



WORLD HEALTH ORGANIZATION

ORGANISATION MONDIALE DE LA SANTE

DISTR.: LIMITED
DISTR.: LIMITEE

VPH/83.43 Rev. 1

ORIGINAL : ENGLISH

GUIDELINES FOR DOG RABIES CONTROL

NOTE TO READERS

The GUIDELINES are intended for use in countries where plans and services for rabies control are being developed, as well as in countries with established rabies programmes requiring assessment with regard to management, overall policies and orientation.

Since only minor textual changes have been introduced, recipients of the 1984 version do not need to apply for the revised version of the GUIDELINES.

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Geneva, June 1987

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INTRODUCTION

The World Health Organization, in close cooperation with the Food and Agriculture Organization of the United Nations and the International Office of Epizootics, has initiated plans for an international strategy and programme of human and canine rabies control. This programme includes international technical cooperation in national programme development, in vaccine production, and in research on dog ecology and operational aspects.

This international programme was initiated in view of the trend of canine rabies which, in most developing countries, is spreading into new areas or increasing in case frequency in already infected areas. The number of governments who wish to eliminate the disease in its canine reservoir is therefore increasing since the results of all efforts to protect human beings by proper surveillance and post-exposure treatment remains unsatisfactory. Shortage of modern vaccines for man as well as the continuing burden due to neuro-paralytic complications and increasing costs of human post-exposure treatment now call, even more than in the past, for the elimination of the disease from its canine reservoirs. Elimination of the infection in dogs is also important where reservoirs are in wildlife, but dogs remain the most important transmitters to man.

It must be understood that, particularly in respect of canine rabies, it is often the health sector which is confronted with the problem and motivates people for community participation, whereas the execution of control programmes often lies within the veterinary services of the agricultural sector. In order to facilitate the essential intersectoral cooperation and mutual understanding of interests and responsibilities in human and canine rabies elimination, the preparation of a comprehensive technical and managerial guide has become imperative.

The specific guides presented in this document resulted from the amalgamation of numerous comprehensive submissions from a large number of experts from all over the world (see overleaf). Their invaluable contributions reflect, to a large extent, the experience made in success and failure of canine rabies control programmes during the past decades. WHO and the editorial group express their sincere gratitude to all those mentioned in the following pages for their cooperation and apologize if individual opinions and suggestions are not fully included in the text. The great volume of documents submitted called for certain selection for the sake of conciseness. Although the editorial group tried to compile the most pertinent information, the reader of this guide is requested to assess and apply the procedures critically by adapting them to local conditions. The Veterinary Public Health Unit of WHO would in particular welcome any suggestions for the improvement of future issues of this guide.

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ACKNOWLEDGEMENTS

The editorial group wishes to thank all those listed below for their collaboration in preparing this guide for canine rabies elimination.

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1. THE CANINE RABIES SITUATION

1.1 The Epidemiology of Canine Rabies

The increasing importance of canine rabies worldwide necessitates the adaptation of effective control measures to the existing epidemiological conditions in developing countries. Factors of influence to the epidemiology of canine rabies are several, such as the prevalent virus reservoir, the degree of adaptation of rabies virus to dogs and related canines, the natural virus spread, the degree of virus excretion, the existence of asymptomatic carriers, the structure and dynamics of the dog population as well as the correlation of human and canine rabies.

1.1.1 Susceptibility and clinical course

Experimentally, dogs can be infected by numerous routes such as intracerebral, intraneural, intraocular, subcutaneous, intramuscular and intravenous inoculations. Intradermal injection, and inhalation or ingestion of the virus rarely induced rabies in dogs. The susceptibility may be raised by the simultaneous application of immunosuppressive drugs.

In nature the bite is the only relevant route of infection for dogs, to which young dogs up to the age of 4 months are much more susceptible than adults.

Differences in their susceptibility to viruses from other reservoir species seem to exist. Canine rabies caused by viruses from natural reservoirs in foxes, skunks or racoons results less frequently in dog to dog transmission and rabies in other domestic animals than does canine rabies in areas of the urban (canine) type of this disease.

The incubation period of rabies in dogs can vary from 10 days up to several months. The majority of dog cases occur within 21 to 80 days after exposure. For quarantine purposes an important observation is that, in the past, dogs have succumbed to rabies even after a 6 month observation period.

The clinical manifestations are commonly classified as furious and dumb rabies, though most infected dogs show symptoms common to both types such as a short period of excitability followed rapidly by depression and paralysis.

During the prodromal stage dogs show a sudden change in their disposition and become either increasingly alert or apathetic. Fever, dilatation of the pupils, and an increasing muscle tonus may be noticed. The excitement stage is characterized by an unusual restlessness, a watchful apprehensive look, snapping at invisible objects, aimless running, and unprovoked aggressiveness of unexpected strength. Difficulties in swallowing and a characteristic change in the bark or growl are early signs of the subsequent paralytic stage.

In the paralytic stage the dog is unable to take food or swallow water. Paralysis of jaw and tongue, drooling of saliva and paralysis of the hind quarters becomes obvious and death occurs within 3-7 days after the initial symptoms.

1.1.2 Natural transmission

The natural spread of rabies among terrestrial animals or from animal to man depends on the following mechanisms of transmission:

- excretion of infective virus by the salivary glands via saliva
- penetration of infective saliva into wounds, commonly afflicted by the bite of the rabid animal.

Virus in the salivary glands of animals that died of rabies is found in 54-90% of those cases.

These mechanisms of transmission are fully applicable to the dog. The vital question concerning transmission is the earliest time at which virus excretion via saliva may start in a rabies-infected dog. It is generally understood that, in the majority of dogs, virus excretion begins shortly before, with or after the appearance of clinical symptoms. The length of virus excretion as well as the virus titer can vary and have never been completely verified in naturally infected dogs, partly due to the danger involved in such studies. One may assume, however, that the frequency of virus excretion via dog saliva is similar under natural and experimental conditions.

Earlier experiments relating virus excretion to illness have shown that infectious saliva in dogs was observed as early as 3 and 7 days before the appearance of clinical symptoms. In a recent experiment using graded doses of canine rabies virus for inoculation, 16 of 22 rabid dogs had infectious virus in their submaxillary glands. Ten of the 16 dogs excreted virus through the saliva. Eight of the 10 dogs were shown to excrete virus before signs of disease were observed, namely 1 dog on day 7, 1 on day 4, 2 on day 2 and 4 on day 1 prior to the onset of symptoms. In the same study using another virus isolate from a healthy appearing dog from Ethiopia, the earliest virus excretion was noted 13 days before the dog developed symptoms.

