens, and the symptoms are more obvious. Dards concluded that the major cause of death in Portsmouth dockyard was disease in kittens and accidents in older cats. Remfry ( 1981) reports that 78% of 192 feral cats from 38 different sites in Greater London were considered to be in good condition. Twenty per cent were classified as 'poor', suffering from fight injuries, respiratory disease, wasting diseases or ringworm.

Domestic cats are known to support a wide variety of parasites ( Noble & Noble, 1973 ). Ectoparasites are commonly reported in feral cats since they are relatively easy to detect. Sixty-two per cent of the feral cats examined by Kristensen ( 1981) from a colony near Copenhagen were infected with lice or fleas and some had eczema caused by parasites. A high incidence of fleas was reported from colonies surveyed in this study but whether they were observed or assumed is not known ( see Chapter 3 ).

Jarrett (pers. comm.) considered that the results of his tests for exposure of the Winwick hospital colony to F.C.V., F.H.V. and Fe.L.V. were what would be expected from what is known about the epidemiology of each virus, but thought it surprising that none of the cats had antibodies to Fe.L.V.. All of the colony had been exposed to F.C.V. and almost all to F.H.V.. This is not surprising since the social nature of the animals and nomadic behaviour of many of the males make it unlikely that any individuals will escape exposure once a viral disease has entered the colony. Periodic movements of immigrants into the colony may be responsible for colony members contracting diseases, and emigrant cats may spread diseases to other colonies or the domestic cat population. Since F.C.V. and F.H.V. are both common in the domestic cat population the rôle of the colony as a reservoir of these diseases is of little importance.

F.H.V. occurs in young kittens and fatalities result from dehydration, secondary bacterial infection and bronchopneumonia. The carrier state in F.H.V. is characterised by a latent phase with intermittent episodes of virus shedding either spontaneously or as a result of stress ( Gaskell & Wardley, 1978). Virus shedding may be triggered off by a female in oestrus, a sudden drop in temperature, travelling (in a vehicle) and it can also be induced experimentally by the administration of gluco-corticoids, ( Jackson, O.F., pers comm.) which are important in modifying the metabolism in times of mental and physical stress ( Green, 1978).

F.H.V. is the cause of about half of all cat 'flu epidemics ( Jackson, O.F., pers. comm.) the remainder being caused by F.C.V., which is typically milder in its effects. F.C.V. carriers tend to excrete the virus almost continually and 80% of recovered cats remain as carriers.

It is interesting to consider the possibility of the existence of a mechanism of population regulation in which social interactions such as those discussed in Chapter 11 determine the level of stress in the population which in turn regulates the transmission of viral diseases. When the population is dense social interactions occur with high frequency and may cause stress. Stressed carriers excrete virus and infected kittens die. When the population density is low the virus is not excreted. Disease in general becomes more common in animal populations as they increase in density, particularly in individuals weakened by malnutrition ( Curry - Lindahl, 1974).

Fe.L.V. was not present in the colony and it seems likely that the animals will remain free of the disease since it could only be introduced by an immigrant cat and its incidence in the domestic population is low ( Jackson, O.F., pers. comm.). This virus is a cause of chronic and fatal disease in cats. It is transmitted in the saliva and is therefore found more commonly where several cats are living together, for example on breeders premises, than in single cat households ( Francis et al 1977). The disease attacks the haemopoetic system. If a cat excreting

Fe.L.V. comes into contact with a susceptible cat for a short time only, the susceptible cat will usually receive a dose of virus sufficient to produce immunity to further Fe. L.V. infection. However, if exposure is longer susceptible cats become infected: about 60% develop immunity while the remaining 40% will develop a persistent infection ( Jarrett, pers. comm.). If Fe.L.V. was introduced into a feral cat colony there would be regular deaths in both the kittens around 3 - 6 months of age and the adult cats ( Jackson, O.F., pers. comm.). Due to the serious nature of this disease any demonstration of its high incidence in feral cat colonies would probably greatly reduce their acceptability among pet cat owners.

The occurence of viral diseases in other feral cat colonies has not been widely studied. Dards (1979) observed a high incidence of 'cat 'flu' in the cats in Portsmouth dockyard, particularly in kittens, but the virus responsible was not identified. The first two litters of kittens born to the small colony studied by Macdonald & Apps (1978) all died of 'cat 'flu'. Feline panleucopaenia ( feline infectious enteritis) was diagnosed in some of the kittens removed from Portsmouth dockyard. This is a lethal disease but 30% of any population may be immune to it ( Henderson & Coffey, 1973) and only immune animals survive to adulthood. Dards considered it likely that panleucopaenia accounted for a large proportion of kitten deaths in the dockyard. The symptoms of panleucopaenia are, however, difficult to detect by observation and its presence was not identified in the Winwick Hospital colony.

Cat diseases transmissible to man include cat-scratch fever, ringworm, salmonellosis and toxoplasmosis. There is however, little evidence that feral cats are an important source of infection for man and of course any disease or parasite that can be carried by a feral cat can also be carried by a domestic cat. Since man is more likely to come into contact with domestic cats than feral cats it is possible that domestic animals represent the greater health hazard.

Little appears to be known about cat-scratch fever. There are no reliable figures for the incidence of infection and the causative organism has not been isolated ( Southam, 1981). The disease appears to be transmitted by cat scratches so only persons who habitually handle or trap cats are likely to be at risk.

Ringworm, or tinea, is a fungal infection of keratinised structures, such as hair, nails and skin, caused by *Microsporum* sp. or *Trichophyton* sp.( Carpenter, 1972). This disease is only likely to be contracted from cats by persons who handle them.

Salmonellosis in man results from eating food contaminated with *Salmonella* sp.. It is possible that the disease could be transmitted in cat faeces. However, it is unlikely that any outbreak of salmonellosis could be traced to this source and there are other more likely means of contamination, for example human carriers working with food ( Williams & Shaw, 1976).

Recent evidence suggests that _Toxoplasma gondii_ Nicolle & Manceaux ( Protozoa) is an intestinal coccidian of cats and oocysts have been identified in cat faeces (Frenkel _et al_, 1970). _T. gondii_ is one of the most common parasites of man and other vertebrates ( Noble & Noble, 1973), infecting some 30 - 50% of the human race, but disease occurs much less frequently than infection. Toxoplasmosis is most common in warm moist areas but is probably cosmopolitan in distribution. _Toxoplasma_ can invade many types of cells and tissues including cardiac and skeletal muscle, cells of kidney tubules and neurones producing chronic disease and, in rare cases, death. Southam (1981) has pointed out the possible importance of cats in the transmission of _T. gondii_ to patients in hospitals supporting cat colonies. In spite of initial concern, however, the hazard to human health from _T. gondii_ is now thought to be much lower than first suspected ( Anon.b, 1979).

The presence of _Toxocara_ sp. has been reported in feral cats. Three out of five faecal samples which were taken from cats in Portsmouth dockyard and examined for parasites contained the eggs of _Toxocara_ and _post mortem_ examination of two cats revealed roundworms in the stomachs which were probably _Toxocara_ ( Dards, 1981). These intestinal roundworms are transmitted in the faeces and their larvae are capable of living in a wide variety of abnormal hosts including man, frequently in children. Their normal hosts are cats, dogs and related carnivores. Reported cases of Toxocara in man are rare in Britain ( five in 1977, ten in 1978) but one case reported in 1980 is thought to have been contracted from a pet cat ( Southam, 1981).

Probably the most important parasite that can be passed from cats to man, in terms of the number of incidents reported, is the cat flea ( Ctenocephalides felis). This has been a particular problem in hospitals ( Southam, 1981) resulting in the closing of operating theatres and hospital laundries. The health hazard from fleas is not serious but infestation is unpleasant and the treatment of infested premises is expensive.

Viruses are normally only able to infect closely related species. However, Fe.L.V. has recently been propagated in human cell cultures and monkeys inoculated perinatally have developed leukaemia ( Anon.b, 1979). Currently there appears to be no substansive evidence that Fe.L.V. infects man. There is however one virus which can be carried by cats and which can also infect man : rabies.

Although rabies is not endemic in Britain feral cats could play an important rôle in the transmission of the disease if it is ever introduced. In view of the presence of feral cat colonies at ports of entry into the country, including harbours and dockyards ( see Chapter 3 and Dards, 1979) it is possible that illegally or accidentally imported cats could quickly come into contact with other cats. Macdonald ( 1980) has suggested that if British cats become infected with rabies there could be a serious risk of transmission to foxes ( Vulpes vulpes L.). Cats occasionally feature in the diet of foxes ( Baronovskya & Kolosov, 1935) and recent reports of foxes in suburban areas ( Harris, 1977; Macdonald, 1980) make it possible that encounters between foxes and cats are quite common. The Ministry of Agriculture, Fisheries & Food ( M.A.F.F. ) has acknowledged that 'cats would feature prominently in a rabies outbreak' ( Nicholson, 1981 ) but no contingency plans appear to have been made to deal specifically with feral cat colonies. However, M.A.F.F. biologists have recently completed a survey of feral cats in urban and suburban areas in Bristol and intend to begin radio-tracking feral cats in the docks at Avonmouth ( Page, R.J.C. pers. comm.).

The feral cats at Winwick Hospital were not re-examined after release so the effect of neutering and the veterinary treatment they received on their subsequent health could not be determined, although they appeared from observation to be in good health. The adult mortality rate appeared to decrease in year 2 of the study but since the reasons for many of the adult loss were not known ( see Chapter 6 ) it is not possible to know whether or not neutering and veterinary treatment reduced mortality. A more detailed veterinary study of feral cat colonies, including post mortem examinations, would help to determine the importance of disease in population regulation. If treated and neutered cats were re-examined the effect of these procedures could be determined.

Possible changes in the degree of fighting in the colony could also be monitered before and after neutering if the cats were captured on several occasions.

The evidence presented here suggests that the health of feral cats is generally good and that they do not constitute a serious health hazard to man or other cats. However, the potential importance of feral cats as carriers of rabies should be recognised in view of their wide distribution, abundance and association with man.

# PART V

# DISCUSSION AND CONCLUSIONS

# 14. MANAGEMENT OF FERAL CAT POPULATIONS

## 14.1. BASIC STRATEGIES

A variety of methods have been used or suggested for the management of feral cats. Three basic strategies have been adopted : the reduction of numbers or complete eradication, natural control, and the artificial maintenance of relatively small colonies.

Attempts have been made at the complete eradication of feral cat colonies generally with little success, except with very small groups. Dards (1979) has suggested that the Portsmouth dockyard population did not need to be managed because it regulated its size naturally. This may be true of some other populations. The management of small feral cat colonies is widely practised and neutering is currently popular among many animal welfare organisations. Each of the specific methods used to manage feral cats has advantages and disadvantages. In order to assess the usefulness of each method these must be considered. Most of the methods discussed below have been used to manage feral cats living in urban areas.

## 14.2. REDUCTION AND COMPLETE ERADICATION

Probably the most widely used method of attempting to reduce or completely eradicate a feral cat population is that of trapping and then destroying the animals. This method has been used for many years by the R.S.P.C.A. and various organisations involved in pest control. Cats are usually captured in automatic traps and then destroyed by injection of barbiturates or other drugs, or by the use of toxic gas. A mixture of carbon dioxide and oxygen is commonly used but chloroform has been extensively used in the past. Although chloroform is inexpensive and easy to use it is now considered to be hazardous to the operator and inhumane.

Trapping and destruction of feral cats is humane if carried out by properly trained personnel. It can be effective if well - organised, especially when the number of cats involved is small. However, in practice, trapping cats is usually difficult. Automatic cat traps are ineffective and prone to interferences by cat - lovers. Manually operated traps are more useful but require the presence of trappers for long periods of time (see Chapter 12). The use of automatic traps is therefore largely ineffective for large populations while the employment of manual traps is expensive in terms of time and labour.

The total eradication of large feral cat colonies appears to be rare, even if this was the original intention. Most of the colonies investigated by this study (Chapter 3) had been subjected to removal operations (usually trapping) at some time but were, nevertheless, still in existence. In order to completely eradicate an entire population a trapping operation must be well - organised and continued long after it ceases to be cost - effective. This is unlikely to be achieved if a commercial pest control organisation is employed. In order to assess the success of a trapping operation the precise number of cats present in the population must be known at the outset. Unless the colony is very small or someone who knows all of the cats is available, the number cannot generally be determined. It is therefore impossible to know whether or not any cats remain to be captured at the end of the trapping operation. The result of incomplete eradication is that the population is temporarily reduced and the site usually becomes repopulated within a short time due to births and possibly immigrants. The problem of trapping cats is made more difficult because those that remain after any trapping operation are likely to be the more wary animals and this characteristic may be inherited by their offspring (see Section 12.9).

Some feral cat colonies appear to be controlled by periodic trapping, sometimes on an annual basis. Often trapping begins when cat numbers increase, usually due to births. In many cases trapping is prompted by outbreaks of fleas (especially in hospitals) or some other incident related to the presence of cats, for example the discovery of dead cats under buildings or in heating ducts. These periodic removals may have very little effect on population size, especially if only sick or young animals are removed. Often only a token effort is made to remove cats in order to appease complainants.

Shooting, presumably with rifles, has been used to reduce feral cat colonies. This was reported from five hospitals and a Royal Naval establishment located by the survey of feral cat colonies. (Methods of management were not examined in detail by the survey). Shooting by crossbow has been reported by Hammond (1981), who considered this weapon unsuitable.

Shooting by marksmen with high - powered rifles is considered to be a humane method of killing cats (Remfry, 1981) and is likely to be very efficient since, in theory, once a cat is located it can be killed quickly and easily. In the event of a rabies outbreak in Britain shooting feral cats is likely to be the most effective method of reducing populations.

The shooting of cats is unlikely to be acceptable as a means of reducing feral cat colonies except in an emergency. The general public would undoubtedly find this method unpleasant and possibly dangerous since most colonies are associated with human activities (see Chapter 3) and precautions would have to be taken to exclude people from areas where marksmen were operating.. This would be difficult on premises such as hospitals and large factory complexes. An additional problem is that injured cats are likely to escape to inaccessible places and suffer unpleasant deaths.

Poisons have been used to kill feral cats, usually left in food and spread around the premises concerned. Poison is easy to use, relatively inexpensive and requires little time or man - power. It can be placed in areas which are inaccessible for other purposes such as setting traps or shooting. However, poisons are indiscriminate in their action and non - target organisms may take poisoned bait. During the trapping operation at Winwick Hospital a psychiatric patient 'stole' a piece of chicken which was to be used as bait for a trap. Patients in psychiatric hospitals often scavenge food from waste bins and it is possible that they could take poisoned bait if it was left in an accessible place. Other animals, including pets, could also take such bait by accident.

It is difficult to administer the correct dose of poison to a cat if the poison is obtained from food. Alphachloralose, a humane stupefying substance, appears to have been used by some unscrupulous pest control organisations. Normally cats are not killed by this substance because it is difficult to give a lethal dose, but in cold conditions they may die from hypothermia under the narcosis induced by the drug (Remfry, 1981). If inappropriate poisons or insufficient doses are given cats could die inhumanely. It is normally illegal to poison cats in England and Wales but in the event of a rabies outbreak the Ministry of Agriculture, Fisheries and Food, has plans and powers for the local short - term eradication of wild and stray animals which include the use of poisons.

Dogs (a breed of terrier) appear to have been used to clear heating ducts of cats in the Royal Naval establishment referred to above which employed shooting as a control measure. It is uncertain whether they were used simply to chase cats out into the open where they could be shot, or used to kill cats by attacking them. This practice must be considered to be inhumane and could be extremely dangerous if used with rabid cats. However, it has the advantage that cats may be cleared from inaccessible areas.

A virus has recently been used in an attempt to reduce a feral cat population inhabiting an island. Feline panleucopaenia (feline infectious enteritis) was sprayed on a population of several thousand cats on Marion Island in the south Indian Ocean. Control was considered necessary because the cats were having a destructive influence on the island's avifauna, particularly burrowing petrels (Procellariidae) (van Aarde, 1977). The use of a viral disease to control an animal population has the advantage that it is self - perpetuating once introduced and it should be able to deal effectively with large populations. However, the use of disease to control mammals is generally considered inhumane.

The introduction of panleucopaenia on Marion Island has been condemned by animal welfare organisations such as the R.S.P.C.A. and the International Society for the Protection of Animals. Panleucopaenia causes unpleasant symptoms. Pathological changes occur in the small intestine and the production of white blood cells is depressed thereby increasing susceptibility to secondary infection. Death may take up to 14 days after infection. Furthermore it is unlikely that infection would be 100% effective and now that the disease has been introduced it would be almost impossible to eradicate (Anon. , 1977).

The only indigenous mammals present on the island appear to be four species of seals which the virus does not affect as is the case for the indigenous bird species ( Anon., 1977). However, it is ecologically irresponsible to introduce any type of organism into an environment where it has not previously been present without first examining the possible consequences of such action. Viruses have a complex ecology which is often incompletely understood. Pimentel (1961) has described genetic changes which have occurred in the myxomatosis virus and the rabbits which it was introduced to control in Australia. The virus evolved attenuated strains while the rabbits became more resistant. This resulted in the establishment of a smaller rabbit population. When myxomatosis was introduced into England in 1953 it almost completely eliminated the rabbits in infected areas. However, since 1956 many more rabbits appear to have been recovering from the disease. This appears to be due to genetic changes similar to those that occurred in Australia (Fitter & Fitter, 1967).

The use of viruses of any kind to control feral cats in areas inhabited by domestic cats or other susceptible mammals (Felidae, Procyonidae and Viverridae are susceptible to feline panleucopaenia) would be irresponsible even if the disease was endemic. Once introduced it would probably be uncontrollable and unpredictable.

The problems associated with the long - term eradication of feral cats have been discussed by Remfry (1981). It is usually difficult to capture or kill all of the cats in any colony unless it is very small. Consequently the population will recover over a period of time. If complete eradication is achieved cats may re - colonise the habitat if the environment is still favourable. This phenomenon has been observed or assumed to occur in a number of colonies (for example, Remfry, 1981; Tabor, 1981; Young, 1981). During the course of this study visits were made to a number of premises formerly inhabited by cats where successful proofing of buildings and securing of waste food, following eradication, appeared to have made the environment unsuitable for future re - colonisation. However, where the premises are large and complex this may be almost impossible to achieve. In addition, it is usually difficult to persuade cat - lovers to stop providing food. Such persons frequently interfere with removal operations by, for example, springing or destroying traps and sheltering cats.

## 14.3. NATURAL CONTROL

Many animal populations appear to be in equilibrium with the environment resulting in a population size which either remains quite constant with time or exhibits some form of stable oscillation in numbers (see Section 6.11.). A reduction in the size of such a population would probably result in an eventual return to the original level of abundance provided that a viable population remained and the carrying capacity of the environment was unchanged. Reduction of some animal populations has little long - term effect on population size since the culled animals are surplus individuals, old or young animals, and culled individuals may be replaced by immigrants. In harvested populations a reduction in population size may cause a decrease in adult mortality and increased fecundity of surviving adults (e.g. Nicholson, 1954).

It is possible that some feral cat populations, (especially those which are large and long - established) are in equilibrium with their environments, and left unmanaged population size would not change unless the environment became more or less favourable due, for example, to a change in the availability of food or cover.

In 1975 a long - term programme of culling the feral cat population of Portsmouth dockyard ended. Culling appears to have had little effect on the population since it did not increase in size when culling ceased. Dards (1979) observed that between 1976 and 1978 the number of adult cats in the dockyard remained stable and may even have been in decline in the long - term, probably due to unfavourable changes in the environment as a result of the redevelopment of old sites. Dards concluded that management of the population appeared to be unnecessary in view of its stability and the possibility that its size is regulated by social behaviour. She suggested that social factors may have been responsible for the negative correlation found between pregnancies per female and group size possibly brought about by the inhibition of conception or stimulation of early intra - uterine mortality in large groups.

If a social mechanism of population regulation exists in feral cats the methods of population control discussed in Section 14.2. are clearly of limited value once the carrying capacity has been reached. However, it is the seasonal production of kittens which is of concern to many people and a self - regulating population will still reproduce. To the layman the production of kittens is synonymous with population growth and their appearance often leads to demands that the population should be reduced. Periodic culling probably satisfies the complainants that some action is being taken to control the cats even if it has no long - term effect on population size.

By considering feral cats to be wild animals and allowing them to regulate their numbers by natural means the problem of control is solved. Unfortunately, in many cases it is likely that the carrying capacity of the habitat will be high, supporting more cats than will be willingly tolerated by man.

## 14.4. ARTIFICIAL MAINTENANCE OF SMALL COLONIES

Some feral cat colonies are managed by persons who assume responsibility for regularly culling the animals. Such a colony exists at Menwith Hill U. S. Station near Harrogate in North Yorkshire. This is a military installation occupied by American and British personnel. The installation contains accomodation, in the form of houses and blocks of flats, which is used by some of the American personnel. In addition the station contains support buildings such as warehouses, workshops, garages, a school, a club - house and a cinema. The site as a whole is surrounded by agricultural land and is self - contained.

The resident staff are allowed to keep pets and in the past cats have been abandoned when families have returned to the United States. This has resulted in the gradual build up of a feral cat population. The keeping of pet cats is now strictly controlled and each individual animal is registered by the authorities. The size of the feral cat population is closely monitored by two British employees who work in the grounds of the station and provide food for the animals at their own expense. The American authorities have agreed to allow a colony of approximately 25 cats to live on the station provided that it does not increase in size and the animals are confined to a relatively small area of the grounds.

The cats live in four social groups and make extensive use of the underground heating system which runs between the buildings on the station. They are fed at the same time and in the same places each day to discourage them from wandering to other parts of the station . All of the cats are entire and breed freely. Sick cats are removed for veterinary treatment if possible. Young kittens are removed for homing if healthy or destruction if severely diseased. Some kittens are allowed to remain in the colony to replace natural losses of adults. Adult cats are rarely removed.

The culling system used to manage the feral cat population at Menwith Hill appears to work well and is humane. The colony was visited regularly throughout this study over a period of two years and the population of adult cats remained stable in size. However, many dead kittens were found in the colony, often underground, and it is possible that those kittens which were artificially removed would have died if they had remained in the population.

Culling of the population requires a considerable investment of time especially when kittens need to be located and captured. Feeding of the animals is expensive and it is possible that its reduction would cause a decrease in natality and increased mortality, removing the need for culling. However, the interest shown by a small number of people in the cats at Menwith Hill appears to have guaranteed a safe future for a colony which was previously subjected to removals and harassment. Recently permanent shelters have been constructed for the cats and the authorities have provided money to pay for food and milk. Even if the removal of kittens has no effect on population size it has satisfied the authorities that the cats are being controlled.

Attempts have been made to manage feral cat colonies by the chemical or surgical prevention of reproduction. These methods are popular with animal welfare organisations because they are considered humane and they prevent the production of large numbers of kittens which would otherwise die in unpleasant circumstances.

Remfry (1978) has conducted field trials with a synthetic progestagen administered orally in the form of a pill wrapped in minced meat. Fourteen cats living in a disused hospital were dosed with megestrol acetate (Ovarid; Glaxo) once each week for a period of ten months. Both sexes were given the drug but only the females were examined in detail. Only one of the seven females received her dose each week, while another female was successfully dosed on only six out of 22 attempts. Reproduction was successfully prevented in five of the females while the other two successfully reproduced after dosage had stopped. Remfry found some evidence that sporadic dosing caused pyometra (pus in the uterus) and three of the females which were trapped and examined nine to 23 days after the final dose showed some reproductive activity. Endometrial hyperplasia (excessive formation of lining tissue in the uterus) was recorded in one cat.

Remfry (1978) has discussed the success of other trials using progestagens to control oestrus in the cat, including the apparently successful long - term administration of medroxyprogesterone acetate (Perlutex; Leo Laboratories) in Denmark. Out of a total of 504 female feral cats registered for dosage in 1976 - 7 only 20 were thought to have become pregnant. Normal litters were produced by 14 of these cats, five aborted and one died during parturition. Six cats died or were destroyed because of mammary tumours, pyometra, cystic ovaries or accident. The use of progestagens for the control of oestrus in the cat has been reviewed by Evans and Jemmett (1978).