The WHO Expert Committee on Rabies has recommended an observation period of 10 days for dogs and cats following human exposure. If rabies symptoms develop after that 10 day period, it is safe to assume that virus was not present in the saliva at the time of the bite. A change of this general policy is presently not indicated despite the above findings with a particular ethiopian virus which has arisen from a very special situation. Under these exceedingly rare conditions which have so far been observed only in Ethiopia and in one dog from Surandi/India, it may be warranted to kill the respective animals immediately for diagnostic purposes or to observe them for a longer period than that recommended by the WHO Expert Committee. The diagnostic procedures to be used must be such as to give positive results in an infected animal at that stage of the disease.

The dynamics of canine rabies transmission are much different from those of wildlife rabies in Europe or North America. With the fox as the vector of the disease, rabies is expanding gradually and at a steady pace of approximately 40km per annum. A passive spread of wildlife rabies over large distances, for example by importing infected wild animals, appears to be of minor importance. One exception was the recent introduction of racoons for hunting purposes from racoon-rabies infected areas of the southern USA into Virginia. This started such an epidemic among racoons that concern has been raised due to the presence of rabid animals even in residential areas of Washington D.C.

In contrast, in areas of urban rabies, a dog in the furious stage of rabies may, within a few hours, cover a distance equal to the yearly spread observed in fox rabies. In this short time span it can infect dogs as well as other animals and humans. After a period of months, the route that this dog followed can be fairly accurately reconstructed from the new outbreaks of rabies cases.

The same pattern can be observed when an infected dog either actively or passively crosses a border into a rabies-free country whether due to smuggling or by accident. This situation is complicated by the fact that people unaware of rabies could be exposed and do not seek treatment with the result that human cases are often the first indication of the presence of rabies. The control over the illegal introduction of dogs into rabies-free countries is increasingly complicated due to rapid transportation systems available to the general public (boat, private plane).

The natural epidemiological spread of canine rabies depends on the tradition of human-dog relations as well as on structure and density of the existing dog population. Stray dogs are known to play a crucial role in the spread of rabies. These dogs find ideal living conditions in urban areas. This development is favoured by increased mobility of human populations and a steady improvement of economic conditions. Unfortunately, our knowledge of the ecology of the dog, including non-supervised dogs, in urban and rural areas is limited and should be intensively studied in the future (see also Chapter 2).

The reservoir of canine type rabies is not only the dog but possibly the wolf and the jackal. Chains of infection between these animals and the dog have been shown to exist. However, it is a common observation that dog to dog transmission is sufficient to cause a persistent epidemic over many years. Without intervening control measures, the rabies situation becomes an ever-increasing threat.

Mass immunization of dogs and elimination of strays have been shown to be effective measures to interrupt the canine transmission cycle. Successful national programmes in the past have been reported for instance from Hungary (1935-1944), Japan (rabies-free since 1956), Malaysia (1953-1956) and USA (1950-1965). Recently Argentina has reported that between 1977 and 1982 canine rabies in the province of Buenos Aires, causing 90% of the total national cases in the past, has been almost completely eliminated.

The occurrence of rabies by continent and the correlation between human and canine rabies is shown in Section 1.2. Worldwide, more than 90% of all human rabies cases are caused by dogs, even in those areas where wildlife rabies is predominant.

The susceptibility of man for rabies is relatively low. According to statistics, on average only 15-20% of people who have been bitten by proven rabid animals and received no post-exposure treatment die from rabies. Factors like individual disposition and age seem to influence the morbidity rate.

Of further importance are the localization of the site of the bite and the severity of the wound. Bites on the head, face and neck are the most dangerous and the mortality rate proves to be high. These are followed by lesions on the upper extremities, the trunk and the legs. Bites on arms and legs are registered in almost 2/3 of the cases, about 15% on the head, face and neck and the rest on the trunk.

The question of asymptomatic rabies, especially the excretion of rabies virus by healthy-appearing dogs, is raised from time to time. As a rule, rabies in dogs is always considered a fatal disease. It is known, however, that dogs can survive an experimental rabies infection with or without sequelae. Such dogs are subsequently shown to be immune. Persisting virus was not demonstrable in the CNS, salivary glands, or other organs. It is possible that such cases could occur in nature.

Reports of asymptomatic dogs from Ethiopia which contained infectious rabies virus in their saliva are considered a scientific curiosity. These observations however must be taken into account but should be regarded as a very rare event. The conditions which lead to this event need intensive research and careful evaluation of the responsible virus strains.

Another popular, however untrue, belief is that immunized dogs, following exposure to street virus, are capable of excreting this street virus without becoming ill. Multiple experiments conducted in several laboratories have shown that this belief is wrong.

Future research should also study the possible occurrence of the so-called rabies-like viruses in dogs, especially on the African continent. Recent studies with monoclonal antibodies permitting a specific differentiation of virus strains have demonstrated the existence of such rabies related viruses in bats and a cat in South Africa and in a dog and cats in Zimbabwe. Experimentally, one of these isolates induced clinical rabies in dogs with virus being excreted through their saliva. Evidence of natural transmission cycles of such virus among carnivores would pose a serious public health problem and might require the application of a polyvalent vaccine.

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1.2 The Occurrence of Rabies in Dogs and in People

1.2.1 Introduction

Since ancient times rabies has been recognized as a dog's disease. Its poison (Latin = virus) was early suspected to be transmissible to man and beast through the saliva of mad dogs.

The disease in man was and is a much-feared condition, and many painstaking procedures, of superstitious and medical origin, were recommended for its cure or prevention. The knowledge of the inevitable fatal outcome of the disease once symptoms appear makes rabies a dreadful menace to victims of bite cases and other animal exposures.

Worldwide, the dog is still the principle vector in transmitting rabies to man, irrespective of whether the reservoir hosts are wildlife animals or dogs themselves.

Canine rabies is a serious and ever increasing problem in today's rapidly growing metropolitan or industrial areas where a poorly controlled stray dog population is equally fast expanding. This is the case in various countries of Latin America and in some cities of Africa, Asia and Europe. On the other hand, canine rabies has become predominantly a rural problem in most countries of Africa and in parts of Asia.