The use of contraceptive pills could be an efficient method of controlling feral cat populations without the need for subjecting the animals to trapping and handling. It has also been reported that regular dosage with progestagens makes cats more docile (Remfry, 1978). However, the use of these drugs requires a long - term investment of time on the part of feeders and it is clearly difficult to ensure that each cat receives its dose. In addition the administration of progestagens over long periods produces side effects which may occur with greater frequency if dosage is intermittent (Remfry, 1978). Kristensen (1981) has noted that female house cats treated with the pill develop a tendency to obesity, aggressiveness (c.f. Remfry, 1978), endometrial hyperplasia, inflammation of the uterus, mammary gland tumours and difficulties in giving birth.

It has been suggested that effective control of feral cat populations could be achieved by vasectomising dominant males (Kendall, 1979 ). Mature female cats are polyoestrous and ovulate spontaneously. Mating with a vasectomised dominant male would end oestrus in a female without producing pregnancy. Castration of males eliminates the sexual aggressiveness caused by androgens and leaves females to breed freely with less dominant entire males. It has, therefore, been suggested that it would be necessary to castrate many more males to match the effect of vasectomising only the dominant cats and preserving the sexual hierarchy.

The existence of a sexual hierarchy among male feral cats does not appear to have been established. Dards (1979) observed up to six male cats in attendance on a single female in Portsmouth dockyard but no fighting was observed between the attendant males. Dards could not determine whether more than one male mated with any female but thought it likely that multiple matings occurred when a group of males was present. Dards (1979) found no direct evidence of a dominance hierarchy among the males in the population but thought it was likely that such a hierarchy existed. No evidence for a hierarchy was found in the feral cats at Winwick Hospital. In his artificial communities of cats Leyhausen (1979) observed that a male's 'rank' was not a decisive factor in determining which animals mated with the females. However, he has observed fighting between 'free - ranging' males in the presence of oestrus females.

Even if a sexual hierarchy is established in a population the vasectomising of only dominant males is unlikely to be an effective method of population control since as long as entire females are present it is likely that they will eventually mate with the entire males. Leyhausen (1979) observed that tenacious males successfully mated with females even when these females normally preferred to mate with one particular (different) male. Apart from the fact that it would probably not successfully prevent reproduction if some cats were not treated, vasectomising males does not reduce libido or spraying of urine and would therefore not reduce the nuisance caused by the animals.

Neutering is probably the method which is most frequently used by animal welfare organisations in Great Britain to manage feral cat colonies. Usually attempts are made to trap all of the animals, preferably with the help of persons who know the cats well. If the population is considered to be too large some of the animals are permanently removed. Kittens are homed or destroyed if necessary. The remaining adult cats are neutered, given veterinary treatment, and then returned to the site (see Chapter 12).

A neutered colony can only be successfully established on a site where its presence is acceptable to the human occupants, and where adequate food and shelter are available. Monitoring of the colony is important to detect the immigration of entire animals, to deal with outbreaks of disease and to safeguard the general welfare of the animals. At some sites these functions are performed by 'committees' of interested cat - lovers. The establishment of neutered feral cat colonies at a variety of sites in Britain has been discussed by Hammond (1981), Remfry (1981) and Young (1981).

In Denmark, Kattens Vaern (the Society for the Protection of the Cat ) has carried out a number of experiments involving the reintroduction of neutered feral cats. In Copenhagen problems with feral cats have been dealt with on a large scale using a combination of killing by injection, the controlled distribution of contraceptive pills and the returning to site of neutered cats (Kristensen, 1981). The methods used to establish neutered colonies are basically the same as those used in Britain. However, Kattens Vaern has made great progress in the identification of cats, subsidising veterinary fees, and producing educational leaflets designed to explain its system to the public.

Captured cats are examined and those which are healthy enough to be operated upon and reintroduced are selected. The remainder is destroyed. The residents' preferences regarding reintroduction of specific cats are considered, but for economic reasons males are preferred. Following surgery the cats are treated for worms, vaccinated against cat distemper and influenza, given long - acting antibiotics and vitamins. Finally, the cat has an identification code tattooed into its ear. Kattens Vaern has developed a code system for identifying house cats which consists of the telephone area code of the veterinary surgeon, the last digit of the year, the code letter of the vet and the individual number of the cat. Some 20,000 cats have been marked in this way in Denmark (Kristensen, 1981). In addition the tip of one ear is cut off to indicate that the cat has been neutered. Approximately 500 cats had been marked in this way by 1981.

Domestic cats which have been tattooed may be insured by their owners through Kattens Vaern against ill health and accident provided that they are regularly vaccinated against influenza. Kattens Vaern has negotiated a reduced fee with the Danish Veterinarians' Association for neutering and ear - marking feral cats as part of an approved reintroduction scheme. This combined approach to cat control, involving the neutering and identification of both domestic and feral cats, together with the production of educational materials and the provision of financial assistance towards the cost of neutering feral cats appears to have met with considerable success.

Advocates of neutering have suggested a number of advantages to be gained from the use of this method of control (Hammond, 1981; Kristensen, 1981). The cost of neutering is high but probably less than that of regularly employing a pest control firm to remove cats. The method appears to be humane and generally acceptable to the public. The activity of trappers and the neutering of the cats may even increase interest in the animals.

It has been suggested that the occupation of a site by a neutered colony will prevent the immigration of other cats (Hammond, 1981; Kristensen, 1981; Remfry, 1981) whereas removal of cats could increase the possibility of immigration. Evidence from the study at Winwick Hospital appears to support this view (Chapter 6.). Trapping clearly allows the veterinary examination and treatment of the cats and it has been suggested that neutering tends to make cats more docile (Kristensen, 1981). However, Remfry (1981) has noted that regular feeding and familiarity are also significant in reducing the cat's fear of man.

Unfortunately, some of the advantages suggested for neutering as a control method are of dubious benefit to the animals. Kristensen (1981) has stated that after neutering cats 'will lead more protected lives, free from the hardships of a normal sexual life' . Such comments may be indicative of a less than objective approach to the problem of feral cat control but do not necessarily detract from the usefulness of neutering.

There are a number of problems associated with the use of neutering to control feral cat colonies (Section 6.11). A completely neutered colony, from which entire immigrants are excluded by man, will eventually become extinct. If the colony is to be allowed to die out there is little difference, in the long - term, between trapping the cats and returning them neutered, and trapping them for destruction. However, the complete removal of cats is often unacceptable and, at least in some situations, neutering appears to be a solution to the problem of control. It is often difficult to capture all of the cats in a colony (Chapter 12). Remfry (1981) has suggested that if a constant number of cats is wanted one female should be left unneutered. She has noted that this is usually what happens anyway because most colonies contain several cats which cannot be caught.

If some cats are permanently removed from the colony during a neutering operation it is possible that an abnormal social structure could result, for example in terms of age structure or sex ratio. The possible effects of this are difficult to predict, but would presumably be relatively unimportant in a population which is not reproducing.

In spite of these problems the great interest shown by animal welfare organisations in the use of neutering appears to be justified by its apparent acceptability and success.

## 14.5. A STRATEGY FOR MANAGEMENT

It is not possible to make a quantitative comparison of the relative usefulness of the various control methods discussed above. There is no way of knowing the precise effect that the use of any particular method has had upon the feral cat population of any area since this would require a detailed scientific study. However, it is clear that some methods appear to be more acceptable and more effective than others.

A combined approach similar to that used in Denmark is likely to be the most effective solution to the problem of managing cat populations. Education of the public in responsible pet ownership is undoubtedly important if the recruitment of domestic cats into the feral population is to be reduced. Cat owners should be encouraged to have their cats neutered, although data presented here for a domestic cat population (Chapter 4) indicates that a high proportion is already neutered. Reducing the cost of surgery might encourage the remaining owners to have their cats neutered, except those kept for breeding. The F.C.W.P. has suggested that a law should be passed requiring that all entire cats should be licensed and identified by an ear tattoo (Jackson, O.F., 1981).

Feral cat colonies located at suitable sites could be managed by neutering as far as possible, while contraceptive pills could be used to prevent reproduction in those females which cannot be captured. Obviously, these methods would only be effective at monitored sites. Inhumane and ineffective control methods will probably continue to be used where feral cats are unwanted, but it seems likely that the practise of reintroducing neutered cats to suitable sites will become an increasingly popular method of management in Britain. However, its use is likely to be limited by economics and the availability of suitable sites.

# 15. GENERAL DISCUSSION

Feral cat colonies appear to be common in Great Britain. They are concentrated in the major urban areas and are associated with the presence of housing. Many colonies live in the grounds of hospitals and large industrial premises where cat - lovers and persons who consider cats to be pests differ greatly in their attitudes towards the animals. It would be interesting to study the distribution of feral cats in rural areas as few colonies from such areas were located by this study.

Although domestic cats must be responsible for the establishment of many new cat colonies most domestic cats appear to be neutered. Education of the public and a reduction in veterinary fees could result in the neutering of an even higher proportion of the domestic population. However, established feral cat colonies may also be important in the formation of new colonies due to dispersal, and if the feral population as a whole is to be reduced steps need to be taken to control individual colonies.

Neutering appears to be an effective method of managing a feral cat colony. However, in examining the results of the study presented here two important points must be considered. First, it is not possible to be absolutely certain that the changes in the ecology, behaviour and social organisation in the second year of the study were due to neutering. In some cases changes in the environment may also have been important. Second, the effect of neutering on the cats in Winwick Hospital is not necessarily representative of the changes that occur in all neutered colonies. Many more colonies would need to be studied in order to make generalisations regarding the effects of neutering. In addition studies of caged animals would be useful to examine the effect of neutering on the behavioural interactions between cats in detail.

Before the colony was neutered there appeared to be a seasonal fluctuation in the number of cats present as a result of kitten production, mortality and migration. After neutering the population size remain relatively constant and only one (female) immigrant was recorded. The mortality rate of adults also appeared to be lower in the neutered colony. It is possible that more immigrants would be observed entering a neutered colony located within an urban area with a high density of colonies. Unfortunately, it was only possible to study the Winwick Hospital colony for a single year before and after neutering. It would have been more useful to examine the population for several years before neutering in order to firmly establish the nature of the dynamics of the population. Eventually all of the neutered cats will die and it would be interesting to monitor changes in the colony for many years after neutering.

Changes occurred in the home ranges of some of the cats after neutering. In particular, the range of some males decreased.

The reason for this was unclear since some males showed no change in home range. Changes in the environment, (in the location of feeding sites) may have been important. It would be interesting to examine the effect of neutering on home range in more detail using the methods employed by Dards (1979) to measure areas. It would also be interesting to establish whether or not feral cats hold territories and the effect of neutering on any territorial system that may exist.

The probability of sighting many of the cats increased after neutering. This may have been because the animals became more approachable after neutering or it may have been due to the fact that in year 1 of the study many of the cats were infrequently recorded during the severe winter.

It is interesting that the cluster analysis was able to distinguish between males and females in year 1 on the basis of differences in their home range, temporal distribution of sightings and sociability. Nomadic cats and residents could also be distinguished. After neutering all of the cats appeared to be more similar to each other with respect to the ecological and behavioural characteristics studied. Males and females could not be distinguished and this may have been due to changes in the hormone balance of the cats as a result of neutering.

Before neutering the colony was divided into four social groups containing males and females, with some nomadic males wandering between the groups. After neutering the social groups were more discrete and little change was recorded in the composition of these groups. Few movements of animals between groups were observed and males appeared to be more tolerant of the presence of other males. It would be interesting to examine the long - term stability of the social groups.

The effects of neutering described above are likely to make the presence of feral cats more acceptable to man. Neutering appears to stabilise overall population size and the structure of the social groups. In addition the animals are more localised in their distribution after neutering.

The trapping of feral cats is time - consuming, even when undertaken by a professional trapper, and it is likely to be difficult to capture all of the cats especially in large colonies. The use of traps appears to be a humane method of capturing feral cats and relatively few cats sustained injuries. The development of more efficient automatic traps than those currently available would probably reduce the amount of time required to catch cats.