To assess the occurrence of rabies in dogs and to correlate it to the disease in man would require the compilation of comparable surveillance data from many parts of the world. Reliable data are collected and evaluated at regular intervals in countries with functioning veterinary and diagnostic services. Such data are, however, either unavailable or incomplete from countries where the rabies problem is most serious. The following compilation of data taken from the WHO World Survey on Rabies, from national reports and from individual contributions - being far from complete - are intended to give an account of the existing rabies situation. The data indeed reflect the fears of rabies experts and of national and international agencies that canine rabies is increasing on a worldwide scale, despite the knowledge and the available means to effectively control it.

1.2.2 Rabies occurrence in the Americas

In the following the status of rabies in the Americas during the 11-year period from 1970 to 1980 is described. Information has been obtained from various sources and summarizes the data received at the Pan American Zoonoses Center in Ramos Mejia, Argentina (Tables 1.1, 1.2).

Despite the efforts made during this decade, rabies continues to be a major problem in the hemisphere. Some progress has been made in a few countries, but most of them are very far from reaching the goal set at the beginning of the decade, namely to control and eventually suppress canine rabies in the main cities of Latin America, with a view to eradicating human rabies in those areas. The incidence of rabies in dogs for the last year for which statistics are available, between 1977 and 1980, ranges between 0 and 793 for every 100 000 dogs in the major cities. Annual averages for the decade in Latin America and the Caribbean were over 18 000 dogs with rabies and more than 300 000 persons treated with post-exposure vaccination. The annual average number of human cases reported in the Region was 280. During the 11-year period under review, cases of rabies in the Americas have not decreased.

Table 1.1: Reported cases in LATIN-AMERICA, by country and species, 1970-1980

Country	Dogs	Cats	Farm Animals	Wildlife	Un- specified	Human	Totals
Argentina	16445	1494	4280	81	3	77	22380
Belize	72	3	39	3	-	3	120
Bolivia	4156	86	479	29	6	41	4797
Brazil	25622	1854	21392	118	2891	1156	53033
Colombia	40779	2520	927	1307	323	127	45983
Costa Rica	141	9	43	6	-	1	200
Cuba	995	357	147	322	41	13	1875
Chile	69	6	36	3	-	2	116
Ecuador	9754	490	279	74	1339	197	12133
El Salvador	565	98	617	39	4	106	1429
Grenada	24	13	141	446	4	1	629
Guatemala	2445	88	123	19	-	42	2717
Haiti	554	5	-	-	54	17	630
Honduras	2759	96	465	15	271	44	3650
Mexico	76102	2459	4560	1287	278	652	85338
Nicaragua	1780	84	149	21	2	23	2059
Panama	61	5	124	3	-	2	195
Paraguay	2512	115	362	33	1	24	3047
Peru	6915	317	331	50	13	126	7752
Domin.Republ.	1150	156	47	76	3	31	1463
Surinam	1	-	26	-	-	-	27
Trinidad/Tobago	5	-	131	8	1	-	145
Venezuela	4848	342	3300	35	7	80	8612
Guyana	-	-	134	-	-	-	134
	197754	10597	38132	3975	5241	2765	258464
	= 76.5%	= 4.1%	= 14.8%	= 1.5%	= 2%	= 1.1%	= 100%

Table 1.2: Reported rabies cases of NORTH AMERICA by country and species, 1970-1980

Country	Dogs	Cats	Farm Animals	Wildlife	Un- specific	Human	Totals
Canada	1043	877	5285	12517	-	1	19724
USA	1972	1607	3804	34993	10	22	42408
Totals	3015 = 4.9%	2484 = 4.0%	9089 = 14.6%	47511 = 76.5%	10 0.1	23 0.1	62132 = 100%

For purposes of reporting, cases of rabies in the Americas have been grouped into two large areas each with very different characteristics. The first is comprised of Canada and the United States (Table 1.2), where there are very few cases of rabies in human beings since rabies in dogs has been almost totally eliminated. These two countries, however, face a difficult problem: the presence of the disease in wild animals.

A total of 5 150 laboratory-confirmed rabies cases were reported in the United States and its territories in 1979. This total was 67 per cent higher than the average annual total for the preceding five years and was 1 852 cases over the total reported for 1978. Forty-eight states and Puerto Rico reported infected animals in 1979; only the District of Columbia, Idaho, Guam, Hawaii, and the Virgin Islands reported no cases. Seven kinds of animals accounted for 98% of the reported cases. These were skunks (59%), bats (15 per cent), raccoons (10%), cattle (4%), dogs (4%), cats (3%), and foxes (3%). Wild animal species accounted for 87.6% of the total reported cases, domestic animals accounted for 12.3%, and humans accounted for less than 0.1%.

Canada has not reported human cases since 1971, but cases in wild animal species still represent 76% of the total reported cases. However, the information for 1980 shows a reduction of almost 50% (698 cases) in wildlife animals from 1979 (1229 cases).

The second area comprises the rest of the countries in the Americas. In Latin America and parts of the West Indies, the above-described situation is reversed: the number of cases in man and dogs being high but that in wildlife considerably lower (Table 1.1). The principal transmitters of wildlife rabies in this area are the introduced mongoose and various species of bats, especially hematophagous "vampire" bats that cause paralytic rabies in cattle.

This unequal distribution of wildlife rabies between the northern and southern areas of the Americas should not lead one to assume that it is not a problem or is unimportant in Latin America. Probable explanations for the differences are that rabies in wildlife in Latin America has not yet been adequately investigated, surveillance is inadequate, and reporting is incomplete.

In countries where urban rabies has been controlled, wildlife rabies remains a threat for man and domestic animals since it could be reintroduced by wild animals unless constant surveillance and protective measures are maintained.

Overall status of rabies in the Americas

Rabies in the Americas exists in two epidemiologic forms: a) urban rabies propagated primarily by dogs; and b) wildlife rabies transmitted by a variety of mammals, primarily carnivores and bats.

Urban rabies

Human and canine rabies constitute a problem essentially urban in nature, one which becomes more critical in the surrounding areas of large and medium-sized cities.

Dog bites are the cause of the vast majority of human cases of rabies in the Americas, as well as of a great number of wounds requiring preventive treatment for rabies, medical and/or surgical care.

In North America dog control measures have always been an effective tool in the control of rabies and continues to play a role even though wildlife provides the foci of infection. The effectiveness of the "Canadian Rabies Control Programme" can be measured by the fact that over the last 10 years no person has died of rabies because of contact with a rabid animal.

The population explosion in Latin America and the Caribbean has produced an enormous increase in the number of urban inhabitants, as well as in the population of urban animals, in particular dogs, cats and rats. In the decade of the 1980s, 80% of the population of several Latin American countries will be concentrated in urban areas⁽¹⁾.

(1) The Organization of American States defines an urban area in the Americas as cities with more than 20 000 people.

Urban rabies as a problem in almost all Latin American and some Caribbean cities has social, epidemiologic, and economic characteristics that are completely different from wildlife rabies. Dogs and cats account for more than 96% of the animal cases and are the transmitters of almost all human cases. Only Guyana, Jamaica, and Uruguay are free of rabies. Chile has an excellent programme for the control of rabies and maintains a low incidence. Panama City began a successful programme in 1957 and has remained practically free of urban rabies. Effective programmes against urban rabies were carried out in such large cities as Bogota and Cali, Colombia, in 1976 - 1977; in Lima, Peru in 1973-1974, and in Buenos Aires, Argentina in 1972 and 1979.

Rabies risk and infection rates vary from country to country and within each country. For many reasons the information available cannot be applied to all countries. Epidemiologic investigations carried out in some Latin American cities have made it possible to quantify the problem.

Brazil and Mexico have reported two-thirds of the total human cases of the Region, followed by Ecuador, Peru and Colombia (Table 1.1). However, the two countries with the highest number of cases also have the largest human populations. An estimate has been made of the rates per million inhabitants. These rates show that the problem is more serious in Ecuador 2.5, El Salvador 2.4, and Honduras 1.3 than in Brazil 0.9 and in Mexico 1.0.

Many studies show that children account for the largest percentage of mortality. According to information available, and despite considerable under-registration, the 1-14 year age group is the most affected. In some regions, antirabies immunoprophylactic treatment rates are 13 per 10 000 population. Another serious problem is the high incidence of bites and the high cost occasioned by the medical care of the persons exposed.

No estimate of the cost of treatment, which for the most part is carried out with suckling mouse brain vaccines (SMBV), has been made in Latin America. These vaccines are much cheaper than those used in the United States and Canada. It is of interest to note that the cost of treating the persons exposed to one rabid raccoon in Florida was US\$ 21 624, a figure which does not include the time of state and federal epidemiologic and laboratory personnel. A general estimate of the cost for administering rabies vaccines to dogs in Latin America using the suckling mouse brain vaccine is US\$ 0.25 to 0.50 per dose.

Information available makes it possible to speculate that in Latin America and the Caribbean there is a dog population of between 29 and 49 million, or a ratio of 1:13 to 1:8 per inhabitant. Comparison of these figures with the data for canine vaccine production shows that there is a deficit of between 10 and 28 million doses for dogs alone.

The cases of rabies in animals living in close contact with human beings are shown in Tables 1.1 and 1.2. The cases in dogs reported over the 11-year period indicate that more than two-thirds occurred in Mexico, Colombia, and Brazil. The number of dogs vaccinated against rabies in each of those countries' large cities failed to reach the goal of 80 per cent, although

three countries came fairly close in 1977, 1978, and 1979. Levels range from 1 per cent to 75 per cent, the median being 35 per cent. As is evident, vaccination of dogs is not sufficiently widespread to keep the disease under control. Elimination of stray dogs has not yet been completed; figures in the 10 countries that reported were between 7 per cent and 60 per cent, the median being 20 per cent.

The importance of cats in relation to the problem of rabies has not been clearly recognized. During the period under review, over 13 000 cases of rabies in cats were reported - by no means a small number in view of the potential risk they represent for man. A little over half of the cases of rabies in cats were reported from Colombia, Mexico and Brazil followed by Argentina, United States, Canada and Ecuador. However, the fact that the elimination of rabies in dogs leads to its disappearance in cats is widely accepted and, consequently, the epidemiologic importance of this species is considerably reduced. Nevertheless, although it is true that the vaccination of cats is not as simple as that of dogs, it would be useful to insist, in so far as possible, that cats be included in any canine mass vaccination campaign.

Rabies in farm animals

In the developing world, rabies constitutes not only a threat to human life but also a serious loss to the livestock industry.

On the basis of the available information, it may be inferred that cases of rabies in bovines continues to be under-reported. This is due to the fact that most of the countries affected by the disease lack adequate and efficient reporting systems. In most instances for cases reported in bovines, only clinical diagnosis is available. This is due to the fact that most cases occurred in field conditions, which makes it difficult or even impossible to forward samples to laboratories located in often distant large cities. The figures in Table 1 show the vagaries of this reporting; thus, the information requires a cautious interpretation.

No rates have been estimated for the number of cases in relation to the cattle population of the countries due to the possibility of under-reporting and the differences in risk of exposure in different areas of the same country with considerable variation among herds. However, for the information available, the largest number of cases occurred in Brazil, Canada, Mexico, Argentina and Venezuela.

Rabies affecting bovines is primarily a problem of the southern area of the hemisphere where it is transmitted by vampire bats. Bovine rabies is of great concern, since cattle losses have a tremendous economic impact on the livestock industry. In discussing the annual monetary loss the figures show a great disparity between the cases actually reported and the estimated "real" annual number in which the reported cases represented a percentage ranging from 3% to 60% of the estimated annual mortality.

Losses for bovine rabies probably have been under-reported primarily due to the difficulties in establishing the number of deaths and in confirming the etiology of rabies in the laboratory. Under-reporting may also result when occurrences in the field are not reported to the animal health authorities or when reported cases have been inaccurately diagnosed.

While bovine rabies is primarily transmitted by vampire bats, other mammals also transmit rabies to livestock. Since both types of rabies can exist simultaneously in an area, it is sometimes difficult to determine on the basis of symptomatology whether rabies is caused by vampire bats or by carnivores. However, the presence of bat bites, multiple cases and paralytic symptoms will suggest rabies transmitted by vampire bats.

The cases of rabies reported in other domestic livestock, in the order of those most affected, are: horses, swine, sheep, and goats. In the past 11 years the countries of the Region have reported an average of 500 cases of rabies in domestic animals other than bovines. Brazil, Canada, Mexico, United States, Argentina and Colombia recorded the highest number of cases. Again, these are the countries with large livestock populations. During the period 1970-1980, the Rabies Surveillance Programme of the Pan American Zoonoses Center registered 5 465 cases of rabies in equines, pigs, goats and sheep in the three sub-regions of the hemisphere. North and South America reported 5 400 cases, compared to Central America which only reported 65. The real prevalence of rabies in these species and its economic implications require further studies as well as better reporting and diagnostic systems.