Trapping did not result in dispersal of the cats in the colony either during the trapping operation or after the release of the cats. Cats were not driven away from the areas they normally inhabited by the presence of trappers and cats which escaped from traps were recaptured with relative ease.

The health of the feral cats at Winwick Hospital was relatively good when they were captured and appeared to remain good after neutering. It would have been useful to confirm this by veterinary examination at the end of the second year of the study. The acceptability of feral cats living on premises occupied by man is likely to be affected by the health of the animals. Neutering may be important in this respect because a reduction in movements of cats between the social groups is likely to reduce the possibility of the transmission of disease.

From a biological point of view there may be no need to manage feral cat colonies. Dards (1979) suggested that the cat population in Portsmouth dockyard regulated its size naturally, possibly as a result of social behaviour. This may also be true of other colonies. The availability of food and shelter, and the effect of disease may all play a part in population regulation. It is possible that there is a relationship between the spatial dynamics of populations and population regulation (Begon & Mortimer, 1981). Spatial distribution and density may be 'co - regulated' by a density - dependent tendency of individuals to migrate away from areas of high density and a density - dependent tendency to migrate towards areas of high environmental quality (Taylor & Taylor, 1977). It is likely that an understanding of population regulation will ultimately depend upon the consideration of the distribution of animals as well as their abundance. Social organisation and behaviour may also be important factors.

If some form of management of feral cat colonies is considered to be necessary neutering appears to be the most acceptable. It is expensive, but appears to have no deleterious effect on the animals and is infinitely preferable to extermination.

## SUMMARY

1. Colonies of feral cats (<u>Felis catus</u> L.) have been known to exist in urban and industrial locations in Great Britain for many years. They are welcomed by cat - lovers but in many situations they are considered to be pests. The aim of this study was: to investigate the distribution, abundance and habitat preferences of feral cats in Great Britain; to examine the potential of the domestic cat population in contributing to the feral population; and to examine the effect of neutering on the ecology, behaviour and social organisation of a feral cat colony and its effectiveness as a means of population management. In addition, since the cats had to be trapped in order to neuter them, the effect of trapping on the animals was recorded and they were examined by veterinary surgeons for signs of disease and physical damage.

2. Feral cat colonies were located and examined using a postal questionnaire survey. Information was provided by a number of organisations involved in the welfare or control of feral cats. A total of 704 colonies were reported and questionnaires were returned from 287 (40.8% ). Hospitals, industrial sites and residential properties were the most common habitat types utilised, but hospitals may have been over - represented as they were investigated in detail. About 75% of colonies were associated with housing and this may be indicative of their origin. Most colonies were small (45% had 1 - 10 cats), thought to have

existed for more than five years, and were often subjected to removals. Man actively provided food for many colonies and food was also obtained from waste bins. Over 80% of colonies were considered to cause a problem and 46% were thought to be of possible benefit. Neutering had been considered as a control measure for about one quarter of the colonies but had been used in less than 10% .

3. A total of 686 colonies were precisely located and concentrations were found around major centres of high human population density. Approximately 12,300 feral cats were located by the survey and the total feral and 'unwanted' cat population of Great Britain was estimated to be around one million. Historical evidence suggests that the feral population is not of recent origin and there is no evidence of a recent increase in numbers.

4. The domestic cat population of an urban area (South Stockport) was examined by distributing a questionnaire to 1020 households. They owned a total of 464 cats : one cat for every 9.5 people. About one third of the households had at least one cat. Most households which possessed cats had only one. There was a significantly higher proportion of females (56.5% ) than males (43.5 % ) and more females (83.6% ) than males (70.8% ) were neutered. Neutered cats comprised 78% of the total population. The domestic cat population of Britain was estimated to be 5.9 million, including 0.8 million unneutered males and 0.5 million

unneutered females. It is suggested that neutering these females would be a biologically and economically useful strategy to adopt to reduce recruitment into the feral cat population.

5. Twenty - two feral cat colonies were visited and the colony at Winwick Hospital, Warrington, Cheshire was selected for further study. This is a large psychiatric unit situated in its own extensive grounds in a rural area and is considered to be typical of the habitats utilised by cats. It consists of a complex of buildings linked by corridors, under which runs a system of underground heating ducts and subways. The cats had access to all parts of the hospital and there was no effective boundary to immigration or emigration. This study was conducted around the main buildings in an area of about 17 ha.

6. Initially the colony was visited a number of times to identify the cats present. The colony was then visited 64 times between July 1978 and June 1979 (Year 1) and 64 times between July 1979 and June 1980 (Year 2). The adult cats were captured, neutered and returned to the site in July 1979. The ecology, behaviour and social organisation of the cats were studied in both years and the colony was used as its own control to examine the effects of neutering.

7. Cats were identified primarily by differences in coat colour and pattern and each was assigned an identification number.

Cats under six months old were considered to be kittens. The study area was divided into 56 zones (57 in year 2) each of approximately 0.2 ha. The zones were examined for the presence of cats in the same sequence on each visit. Recordings were made of the time of each observation, the zone, cats present and any interesting behaviour (e.g. aggression, suckling kittens). Around 30 adult cats were present in the colony at any one time, with males and females present in approximately equal numbers. Nine adult males and ten adult females were selected for detailed study of the effect of neutering as they were the most frequently seen. Three males were used as 'controls' : two could not be captured and were therefore entire throughout the study, the third male was already neutered before the study began.

8. Before the colony was neutered there appeared to be a seasonal fluctuation in the number of cats present in the population as a result of natality, mortality and migration. Male immigrants were observed when females were in oestrus. After neutering the population size remained relatively constant and only one (female) immigrant was recorded. She was the only individual observed to produce kittens in year 2. The mortality rate of adult cats appeared to be lower in the colony after the cats were neutered. Ultimately a neutered colony must eventually become extinct unless immigration occurs. When captured for neutering almost all adult female cats were pregnant or had kittens. Some had young kittens and were also pregnant. The reproductive potential of an

unneutered colony is clearly very high but most kittens appear to die, probably due to disease.

9. The ecology and behaviour of the 19 study cats were examined in terms of the home range of each cat (the zones utilised), the probability of sighting and the dispersion of these sightings in time (throughout the year), and the sociability of each cat (the extent to which it was seen with other cats). Single linkage cluster analysis was used to examine the ecological and behavioural affinities between cats in terms of these characteristics before and after neutering. Before neutering male ranges tended to be larger than those of females. Changes occurred in the home ranges of some of the cats after neutering. In particular, the range of some males decreased. The reason for this was unclear and in some cases may have been due to changes in the environment. The probability of sighting many of the cats of both sexes increased after neutering, possibly because the animals became more approachable. There was a slight increase in sociability after neutering and the index of dispersion of sightings in time decreased, suggesting less temporal clumping of sightings. The cluster analysis distinguished between males and females before neutering on the basis of differences in their home range, temporal distribution of sightings and sociability. Nomadic cats and residents could also be distinguished. After neutering all of the cats appeared to be more similar to each other with respect to the characteristics

studied. Males and females could not be distinguished and this may have been due to changes in the hormone balance of the cats as a result of neutering.

10. A mathematical basis for the study of associations between pairs of cats in a population has been developed, using network analysis. It has been shown that there is a relationship between population size (p) the number of groups into which a population is divided (g) and the number of associations of pairs of cats observed within the population ($A_{pop}$). $A_{pop}$ is a maximum ($A_{max}$) when the population exists as one large group with each individual associating with all of the others. $A_{pop}$ is greatly reduced if the population is divided into a number of small exclusive groups of equal size. It is suggested that natural selection may tend to cause group sizes to remain small and equal due to changes in natality, mortality and the migration of individuals between groups and this will reduce the number of individuals with which any animal must interact. If the number of associations observed within a population ($A_{obs}$) is expressed as a percentage of $A_{max}$ (this percentage has been called m) a measure of the degree of grouping is obtained. Low values of m suggests that a population is divided into a small number of equal sized discrete groups. High values of m suggest that individuals within a population all tend to associate with each other. Using these methods it has been shown that neutering tends to result in the formation of more discrete social groups. Before neutering the

colony was divided into four social groups containing related males and females, with some nomadic males wandering between the groups. After neutering the groups were more clearly distinguishable and little change was recorded in their composition. Few movements of animals between groups were observed and males appeared to be more tolerant of the presence of other males.

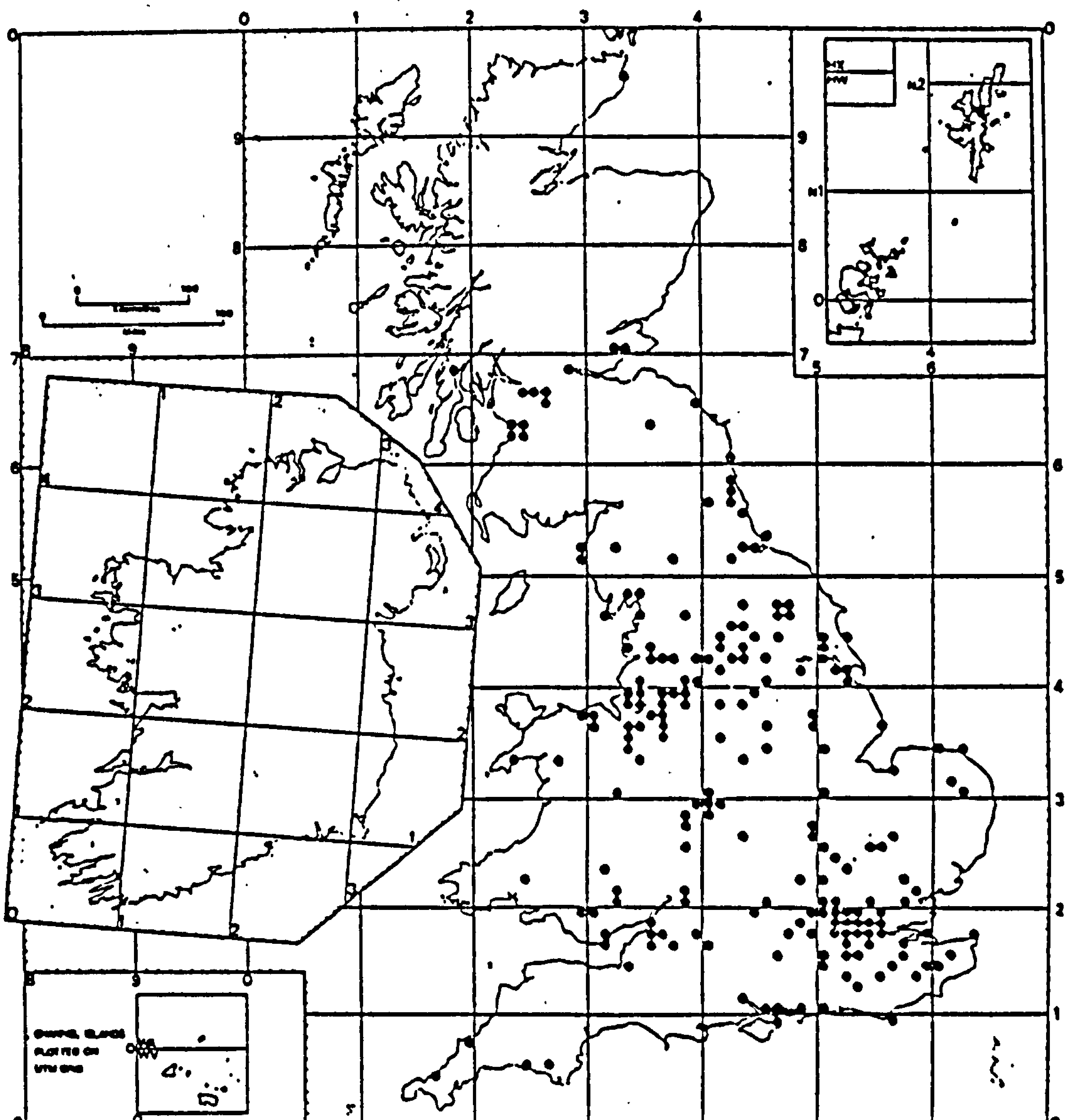
11. During a 12 day trapping operation 66 cats were captured alive (23 males, 18 females and 25 kittens) including six adult males and three adult females, which had not previously been recorded. Most of these 'unknown' cats were considered to be immigrants. About 75% of all the 'known' cats were captured after three days. Two adult males, one adult female and two kittens could not be captured. Trapping appeared to be a humane method of capturing cats. Some males sustained minor damage as a result of striking the head on the sides of the traps. Cats which escaped from traps were easily recaptured. Most cats were captured in the areas where they normally lived and trapping did not cause a dispersal of cats either during or after the trapping operation.