Rabies in wildlife

As has been stated, the problem of rabies in wildlife is apparently more serious in North America. Over 80% of the reported cases in the Americas occur in Canada and the United States (Table 1.2). This difference with the remaining countries may be due to a higher actual incidence or to the degree of concern with which those two countries view the problem. Another factor may be that the United States and Canada have the advantage of more advanced laboratory and reporting services.

Skunks, foxes, bats, mongooses and raccoons are the wild species in which rabies occurs most frequently. Since the number of wild animals is unknown, relative figures cannot be estimated. The number of cases of rabies in animals of unstated species as reported by each country in the hemisphere are included too. During these years (1970-1980), 5 251 such cases were registered in the Region. Brazil 55% and Ecuador 25%, recorded the largest number of cases. It is assumed that a great number of these cases occurred in wildlife species.

Wildlife rabies cases are reported in the monkey, paca, rodents, coatimundi, badger, squirrel and alpaca in Latin America and in the ground hog, jack rabbit, weasel, mole, antelope and bobcat in North America. In some of these species, differential diagnosis should be performed before they are reported as "rabies cases". There are many pathological conditions that are responsible for abnormal behaviour in these animals that may resemble rabies; for example cerebrospinal nematodosis in woodchucks (*Marmota monax*) causes an abnormal behaviour suggestive of rabies. Also it is very necessary that proper taxonomic identification be made of the species reported with rabies. Whenever possible the scientific name of the animal should be included in the report:

Rodents and lagomorphs

A situation requiring further investigation involves the incidence of the disease in rats, mice, rabbits and hares. These rodents and lagomorphs do not appear to play any role in the epidemiology of the disease in the Americas. However, in parts of Europe repeated isolations of rabies viruses have been made from wild rodents.

Some viruses isolated were recently shown by monoclonal antibody technique to have antigenic determinants identical to those of European fox rabies isolates. Their epidemiologic significance has not yet been determined.

During the period 1975-1980, there was an increase in the number of cases in rats and other rodents reported from several countries in Latin America.

Rabies in wild carnivora

The keeping as pets of such wild animals as skunks, foxes and raccoons has been increasing in recent years, especially in the United States. There has been a simultaneous increase in reported rabies in these wild animals. These have often resulted in many persons being exposed and requiring antirabies treatment (23, 24). Long incubation periods have been described in wildlife. There is no vaccine currently licensed for immunizing wildlife against rabies. Since no practical way exists to ensure people against rabies infection in wild animal pets, the WHO Expert Committee on Rabies recommends against the keeping of wild animals as pets (23, 24).

In these species the most affected is the striped and spotted skunk 41%; followed by the grey, red and arctic foxes 40%; mongooses 5%; raccoon 3%; and other 2%. These percentages, to which we have to add 9 per cent for bats, correspond to the figures provided by the countries to the Zoonoses Center between 1975-1980. Other species mostly reported in North America are coyotes, bears, mountain lions, and wolves, especially in the arctic region.

Rabies in mongooses

The introduction of the small Indian mongoose (*Herpestes auropunctatus*) onto some of the Caribbean islands has resulted in propagation of the disease, and this species now represents a major public health problem, since it attacks domestic animals and man. The problem of rabies in mongooses is registered in Cuba, Dominican Republic, Grenada and the United States (Puerto Rico and Virgin Islands).

The epizootiology of rabies in the West Indian island of Grenada is particularly interesting and deserves special mention. Grenada is a small island of 350 km² (220 square miles) with a human population of over 95 000. Several vigorous trapping campaigns and poisoning attempts have been undertaken to reduce the canine and mongoose population in Grenada since 1956. During the period 1968-1977, it was discovered that a high proportion of the mongooses had acquired a natural immunity to rabies as indicated by the presence of rabies-serum neutralizing antibodies. There was a significant correlation between a high proportion of mongooses with antibody and a low incidence of rabies and vice versa. This led to the statement by Everard et al. (1976) that: "Wildlife reduction programmes may, therefore, have an adverse effect when neutralizing antibody-protected animals are killed indiscriminately, especially if these constitute a high proportion of the population". Thus under such circumstances, killing may be an ineffective control technique.

Rabies in bats

Bats of numerous species in the Americas, both insectivorous and hematophagus (vampires) have been found with rabies infection.

Insectivorous bats

Rabies in insectivorous bats is the most important public health hazard associated with bats. Its impact in the North American area has been exaggerated since infected bats rarely attack human beings without provocation. However, when a bat bites a human being, the incident is usually exacerbated by the media. In 1953 the first bat was reported rabid in the United States but the problem probably existed prior to that year. Rabies has been reported in 30-40 bat species indigenous to the United States and Canada, and it has been detected in all 48 contiguous States and most of the Canadian provinces. In Grenada, rabies was confirmed in an insectivorous free-tailed bat, Molossus major, and a fruit-eating bat, Artibeus jamaicensis, both commonly found around people and buildings. Similar findings in these and in other species of insectivorous and fructivorous bats have been reported repeatedly. The increase in numbers of rabid bats reported may actually only reflect the degree of human interest in the problem. The rabies prevalence rate in insectivorous bats is usually not greater than 2 per cent (WHO Rabies Reports 1973 and 1980). Since 1953 there have been eight human fatalities in the United States attributed to the actual bites of rabid bats, in addition to two other human deaths due probably to non-bite aerosol transmission in a Texas cave.

An important epidemiologic question regarding rabies in insectivorous bats is their possible viral transmission to terrestrial mammals by bite, ingestion or aerosol. Natural transmissions of rabies from insectivorous and vampire bats to other terrestrial animals by biting (except vampire bat-transmitted rabies to people and livestock) have not been observed. Experimental transmission from rabid bats with infectious saliva to other susceptible animals by the bite route has proved extremely difficult. Foxes and coyotes held in screened cages to protect them from bat bites, in some bat caves and laboratories, have died of aerosol contact with Mexican free-tail bats (Tadarida brasiliensis). Various terrestrial mammals search bat caves for food that includes bats. Rabies transmission by ingestion of bats should be further investigated since infection of carnivores by this route is a possibility. Skunks have been experimentally infected by feeding upon mice that had died after being inoculated with bat rabies virus. There are no known cases of dogs or cats being naturally infected by bats and several experimental attempts to infect them by bat bite have been unsuccessful. If man can be infected through bat bites it is possible that some wild animals can likewise be infected.

Insectivorous bats do not appear to be asymptomatic carriers of rabies virus since no salivary gland isolates have been obtained without the simultaneous presence of virus in the brain. These bats are not asymptomatic carriers of rabies since evidence indicates that they can either survive the exposure to rabies without becoming infected or they die like other mammals. It may be concluded that the bat rabies problem in the northern area of the hemisphere is generally similar to rabies as it occurs in carnivores. It differs in that bats are capable of flying and infected bats rarely attack; nevertheless, they may become a nuisance in buildings or pose a public health hazard. Observations of free-ranging bats in Canada, with probable furious rabies, suggested that bats do not generally identify humans as targets for attack. Independent trends in infection rates suggested that spread of rabies is primarily intraspecific but there is evidence that migratory bats play a role in introduction and maintenance of rabies in bat communities in northern temperate climates.

Vampire bats

Vampire bats are found only in the western hemisphere from northern Mexico to northern Argentina and on the island of Trinidad. Paralytic rabies transmitted by vampire bats is the most important rabies problem in the area of the southern region and is the major cause of death in cattle. The sole diet of vampire bats is the blood of vertebrates and disease transmission occurs while the bats feed.

While bovine paralytic rabies is primarily transmitted by vampire bats, other animals transmit rabies to livestock. On the basis of symptomatology, it is sometimes difficult to determine whether rabies is caused by vampire bats or by dogs or other carnivores. However, the presence of bat bites, multiple cases, paralytic symptoms and absence of canine rabies in an area suggest rabies by vampire bats, since both types can exist simultaneously in an area. It is also a human health problem because close to 180 human rabies deaths attributed to vampire bat bites have been reported from several Latin American countries since the Trinidad outbreak in 1929.

There are three species of vampire bats and the common vampire, Desmodus rotundus, is the most important transmitter of rabies. Desmodus is found from sea level to altitudes above 3 000 metres. It normally inhabits caves and trees in a wide variety of ecosystems including savannahs, swamps, deserts, forests and, not uncommonly, cities. It lives in colonies of small groups of 50 to 1000 or more. It is uncommon in forests where there is little livestock, but its numbers increase with the introduction of domestic animals. Vampire bats were probably not numerous before the introduction of livestock into the Americas, and present high populations appear to be linked to the increasing cattle population. This introduction implies an almost inexhaustible and varied food supply. Moreover, the presence of bats is favoured by an accompanying increased variety of man-made roosts such as mines, tunnels, culverts, buildings, steeples and archeological ruins.

Despite species plasticity and their specialized anatomy, vampire bats are fragile. They have an unusually lengthy gestation period of 7 1/2 months and produce a single young a year. These factors and a longevity of over 12 years suggest that once a population of Desmodus is reduced either by rabies or control measures its rate of recovery is slow.

Rabies in vampire bats appears to have existed for an unknown period before the discovery of America. Vampire bats must have fed on wild mammals and birds before the introduction of domestic animals into the New World. The present diet of Desmodus consists mainly of blood from domestic animals, wildlife and occasionally human beings. It selects livestock in preference to wild animals and prefers particular breeds of cattle under certain circumstances. In Trinidad the bat's usual victims are cattle, horses, donkeys, mules, sheep, pigs, dogs and man, while cats appear unaffected.

Laboratory studies in Mexico revealed that Desmodus will feed on such wild animals as armadillos, porcupines, opossums, raccoons, skunks, cave rats, coyotes, bats, a variety of birds including hawks and, surprisingly, also snakes (rattlesnakes, coral snakes and boas), lizards, crocodiles, turtles and large marine toads. Desmodus has significantly altered its feeding preferences within the last 400 years.

Such a catholic diet suggests that Desmodus is an opportunistic feeder preying upon the availability of livestock and wildlife. It further

indicates that the vampire bat is a true parasite, predator and vector of diseases to livestock and human beings. The bat is an excellent parasite since it neither causes excessive damage to its host nor depletes its food supply.

The rabies virus of vampire bats is also a well-adapted parasite since it lives in harmony with its host, requiring only resources to maintain its existence and ensure its transmission. Bovines are not suitable hosts since there is little opportunity for viral transmission to another host. In vampire bats, however, rabies virus is ideally located, living in the bat for extended periods. When the virus invades the salivary glands, it is ready for transmission during the course of normal feeding. The relationship between rabies virus and the vampire bat is probably the result of long evolution and indicates an unusual genetic resistance to the virus.

Rabies in vampire bats requires clarification since some characteristics are not accepted by all authorities. Overwhelming evidence indicates that vampire bats generally die of the disease although there are early reports of the salivary carrier state. Those reports indicated that many infected bats survived the infection; some bats were asymptomatic throughout the infection, others showed signs of paralysis and later recovered and some bats died. Reports of shedding rabies virus in the saliva may have been based on the incorrect identification of other viruses that have been frequently isolated from bat saliva. Studies show that there has been no isolation of rabies from salivary glands where brain specimens were also negative. Vampire bats appear to react to rabies virus as do other animals, with variable incubation periods and excretion of virus in the saliva being observed. After a variable incubation period the bats die, but asymptomatic transmission does not occur.

The results of earlier work might have been due to the lack of precision, not then possible, and those experiments should be repeated utilizing modern techniques and facilities. Studies should include the relationship between different serotypes and strains of rabies by monoclonal antibody techniques, which enable the analysis of viruses by selected monoclonal antibodies directed against specific determinants and permitting differentiation and identification of virus strains.

Viral studies in vampire bats also merit further study since it is not known whether the outbreaks in vampire bats are due to seasonal movements, bat-to-bat contact, increased pathogenicity, salivary excretion of the virus or other factors.

Host-preference studies of vampire bats should be continued, especially where new areas are being opened for livestock development. It is possible that unsuspected wildlife may be involved in a sylvatic rabies cycle.

Since vampire bats are found in two parts of the hemisphere where their habitat and ecology are so varied, it is strongly suggested that the above investigations be carried out in different countries from Mexico to Argentina. The detailed symptoms of rabies in livestock are described by Acha and Szyfres (1980) and Baer (1975). These references will provide a basis for any proposed studies.

1.2.3 Rabies in Europe

The prevailing type of rabies in most of Europe is strictly that of wildlife which can be characterized as follows:

- Main vector species is the red fox (*Vulpes vulpes*)
- Secondary involvement of dogs, cats, farm animals and other wildlife animals
- Cyclic occurrence (3-4 year cycle)
- Constant extension into new or previously infected territories at a steady pace (40 to 60 km/year) with natural barriers such as larger rivers and mountain ranges serving as temporary obstacles
- Control measures as applied to wildlife are limited and often ineffective.

During the last four decades rabies has invaded most European countries and is still progressing. It has crossed national borders and natural barriers in all directions and could not be stopped in any particular country.