12. The physical condition of the cats was generally good when captured. Almost all of them had fleas and mites, and damage to teeth was also common. Significantly more males than females had cat bites, but no fighting was observed. The blood of the

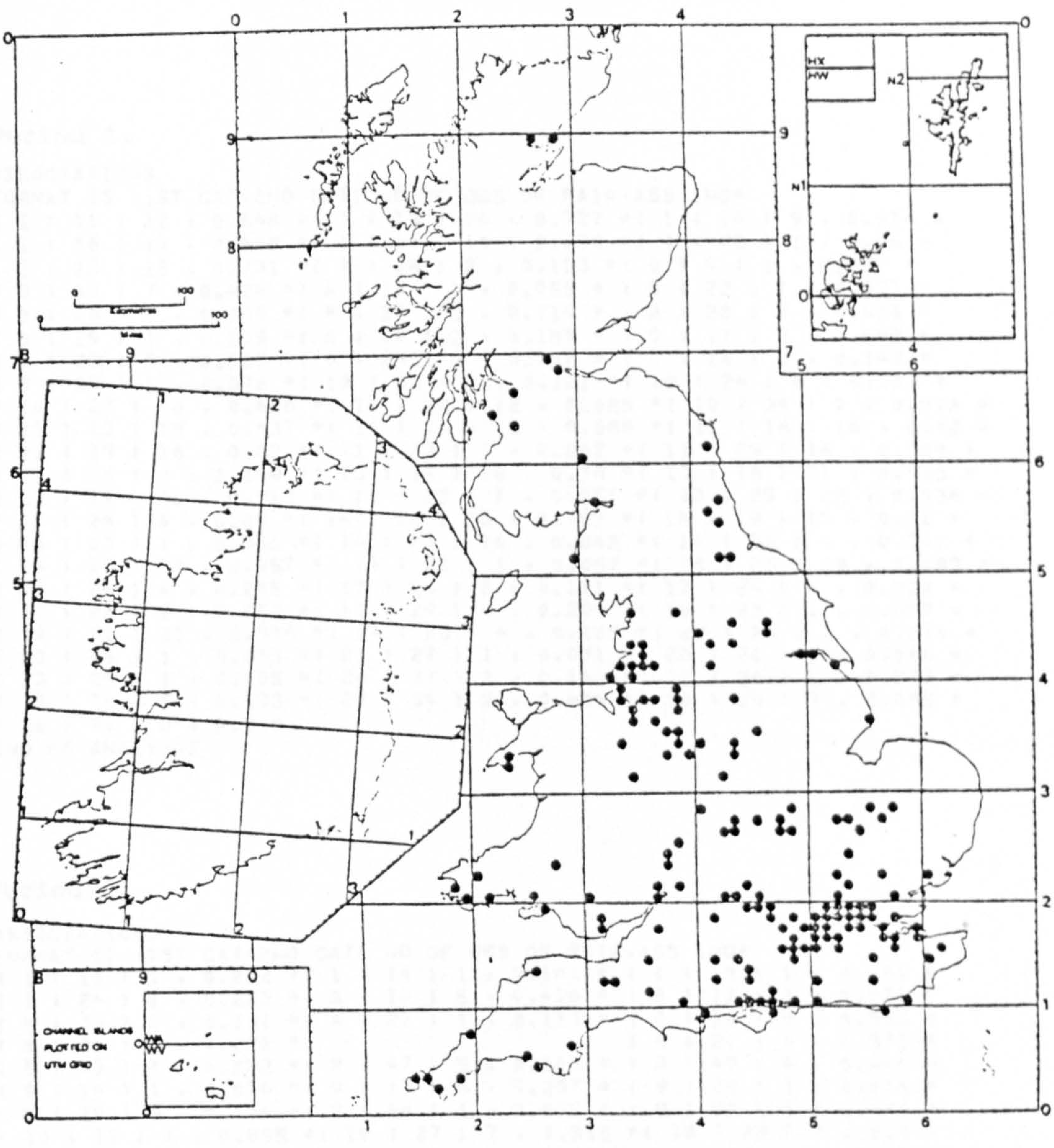
cats was examined for exposure to feline herpesvirus (F.H.V.), feline calicivirus (F.C.V.) and feline leukaemia virus (Fe. L.V.). No antibodies were detected for Fe. L.V., all of the cats tested had been exposed to F.C.V. and most had been exposed to F.H.V. Feral cats were not considered to be a serious health hazard to the domestic cat population or man except in the case of a rabies outbreak.

13. Compared with other methods of control (such as poisoning, shooting, or trapping for destruction) neutering appears to be an acceptable and humane method of managing feral cat colonies. It also appears to be effective although it must be emphasised that it cannot be a long - term solution as eventually all of the neutered cats must die and may be replaced by entire immigrants. It is likely that neutering of feral cat colonies will become more common in Great Britain and other western countries due to its popularity with animal welfare organisations.

## MAPS OF CONFIRMED AND UNCONFIRMED FERAL CAT COLONIES



Distribution of 'confirmed' feral cat colonies in 10km squares of the National Grid.



Distribution of 'unconfirmed' feral cat colonies in 10km squares of the National Grid.

## ASSOCIATIONS BETWEEN PAIRS OF CATS RECORDED IN EACH THREE-MONTH PERIOD OF THE STUDY

### Period 1.

```
ASSOCIATIONS
FORMAT IS (1ST CAT:2ND CAT) NO OF OBS OF PAIR,ASS IND*
( 1 : 11 ) 12 , 0.648 *( 1 : 13 ) 16 , 0.727 *( 1 : 14 ) 9 , 0.514 *
( 1 : 16 ) 14 , 0.699 *( 1 : 19 ) 14 , 0.699 *( 1 : 23 ) 1 , 0.06 *
( 1 : 25 ) 15 , 0.731 *( 1 : 26 ) 2 , 0.153 *( 8 : 9 ) 1 , 0.057 *
( 8 : 10 ) 7 , 0.424 *( 8 : 17 ) 1 , 0.055 * ( 8 : 23 ) 1 , 0.071 *
( 8 : 26 ) 1 , 0.095 *( 8 : 27 ) 3 , 0.214 * ( 8 : 28 ) 7 , 0.466 *
( 8 : 29 ) 1 , 0.105 *( 8 : 34 ) 2 , 0.181 * ( 9 : 17 ) 2 , 0.093 *
( 9 : 23 ) 5 , 0.285 *( 9 : 24 ) 6 , 0.342 * ( 9 : 26 ) 2 , 0.142 *
( 9 : 29 ) 1 , 0.076 *( 10 : 23 ) 2 , 0.121 *( 10 : 24 ) 2 , 0.121 *
( 10 : 27 ) 10 , 0.606 *( 10 : 28 ) 12 , 0.685 *( 10 : 34 ) 7 , 0.518 *
( 11 : 13 ) 18 , 0.837 *( 11 : 14 ) 10 , 0.588 *( 11 : 16 ) 16 , 0.82 *
( 11 : 19 ) 16 , 0.82 *( 11 : 23 ) 1 , 0.062 *( 11 : 25 ) 16 , 0.799 *
( 11 : 26 ) 2 , 0.159 *( 13 : 14 ) 16 , 0.78 *( 13 : 16 ) 21 , 0.913 *
( 13 : 19 ) 21 , 0.913 *( 13 : 23 ) 1 , 0.051 *( 13 : 25 ) 22 , 0.936 *
( 13 : 26 ) 4 , 0.25 *( 14 : 16 ) 13 , 0.702 *( 14 : 19 ) 15 , 0.81 *
( 14 : 23 ) 1 , 0.066 *( 14 : 25 ) 16 , 0.842 *( 14 : 26 ) 4 , 0.347 *
( 16 : 19 ) 18 , 0.857 *( 16 : 23 ) 1 , 0.057 *( 16 : 25 ) 19 , 0.883 *
( 16 : 26 ) 4 , 0.285 *( 17 : 23 ) 2 , 0.111 *( 17 : 24 ) 4 , 0.222 *
( 17 : 28 ) 1 , 0.052 *( 17 : 29 ) 4 , 0.296 *( 19 : 23 ) 1 , 0.057 *
( 19 : 25 ) 21 , 0.976 *( 19 : 26 ) 4 , 0.285 *( 23 : 24 ) 3 , 0.214 *
( 23 : 25 ) 1 , 0.055 *( 23 : 27 ) 1 , 0.071 *( 23 : 28 ) 1 , 0.066 *
( 23 : 29 ) 1 , 0.105 *( 24 : 27 ) 2 , 0.142 *( 25 : 26 ) 4 , 0.275 *
( 27 : 28 ) 8 , 0.533 *( 27 : 34 ) 5 , 0.454 *( 28 : 29 ) 1 , 0.095 *
( 28 : 34 ) 6 , 0.5 *
END OF ANALYSIS
```

### Period 2.

```
ASSOCIATIONS
FORMAT IS (1ST CAT:2ND CAT) NO OF OBS OF PAIR,ASS IND*
( 1 : 11 ) 1 , 0.222 *( 1 : 14 ) 1 , 0.181 * ( 1 : 19 ) 1 , 0.181 *
( 1 : 24 ) 1 , 0.222 *( 8 : 10 ) 5 , 0.416 * ( 8 : 17 ) 1 , 0.076 *
( 8 : 23 ) 1 , 0.181 *( 8 : 27 ) 1 , 0.117 * ( 8 : 28 ) 5 , 0.555 *
( 8 : 34 ) 1 , 0.222 *                        ( 8 : 21 ) 4 , 0.571 *
( 8 : 43 ) 1 , 0.222 *( 8 : 47 ) 5 , 0.666 * ( 8 : 49 ) 4 , 0.444 *
( 9 : 14 ) 1 , 0.074 *( 9 : 17 ) 6 , 0.307 * ( 9 : 28 ) 1 , 0.064 *
( 9 : 29 ) 3 , 0.176 *( 9 : 44 ) 1 , 0.079 * ( 9 : 52 ) 1 , 0.086 *
( 10 : 17 ) 1 , 0.055 *( 10 : 27 ) 7 , 0.518 *( 10 : 28 ) 7 , 0.5 *
                       *( 10 : 21 ) 3 , 0.25 *( 10 : 47 ) 6 , 0.479 *
( 10 : 49 ) 5 , 0.357 *( 11 : 13 ) 1 , 0.333 *( 11 : 14 ) 3 , 0.5 *
( 11 : 16 ) 1 , 0.333 *( 11 : 19 ) 3 , 0.5 * ( 11 : 24 ) 2 , 0.399 *
( 13 : 19 ) 1 , 0.25 *( 14 : 16 ) 1 , 0.25 * ( 14 : 19 ) 3 , 0.428 *
( 14 : 24 ) 1 , 0.166 *( 14 : 44 ) 1 , 0.166 *( 14 : 52 ) 1 , 0.199 *
( 16 : 19 ) 1 , 0.25 *( 17 : 27 ) 3 , 0.206 *( 17 : 28 ) 2 , 0.133 *
( 17 : 29 ) 11 , 0.666 *( 17 : 47 ) 1 , 0.074 *( 17 : 49 ) 1 , 0.066 *
( 19 : 23 ) 1 , 0.181 *( 19 : 24 ) 1 , 0.166 *( 19 : 44 ) 1 , 0.166 *
( 19 : 52 ) 1 , 0.199 *( 23 : 24 ) 1 , 0.222 *( 23 : 28 ) 1 , 0.133 *
( 23 : 34 ) 1 , 0.333 *( 23 : 21 ) 1 , 0.181 *( 23 : 43 ) 1 , 0.333 *
( 23 : 47 ) 2 , 0.333 *( 23 : 49 ) 1 , 0.133 *( 24 : 47 ) 1 , 0.153 *
( 27 : 28 ) 4 , 0.38 *( 27 : 29 ) 3 , 0.25 * ( 27 : 21 ) 2 , 0.235 *
( 27 : 47 ) 2 , 0.222 *( 27 : 49 ) 2 , 0.19 *( 28 : 34 ) 1 , 0.153 *
                       *( 28 : 21 ) 3 , 0.333 *( 28 : 43 ) 1 , 0.153 *
( 28 : 47 ) 4 , 0.421 *( 28 : 49 ) 4 , 0.363 *( 29 : 44 ) 2 , 0.21 *
( 34 : 21 ) 1 , 0.222 *( 34 : 43 ) 1 , 0.5 * ( 34 : 47 ) 1 , 0.199 *
( 34 : 49 ) 1 , 0.153 *( 44 : 52 ) 3 , 0.75 *
                        ( 21 : 43 ) 2 , 0.444 *( 21 : 47 ) 3 , 0.399 *
( 21 : 49 ) 6 , 0.666 *( 43 : 47 ) 1 , 0.199 *( 43 : 49 ) 2 , 0.307 *
( 47 : 49 ) 3 , 0.315 *
END OF ANALYSIS
```