The rabies situation in individual countries

Wildlife mediated rabies in Europe and in general is far from being satisfactorily controlled. During the last 3 decades Central Europe has been experiencing rhythmically occurring rabies epidemics which are typical for wildlife involvement. During the 5-year period from 1977-1981 well over 50 per cent of all rabies cases were registered in an area covered by the Federal Republic of Germany, German Democratic Republic, Austria and Switzerland. This territory comprising 481 000 km² - somewhat larger than the State of California - experienced an annual average of over 10 000 rabies cases representing 58% of the total cases registered in all Europe. Of those cases 86.8% occurred in wildlife, 1.9 per cent in dogs, 4% in cats and the rest in farm animals.

The rabies situation for total Europe is summarized (Table 1.3) from data collected by the WHO Rabies Collaborating Centre, Tübingen, from 26 countries participating in the European Rabies Surveillance System for the 5-year period of 1977-1981.

The highest number of rabies cases was recorded in the Federal Republic of Germany (29.4% of all recorded cases) followed by Austria (12.3%), France (9.8%), German Democratic Republic (9.4%), Turkey (8.8%), Switzerland (6.9%), Hungary (6.0%), Poland (5.6%), Czechoslovakia (5.0%) and Yugoslavia (4.4%).

Table 1.3: Reported Rabies cases of EUROPE by country and species, 1977-1981

Country	Dogs	Cats	Farm Animals	Wildlife	Human	Totals
Austria	42	201	395	10075	1	10714
Belgium	4	21	95	254	1*0	375
Bulgaria	-	-	1*1	-	-	1
Czechoslovakia	140	191	30	4043	-	4404
Denmark	-	-	47	326	-	373
Germ.Dem.Rep.	439	568	632	6550	1	8190
Fed.Rep.Germany	443	821	2103	22457	-	25824
Finland *2	-	-	-	-	-	0
France	221	316	1263	6732	2 *13	8534
Great Britain	-	-	-	-	2 *3	2
Greece	13	-	3	-	-	16
Hungary	97	179	86	4875	-	5237
Ireland *4	-	-	-	-	-	0
Italy	-	3	3	799	-	805
Luxembourg	2	8	52	166	-	228
Netherlands *5	1	-	-	2	-	3
Norway *6	-	-	-	18	-	18
Poland	257	474	331	3794	1	4857
Portugal *7	-	-	-	-	-	0
Romania *8	31	28	100	116	3	278
Spain *9	7	3	-	2	-	12
Sweden *10	-	-	-	-	-	0
Switzerland *11	40	446	578	5007	3	6074
Turkey	4678	470	2485	97	5 *12	7735
Yugoslavia	74	71	52	3610	4	3811
	6489	3800	8256	68923	23	87491
	= 7.4%	= 4.3%	= 9.4%	= 78.8%	0.1%	= 100%

without
TUR,GRE,
SPA 1791 =
2.2%

- *0 = acquired in Ruanda (dog)
- *1 = one case in border area (1977)
- *2 = rabies free since 1959
- *3 = acquired in India, rabies free since 1902
- *4 = rabies free since 1903
- *5 = no cases since 1978
- *6 = on island of Svalbard, no case of animal rabies ever occurred on Norway mainland
- *7 = rabies free since 1961
- *8 = no data for 1978/79
- *9 = in North Africa
- *10 = rabies free since 1871
- *11 = including Liechtenstein
- *12 = annual average is about 30 to 50 cases
- *13 = 1 case of corneal transplant
1 dog bite case imported from Tunisia.

The remaining 15 countries (2111 cases) comprise 2.4% of the total cases recorded in Europe. By decreasing order of rabies cases there are Italy (805), Belgium (375), Denmark (373), Rumania (278), Luxembourg (228), Norway (18), Greece (16), Spain (12), Netherlands (3), United Kingdom (2 imported human cases) and Bulgaria (1). No cases were recorded in Finland, Ireland, Portugal and Sweden.

A total of 3427 additional rabies cases in animals (not specified) occurred in the European parts of the Union of Soviet Socialist Republics during the 4-year period 1978-1981.

Involvement by animal species

Wildlife animals

Wildlife involvement averages at 78.8 per cent, ranging from 68 per cent (Belgium) to 99.3 per cent (Italy) in individual countries.

Foxes: The leading animal species of rabies in Europe is the red fox accounting for 74.1 per cent of all recorded cases. The involvement of the fox varies among individual countries. It is negligent to absent in countries such as Turkey, Greece and Spain, is moderate in Rumania (35 per cent), slightly below average in Belgium and Poland, and above average in the remaining countries. In absolute figures, the incidence of fox rabies was highest in the Federal Republic of Germany (19284 registered rabid foxes), followed by Austria (8385), France (6466), German Democratic Republic (5856), Hungary (4827), Switzerland (4239), Czechoslovakia (3838), Yugoslavia (3428), Poland (3161), Italy (675), Denmark (307), Belgium (241), Luxembourg (159), Rumania (98), Turkey (9), Netherlands (2) and Spain (2). In the 1980/81 rabies episode recorded in the Norwegian island of Svalbard, 14 rabid polar foxes were involved out of a total of 18 recognised animal cases.

It should be stressed, however, that the number of recorded fox cases represents just a fraction of the actual cases occurring in nature. According to estimates, 90 per cent or more of the rabid foxes go unrecognized because they are either not accessible or, when found dead, shot or run over by a car are not submitted for laboratory examination.

Mustelids: The badger (1633 recorded cases) and other mustelids (1858 recorded cases) such as stone and tree martens, pole cats, stoat, weasel and fish otter account for 4% of the total rabies cases.

The badger, despite being not too frequent in many parts of Europe, is a quite common victim of rabies of the fox with whom he often shares his living quarters.

Rabies among other mustelids is fox-dependent too. Their involvement was shown to be early within the front-wave movements of an epizootic and decreases thereafter. An independent cycle of infection among mustelids, namely martens, did not establish itself.

Deer: Due to their high numbers, roe deer and red deer are easily victimized by rabid foxes. Cervidae of Europe account for 3448 cases or 3.9 per cent of the total cases registered. Epidemiologically, deer, like cattle, are considered a dead end in the chain of infection.

Other wildlife species are less frequently found rabid. Carnivorous animals being occasionally reported are the arctic fox, jackal, coyote, wolf, European brown bear, raccoon dog and the wild cat. Other rare rabies incidents occurred among the raccoon, wild boar, mouflon, chamois, hedgehog, squirrel, marmot, hare, brown rat and mice, most of these species having no epidemiological importance in the spread of rabies.