## Period 3.

```
ASSOCIATIONS
FORMAT IS (1ST CAT:2ND CAT) NO OF OBS OF PAIR,ASS IND*
( 9 : 14 ) 5 , 0.312 *( 9 : 19 ) 12 , 0.489 *( 9 : 23 ) 4 , 0.258 *
( 9 : 34 ) 2 , 0.105 *( 9 : 44 ) 1 , 0.047 * ( 9 : 53 ) 4 , 0.181 *
( 10 : 27 ) 7 , 0.399 *( 10 : 28 ) 7 , 0.466 *( 10 : 29 ) 5 , 0.322 *
( 10 : 34 ) 3 , 0.181 *( 10 : 44 ) 5 , 0.27 *( 10 : 53 ) 6 , 0.307 *
( 10 : 60 ) 4 , 0.296 *( 10 : 64 ) 4 , 0.319 *( 10 : 21 ) 8 , 0.399 *
( 10 : 43 ) 7 , 0.437 *( 10 : 49 ) 15 , 0.555 *( 10 : 62 ) 6 , 0.387 *
( 14 : 19 ) 5 , 0.303 *( 14 : 23 ) 4 , 0.533 *( 14 : 34 ) 2 , 0.181 *
( 14 : 44 ) 2 , 0.153 *( 14 : 53 ) 2 , 0.142 *( 19 : 23 ) 4 , 0.25 *
( 19 : 34 ) 3 , 0.153 *( 19 : 44 ) 4 , 0.186 *( 19 : 52 ) 1 , 0.062 *
( 19 : 53 ) 7 , 0.311 *( 23 : 34 ) 1 , 0.095 *( 23 : 44 ) 2 , 0.159 *
( 23 : 53 ) 1 , 0.074 *( 27 : 28 ) 4 , 0.296 *( 27 : 29 ) 4 , 0.285 *
( 27 : 44 ) 3 , 0.176 *( 27 : 53 ) 3 , 0.166 *( 27 : 60 ) 2 , 0.166 *
( 27 : 64 ) 2 , 0.181 *( 27 : 21 ) 6 , 0.324 *( 27 : 43 ) 3 , 0.206 *
( 27 : 47 ) 2 , 0.222 *( 27 : 49 ) 10 , 0.392 *( 27 : 62 ) 4 , 0.285 *
( 28 : 29 ) 4 , 0.347 *( 28 : 34 ) 2 , 0.159 *( 28 : 44 ) 6 , 0.413 *
( 28 : 53 ) 5 , 0.322 *( 28 : 60 ) 5 , 0.526 *( 28 : 64 ) 4 , 0.47 *
( 28 : 67 ) 1 , 0.166 *( 28 : 21 ) 9 , 0.562 *( 28 : 43 ) 7 , 0.583 *
( 28 : 47 ) 1 , 0.153 *( 28 : 49 ) 7 , 0.304 *( 28 : 62 ) 5 , 0.434 *
( 29 : 34 ) 2 , 0.153 *( 29 : 44 ) 2 , 0.133 *( 29 : 53 ) 5 , 0.312 *
( 29 : 60 ) 2 , 0.199 *( 29 : 64 ) 3 , 0.333 *( 29 : 21 ) 5 , 0.303 *
( 29 : 43 ) 4 , 0.319 *( 29 : 47 ) 1 , 0.142 *( 29 : 49 ) 8 , 0.34 *
( 29 : 62 ) 5 , 0.416 *( 34 : 44 ) 4 , 0.25 *( 34 : 60 ) 2 , 0.181 *
( 34 : 21 ) 4 , 0.228 *( 34 : 43 ) 3 , 0.222 *( 34 : 49 ) 4 , 0.163 *
( 34 : 62 ) 1 , 0.076 *( 39 : 50 ) 1 , 0.181 *( 39 : 52 ) 3 , 0.545 *
( 39 : 66 ) 2 , 0.307 *( 44 : 53 ) 3 , 0.157 *( 44 : 60 ) 6 , 0.461 *
( 44 : 64 ) 3 , 0.25 *( 44 : 67 ) 1 , 0.105 *( 44 : 21 ) 8 , 0.41 *
( 44 : 43 ) 6 , 0.387 *( 44 : 49 ) 7 , 0.264 *( 44 : 62 ) 5 , 0.333 *
( 50 : 52 ) 2 , 0.285 *( 50 : 66 ) 2 , 0.25 *( 51 : 54 ) 1 , 0.5 *
( 52 : 53 ) 1 , 0.074 *( 52 : 66 ) 2 , 0.25 *( 53 : 60 ) 4 , 0.285 *
( 53 : 64 ) 5 , 0.384 *( 53 : 67 ) 1 , 0.095 *( 53 : 21 ) 4 , 0.195 *
( 53 : 43 ) 4 , 0.242 *( 53 : 49 ) 6 , 0.218 *( 53 : 62 ) 3 , 0.187 *
( 60 : 64 ) 3 , 0.428 *( 60 : 67 ) 1 , 0.222 *( 60 : 21 ) 6 , 0.413 *
( 60 : 43 ) 5 , 0.476 *( 60 : 49 ) 5 , 0.232 *( 60 : 62 ) 4 , 0.399 *
( 64 : 67 ) 1 , 0.285 *( 64 : 21 ) 3 , 0.222 *( 64 : 43 ) 2 , 0.21 *
( 64 : 49 ) 3 , 0.146 *( 64 : 62 ) 2 , 0.222 *( 67 : 21 ) 1 , 0.09 *
( 21 : 43 ) 12 , 0.705 *( 21 : 47 ) 1 , 0.086 *( 21 : 49 ) 17 , 0.607 *
( 21 : 62 ) 6 , 0.363 *( 43 : 47 ) 1 , 0.133 *( 43 : 49 ) 12 , 0.5 *
( 43 : 62 ) 6 , 0.479 *( 47 : 49 ) 1 , 0.054 *( 47 : 62 ) 1 , 0.142 *
( 49 : 62 ) 9 , 0.382 *( 65 : 66 ) 2 , 0.363 *( 65 : 68 ) 1 , 0.5 *
( 66 : 68 ) 1 , 0.191 *
END OF ANALYSIS
```

## Period 4.

```
ASSOCIATIONS
FORMAT IS (1ST CAT:2ND CAT) NO OF OBS OF PAIR,ASS IND*
( 9 : 14 ) 5 , 0.434 *( 9 : 19 ) 5 , 0.277 * ( 9 : 23 ) 3 , 0.272 *
( 9 : 44 ) 6 , 0.413 *( 9 : 53 ) 3 , 0.299 * ( 10 : 17 ) 4 , 0.285 *
( 10 : 23 ) 3 , 0.199 *( 10 : 27 ) 8 , 0.484 *( 10 : 28 ) 10 , 0.526 *
( 10 : 29 ) 10 , 0.588 *( 10 : 34 ) 2 , 0.148 *( 10 : 44 ) 4 , 0.216 *
( 10 : 21 ) 10 , 0.512 *( 10 : 43 ) 5 , 0.37 *( 10 : 49 ) 16 , 0.744 *
( 10 : 62 ) 10 , 0.571 *( 14 : 19 ) 7 , 0.424 *( 14 : 23 ) 3 , 0.315 *
( 14 : 34 ) 1 , 0.125 *( 14 : 44 ) 3 , 0.23 *( 17 : 27 ) 3 , 0.315 *
( 17 : 28 ) 5 , 0.416 *( 17 : 29 ) 3 , 0.299 *( 17 : 34 ) 3 , 0.461 *
( 17 : 44 ) 3 , 0.26 *( 17 : 21 ) 3 , 0.239 *( 17 : 43 ) 1 , 0.153 *
( 17 : 49 ) 6 , 0.413 *( 17 : 62 ) 3 , 0.285 *( 19 : 23 ) 5 , 0.312 *
( 19 : 34 ) 2 , 0.137 *( 19 : 44 ) 2 , 0.102 *( 19 : 53 ) 1 , 0.066 *
( 19 : 64 ) 4 , 0.285 *( 23 : 27 ) 1 , 0.095 *( 23 : 28 ) 1 , 0.076 *
( 23 : 29 ) 2 , 0.181 *( 23 : 44 ) 2 , 0.159 *( 23 : 64 ) 1 , 0.142 *
( 23 : 21 ) 1 , 0.074 *( 23 : 49 ) 3 , 0.193 *( 27 : 28 ) 6 , 0.413 *
( 27 : 29 ) 8 , 0.639 *( 27 : 44 ) 1 , 0.071 *( 27 : 21 ) 11 , 0.733 *
( 27 : 43 ) 1 , 0.111 *( 27 : 49 ) 7 , 0.411 *( 27 : 62 ) 7 , 0.538 *
( 28 : 29 ) 6 , 0.399 *( 28 : 34 ) 2 , 0.173 *( 28 : 44 ) 4 , 0.242 *
( 28 : 21 ) 6 , 0.342 *( 28 : 43 ) 4 , 0.347 *( 28 : 49 ) 10 , 0.512 *
( 28 : 62 ) 9 , 0.58 *( 29 : 44 ) 1 , 0.068 *( 29 : 21 ) 8 , 0.516 *
( 29 : 43 ) 3 , 0.315 *( 29 : 49 ) 11 , 0.628 *( 29 : 62 ) 7 , 0.518 *
( 32 : 39 ) 2 , 0.666 *( 33 : 39 ) 1 , 0.333 *( 33 : 69 ) 1 , 0.199 *
( 33 : 88 ) 1 , 0.399 *( 33 : 97 ) 1 , 0.666 *( 34 : 44 ) 2 , 0.191 *
( 34 : 49 ) 3 , 0.214 *( 34 : 62 ) 1 , 0.099 *( 39 : 97 ) 1 , 0.399 *
( 39 : 68 ) 1 , 0.181 *( 44 : 53 ) 2 , 0.173 *( 44 : 21 ) 3 , 0.176 *
( 44 : 43 ) 1 , 0.09 *( 44 : 49 ) 5 , 0.263 *( 44 : 62 ) 3 , 0.199 *
( 50 : 54 ) 1 , 0.191 *( 50 : 69 ) 1 , 0.166 *( 50 : 65 ) 1 , 0.333 *
( 50 : 66 ) 1 , 0.166 *( 52 : 53 ) 1 , 0.133 *( 52 : 54 ) 1 , 0.133 *
( 52 : 69 ) 3 , 0.375 *( 52 : 86 ) 1 , 0.272 *( 54 : 69 ) 2 , 0.266 *
( 54 : 66 ) 1 , 0.133 *( 54 : 68 ) 1 , 0.142 *( 69 : 86 ) 1 , 0.222 *
( 69 : 88 ) 1 , 0.181 *( 69 : 65 ) 1 , 0.199 *( 69 : 66 ) 1 , 0.125 *
( 21 : 43 ) 1 , 0.093 *( 21 : 49 ) 11 , 0.549 *( 21 : 62 ) 9 , 0.562 *
( 43 : 49 ) 3 , 0.214 *( 43 : 62 ) 4 , 0.399 *( 49 : 62 ) 9 , 0.5 *
( 65 : 66 ) 1 , 0.199 *( 66 : 68 ) 2 , 0.266 *
END OF ANALYSIS
```

## Period 5.

```
ASSOCIATIONS
FORMAT IS (1ST CAT:2ND CAT) NO OF OBS OF PAIR,ASS IND*
( 9 : 23 ) 1 , 0.117 *( 10 : 17 ) 3 , 0.199 *( 10 : 21 ) 13 , 0.604 *
( 10 : 23 ) 1 , 0.048 *( 10 : 27 ) 4 , 0.25 *( 10 : 28 ) 22 , 0.846 *
( 10 : 29 ) 8 , 0.444 *( 10 : 34 ) 8 , 0.432 *( 10 : 43 ) 8 , 0.421 *
( 10 : 44 ) 11 , 0.523 *( 10 : 49 ) 15 , 0.681 *( 10 : 62 ) 10 , 0.54 *
( 14 : 19 ) 9 , 0.62 *( 14 : 23 ) 5 , 0.384 *( 14 : 34 ) 1 , 0.09 *
( 14 : 53 ) 10 , 0.689 *( 17 : 28 ) 2 , 0.142 *( 17 : 29 ) 2 , 0.333 *
( 17 : 49 ) 2 , 0.199 *( 17 : 62 ) 1 , 0.153 *( 19 : 23 ) 5 , 0.322 *
( 19 : 34 ) 2 , 0.148 *( 19 : 53 ) 13 , 0.764 *( 21 : 23 ) 1 , 0.066 *
( 21 : 27 ) 3 , 0.285 *( 21 : 28 ) 11 , 0.536 *( 21 : 29 ) 4 , 0.319 *
( 21 : 34 ) 3 , 0.23 *( 21 : 43 ) 3 , 0.222 *( 21 : 44 ) 5 , 0.322 *
( 21 : 49 ) 9 , 0.545 *( 21 : 62 ) 4 , 0.307 *( 23 : 28 ) 1 , 0.051 *
( 23 : 29 ) 1 , 0.086 *( 23 : 53 ) 4 , 0.258 *( 27 : 28 ) 2 , 0.133 *
( 27 : 29 ) 1 , 0.142 *( 27 : 43 ) 1 , 0.125 *( 27 : 49 ) 3 , 0.272 *
( 27 : 62 ) 2 , 0.266 *( 28 : 29 ) 6 , 0.352 *( 28 : 34 ) 6 , 0.342 *
( 28 : 43 ) 9 , 0.5 * ( 28 : 44 ) 12 , 0.599 *( 28 : 49 ) 11 , 0.523 *
( 28 : 62 ) 9 , 0.514 *( 29 : 34 ) 3 , 0.315 *( 29 : 43 ) 4 , 0.399 *
( 29 : 44 ) 3 , 0.25 *( 29 : 49 ) 5 , 0.384 *( 29 : 62 ) 3 , 0.315 *
( 32 : 100 ) 1 , 0.5 *( 32 : 101 ) 1 , 0.5 * ( 34 : 43 ) 4 , 0.38 *
( 34 : 44 ) 7 , 0.559 *( 34 : 49 ) 5 , 0.37 *( 34 : 53 ) 2 , 0.148 *
( 34 : 62 ) 3 , 0.299 *( 39 : 65 ) 1 , 0.333 *( 39 : 66 ) 2 , 0.307 *
( 39 : 68 ) 2 , 0.285 *( 43 : 44 ) 7 , 0.538 *( 43 : 49 ) 3 , 0.214 *
( 43 : 62 ) 4 , 0.38 *( 44 : 49 ) 7 , 0.437 *( 44 : 62 ) 4 , 0.319 *
( 49 : 62 ) 6 , 0.444 *( 50 : 51 ) 1 , 0.117 *( 50 : 65 ) 2 , 0.266 *
( 50 : 66 ) 6 , 0.545 *( 50 : 68 ) 6 , 0.521 *( 51 : 66 ) 1 , 0.117 *
( 51 : 68 ) 1 , 0.111 *( 51 : 86 ) 1 , 0.222 *( 52 : 114 ) 1 , 0.285 *
( 54 : 68 ) 2 , 0.285 *( 65 : 66 ) 1 , 0.133 *( 65 : 68 ) 1 , 0.125 *
( 66 : 68 ) 9 , 0.782 *( 100 : 101 ) 1 , 1 *
END OF ANALYSIS
```

## Period 6.

```
ASSOCIATIONS
FORMAT IS (1ST CAT:2ND CAT) NO OF OBS OF PAIR,ASS IND*
( 9 : 19 ) 1 , 0.099 *( 9 : 53 ) 1 , 0.074 * ( 10 : 21 ) 12 , 0.51 *
( 10 : 23 ) 1 , 0.062 *( 10 : 27 ) 1 , 0.074 *( 10 : 28 ) 15 , 0.612 *
( 10 : 34 ) 1 , 0.066 *( 10 : 43 ) 7 , 0.399 *( 10 : 44 ) 16 , 0.581 *
( 10 : 49 ) 18 , 0.719 *( 10 : 62 ) 2 , 0.129 *( 10 : 121 ) 5 , 0.263 *
( 14 : 19 ) 11 , 0.628 *( 14 : 23 ) 1 , 0.086 *( 14 : 34 ) 1 , 0.095 *
( 14 : 53 ) 12 , 0.571 *( 19 : 23 ) 1 , 0.083 *( 19 : 53 ) 12 , 0.558 *
( 21 : 23 ) 1 , 0.074 *( 21 : 27 ) 1 , 0.09 *( 21 : 28 ) 14 , 0.636 *
( 21 : 34 ) 2 , 0.159 *( 21 : 43 ) 6 , 0.399 *( 21 : 44 ) 14 , 0.559 *
( 21 : 49 ) 15 , 0.666 *( 21 : 62 ) 4 , 0.307 *( 21 : 121 ) 6 , 0.363 *
( 23 : 44 ) 1 , 0.057 *( 23 : 53 ) 3 , 0.193 *( 27 : 28 ) 1 , 0.093 *
( 27 : 34 ) 1 , 0.399 *( 27 : 44 ) 1 , 0.066 *( 27 : 49 ) 1 , 0.079 *
( 28 : 34 ) 1 , 0.074 *( 28 : 43 ) 7 , 0.437 *( 28 : 44 ) 18 , 0.692 *
( 28 : 49 ) 15 , 0.638 *( 28 : 62 ) 4 , 0.285 *( 28 : 121 ) 9 , 0.514 *
( 34 : 44 ) 2 , 0.121 *( 34 : 49 ) 2 , 0.142 *( 34 : 62 ) 1 , 0.222 *
( 43 : 44 ) 6 , 0.315 *( 43 : 49 ) 7 , 0.424 *( 43 : 62 ) 2 , 0.285 *
( 43 : 121 ) 2 , 0.19 *( 44 : 49 ) 16 , 0.603 *( 44 : 62 ) 4 , 0.235 *
( 44 : 121 ) 10 , 0.487 *( 49 : 62 ) 3 , 0.206 *( 49 : 121 ) 5 , 0.277 *
( 50 : 51 ) 3 , 0.399 *( 50 : 66 ) 7 , 0.823 *( 50 : 68 ) 7 , 0.699 *
( 51 : 66 ) 2 , 0.295 *( 51 : 68 ) 3 , 0.352 *( 62 : 121 ) 1 , 0.117 *
( 66 : 68 ) 6 , 0.631 *( 100 : 101 ) 1 , 1 * ( 117 : 118 ) 1 , 0.5 *
END OF ANALYSIS
```

## Period 7.

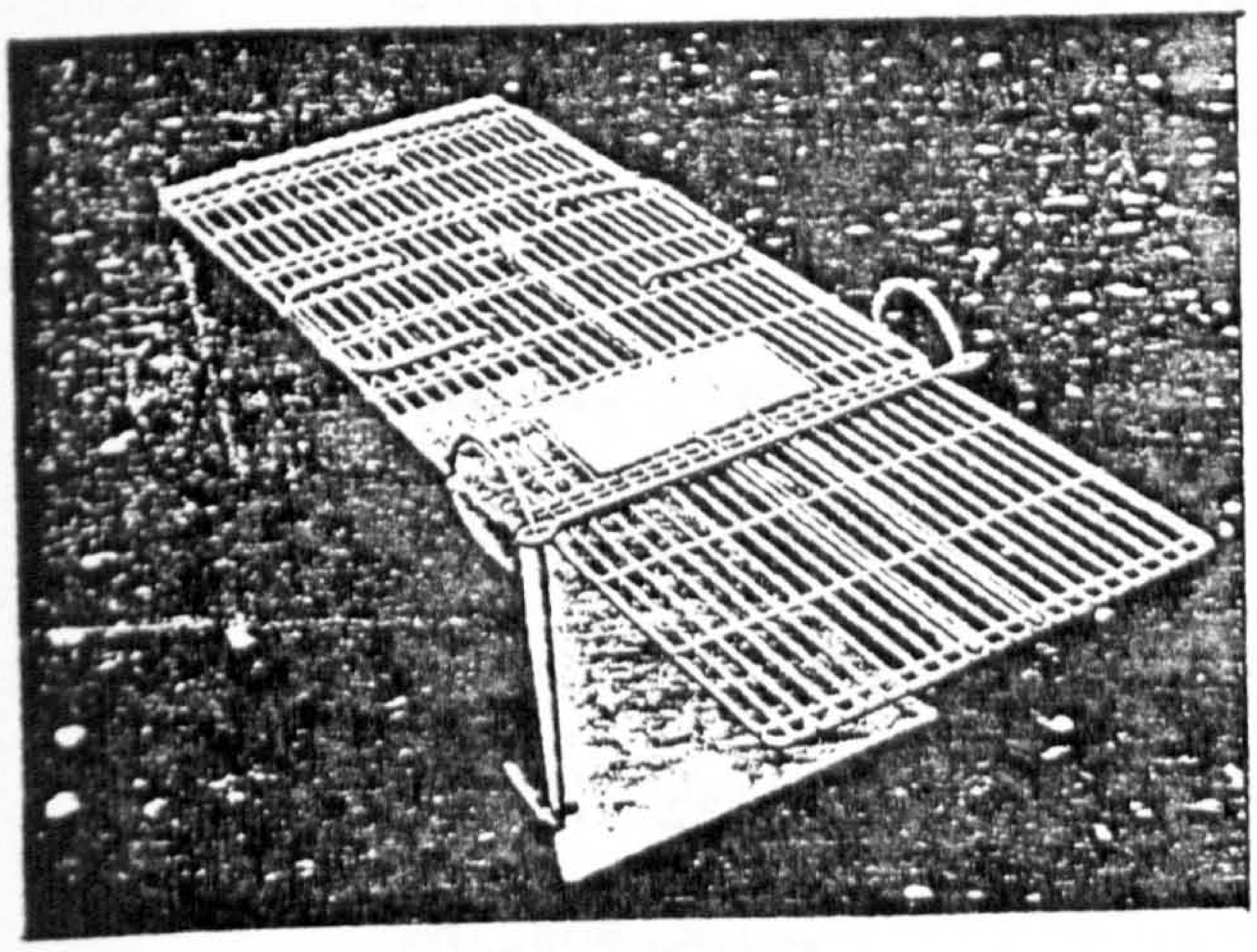
```
ASSOCIATIONS
FORMAT IS (1ST CAT:2ND CAT) NO OF OBS OF PAIR,ASS IND*
( 10 : 21 ) 2 , 0.181 *( 10 : 28 ) 9 , 0.562 *( 10 : 43 ) 3 , 0.315 *
( 10 : 44 ) 9 , 0.529 *( 10 : 49 ) 10 , 0.588 *( 10 : 121 ) 2 , 0.222 *
( 14 : 19 ) 8 , 0.551 *( 14 : 27 ) 1 , 0.117 *( 14 : 53 ) 12 , 0.727 *
( 19 : 53 ) 9 , 0.562 *( 21 : 28 ) 2 , 0.166 *( 21 : 44 ) 1 , 0.076 *
( 21 : 49 ) 2 , 0.153 *( 21 : 121 ) 1 , 0.199 *( 28 : 43 ) 2 , 0.19 *
( 28 : 44 ) 14 , 0.777 *( 28 : 49 ) 13 , 0.722 *( 28 : 121 ) 3 , 0.299 *
( 43 : 44 ) 1 , 0.086 *( 43 : 49 ) 3 , 0.26 *( 44 : 49 ) 14 , 0.736 *
( 44 : 121 ) 2 , 0.181 *( 49 : 121 ) 2 , 0.181 *( 50 : 51 ) 1 , 0.153 *
( 50 : 66 ) 9 , 0.782 *( 50 : 68 ) 7 , 0.699 *( 51 : 66 ) 1 , 0.125 *
( 51 : 68 ) 1 , 0.153 *( 66 : 68 ) 9 , 0.782 *
END OF ANALYSIS
```

## Period 8.

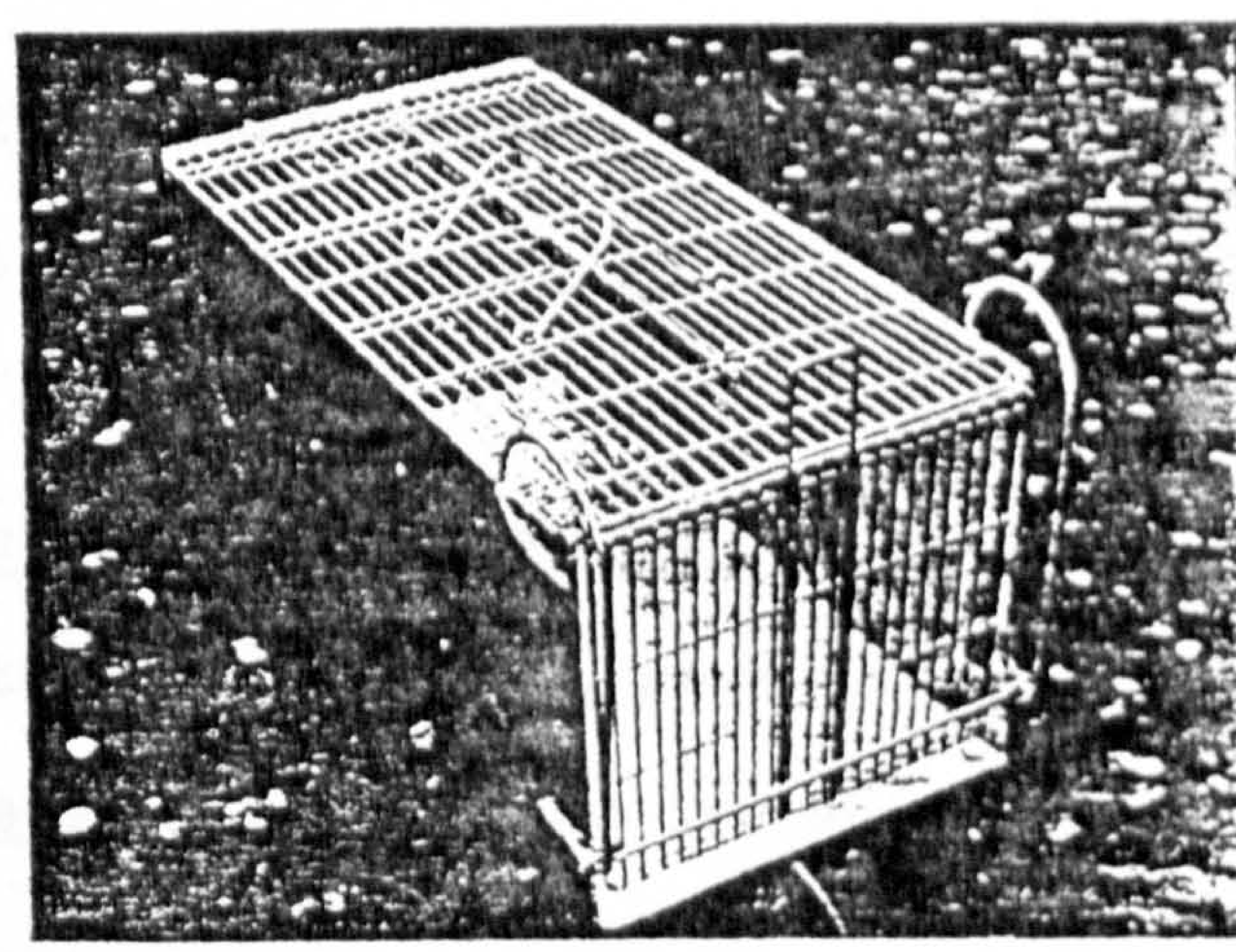
```
ASSOCIATIONS
FORMAT IS (1ST CAT:2ND CAT) NO OF OBS OF PAIR,ASS IND*
( 10 : 21 ) 11 , 0.423 *( 10 : 23 ) 5 , 0.181 *( 10 : 28 ) 18 , 0.562 *
( 10 : 34 ) 2 , 0.088 *( 10 : 43 ) 4 , 0.19 *( 10 : 44 ) 23 , 0.741 *
( 10 : 49 ) 20 , 0.625 *( 10 : 62 ) 14 , 0.518 *( 10 : 121 ) 13 , 0.433
*
( 14 : 19 ) 20 , 0.666 *( 14 : 23 ) 1 , 0.039 *( 14 : 27 ) 1 , 0.054 *
( 14 : 34 ) 2 , 0.099 *( 14 : 53 ) 31 , 0.873 *( 19 : 23 ) 3 , 0.125 *
( 19 : 27 ) 1 , 0.057 *( 19 : 34 ) 2 , 0.105 *( 19 : 53 ) 27 , 0.782 *
( 21 : 23 ) 5 , 0.285 *( 21 : 28 ) 9 , 0.409 *( 21 : 43 ) 3 , 0.272 *
( 21 : 44 ) 9 , 0.428 *( 21 : 49 ) 7 , 0.318 *( 21 : 62 ) 8 , 0.47 *
( 21 : 121 ) 5 , 0.25 *( 23 : 28 ) 5 , 0.212 *( 23 : 34 ) 1 , 0.071 *
( 23 : 43 ) 1 , 0.079 *( 23 : 44 ) 5 , 0.222 *( 23 : 49 ) 4 , 0.17 *
( 23 : 53 ) 4 , 0.135 *( 23 : 62 ) 3 , 0.162 *( 23 : 121 ) 9 , 0.418 *
( 27 : 38 ) 1 , 0.285 *( 27 : 39 ) 1 , 0.199 *( 27 : 52 ) 1 , 0.111 *
( 27 : 53 ) 2 , 0.086 *( 28 : 43 ) 4 , 0.235 *( 28 : 44 ) 16 , 0.592 *
( 28 : 49 ) 15 , 0.535 *( 28 : 62 ) 13 , 0.565 *( 28 : 121 ) 11 , 0.423
*
( 34 : 44 ) 1 , 0.057 *( 34 : 49 ) 1 , 0.054 *( 34 : 53 ) 2 , 0.081 *
( 34 : 121 ) 1 , 0.06 *( 38 : 39 ) 1 , 0.399 *( 39 : 50 ) 1 , 0.111 *
( 39 : 51 ) 1 , 0.117 *( 39 : 66 ) 1 , 0.133 *( 39 : 88 ) 1 , 0.399 *
( 43 : 44 ) 3 , 0.187 *( 43 : 49 ) 2 , 0.117 *( 43 : 62 ) 4 , 0.333 *
( 43 : 121 ) 2 , 0.133 *( 44 : 49 ) 17 , 0.629 *( 44 : 62 ) 9 , 0.409 *
( 44 : 121 ) 14 , 0.559 *( 49 : 62 ) 12 , 0.521 *( 49 : 121 ) 11 , 0.423
*
( 50 : 51 ) 9 , 0.666 *( 50 : 66 ) 6 , 0.479 *( 50 : 68 ) 7 , 0.482 *
( 51 : 66 ) 4 , 0.333 *( 51 : 68 ) 6 , 0.428 *( 52 : 63 ) 2 , 0.25 *
( 62 : 121 ) 5 , 0.238 *( 66 : 68 ) 3 , 0.23 *
END OF ANALYSIS
```

# R S P C A CAT TRAPS

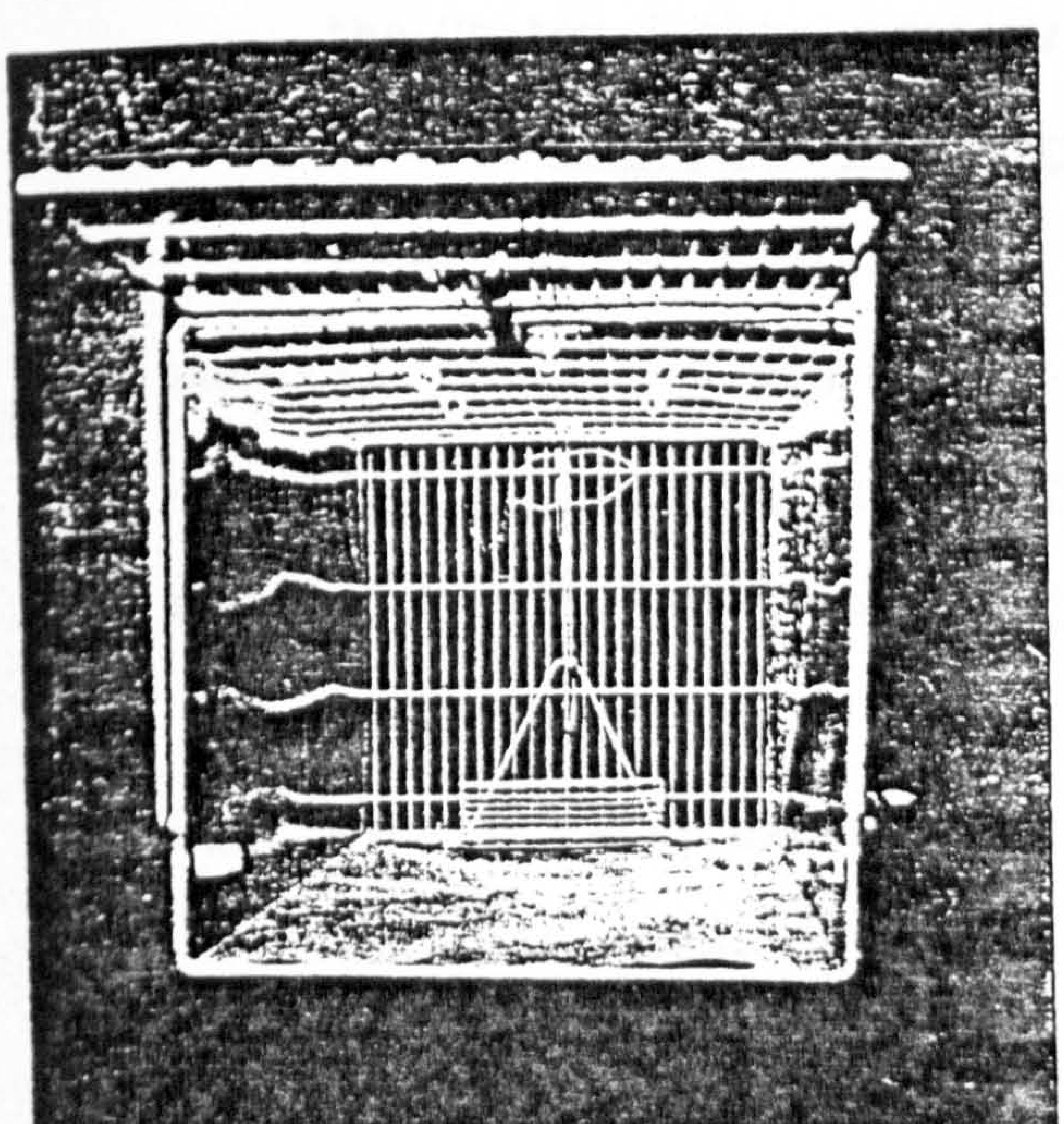
SIZE 25 × 12 × 12½ INCHES
63·5 x 30·5 x 32 cm.



Trap open
The card is only to clarify the setting position



Trap closed



Internal view
Showing bait ring and treadle. The movement of either springs the trap

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