Domestic animals

Rabies in domesticated animals is commonly observed both in urban type and wildlife rabies. In Europe it accounts for 21.2 per cent of the total rabies cases.

Dogs: There are at least two categories of European countries when canine rabies is concerned.

Urban type rabies is prevailing in Turkey, Greece, Spain, the USSR and the Maghreb countries of Northern Africa: Morocco and Algeria also belonging to the European Region of WHO. Wildlife or sylvatic type rabies is dominating in the rest of the continent. Eventually, Rumania and parts of Yugoslavia may be considered areas where both types of rabies occur independently.

In the 5 year period of 1977-1981, a total of 6489 dogs were diagnosed for rabies in European countries representing 7.4 per cent of the total rabies cases. If the rabies cases from Turkey, Greece and Spain are omitted from the totals there will be 1791 dog cases from all countries experiencing wildlife rabies accounting for only 2.2 per cent of the total rabies cases.

The involvement of dogs in Turkey where urban type rabies exists is 60.5 per cent. In Rumania dogs account for 11.2 per cent of all rabies cases.

In individual countries having wildlife rabies the incidence of dog rabies is considerably lower. For individual countries the involvement of dogs is in decreasing order as follows: German Democratic Republic (5.4%), Poland (5.3%), Czechoslovakia (3.2%), France (2.6%), Yugoslavia (1.9%), Hungary (1.9%), German Federal Republic (1.7%), Belgium (1.1%), Luxembourg (0.9%), Switzerland (0.7%) and Austria (0.4%).

No rabies cases were recorded in dogs in Denmark and Italy during the period 1977-1981.

Correlation of canine to human rabies

During the 5 year period, 23 human cases have been brought to our attention. The figures for Central Europe are most likely correct and complete. For Turkey, however, having canine rabies exclusively, at least another 150 human rabies deaths are estimated to have occurred during this period. This greatly changes the picture when human rabies is correlated with urban or sylvatic type rabies. In Turkey, 19.4 human cases occurred for each 1000 animal rabies cases, 60% of which were dog rabies. In all other European countries together this ratio is estimated at 0.3 human cases per 1000 animal cases, 78% being wildlife rabies. These figures are comparable to the data given for the Americas: 10.7 human rabies deaths per 1000 animal cases in Latin America (Table 1.1) and 0.4/1000 animal cases in the United States and Canada (Table 1.2).

Of the 23 human cases listed in Table 1.3, 8 cases cannot be accounted for as to the source of the exposing animal, though it is most likely that it may

be dogs (3 from Rumania and 5 from Turkey). Of the remaining 15 cases 10 (= 66%) were caused by dogs, 2 by foxes, 1 by a cat, 1 by cattle and 1 by corneal transplant. When omitting 4 human rabies deaths acquired abroad through dog bites, still over 50% of the cases were attributable to the dog. This clearly indicates that the dog is the main vector species in transmitting rabies to man, even though wildlife rabies is predominant and outnumbers canine rabies almost fortyfold.

The 11 human cases originating in European countries give rise to major concerns as to the awareness of both the public and the medical personnel regarding the potential dangers of rabies.

Of the 10 persons exposed to rabid animals only one received post-exposure treatment (serum plus 6 doses of Hempt vaccine) in time. In 3 further persons antirabies treatment was started only after symptoms had begun. One veterinarian had been pre-immunized with Duck Embryo Vaccine, but antibody levels had not been determined prior to or at the time of the exposure to the rabid animal.

According to the case histories 8 patients had not been aware of or were even negligent towards the risk of having contacted rabies.

Even more distressing is the fact that in 4 cases unawareness and even negligence may be attributed to responsible personnel. This includes the one case in which rabies was transmitted from human to human by corneal transplant.

This simply indicates that the awareness of the public and of professionals needs constantly to be raised and stirred by public information and education, especially in areas where dog rabies is rare.

Cats

On average, cats accounted for 4.3% of the total rabies cases in Europe (Table 1.3) ranging from 0.4% (Italy) to 10.1% (Rumania) in individual countries.

Their involvement in rabies appears to be lesser than dogs with an average ratio of 0.6 cat cases for every rabid dog. This does not hold true if again urban type rabies is considered separately from wildlife rabies. In Turkey, with urban type rabies, the cat/dog ratio is 0.1. In all other countries with predominant wild-type rabies the average ratio is 1.7, indicating that far more cats than dogs are found rabid when wildlife is involved. Countries with far beyond average cat/dog ratios (partly due to compulsory dog vaccination) are Switzerland (10.5), Belgium (5.1), Austria (4.8) and Luxembourg (4.0). These figures indicate that in wildlife rabies the cat is more frequently infected via rabid wild animals, namely the fox, than through contacts with rabid dogs.

It is common knowledge that rabies control efforts generally include cats as well as dogs, but are rarely if ever executed properly. Rabies vaccination of urban cats is of no importance in wildlife rabies, and is rarely applicable in rural areas. Free-roaming ownerless cats, not controlled or having been set free by their owners, have become a major nuisance in many parts of Central Europe. As discussed above, the awareness of the public needs to be raised and focused also on the potential danger of cats in transmitting wildlife rabies to man.

Farm animals

Among the domestic animals reported, rabid cattle rank highest (8021 cases = 9.2% of totals). In local epidemics, first rabies victims among grazing cattle are usually a good indicator that wildlife rabies is in the process of being established in that area. Quite often rabies is diagnosed in cattle sometime before the disease is recognized in foxes. Cattle and other non-carnivorous farm animals are believed to be dead ends in the infection chain. Human exposures, however, to symptomatic ruminants showing signs of 'faking' foreign bodies in the oesophagus have repeatedly resulted in mass treatments of people and in occasional cases of rabies in man. Rabies in cattle may cause heavy economic losses and preventive vaccinations may be seriously considered.

Rabies in horses is relatively rare but may eventually cause enormous public health efforts in evaluating all contacts especially when personnel, visitors, tourists, etc. have been exposed to riding horses.

1.2.4 Rabies in Africa

Rabies case data for a number of African countries are shown in Table 1.4. Dogs are responsible for the persistence and dissemination of rabies in North, East, West and Central African regions. The majority of recorded human deaths due to rabies is attributable to dogs. Under-reporting of animal cases especially in dogs is most likely to be responsible for the high overall percentage of human rabies in relation to animal rabies. The main reasons for this may be seen in the scarce number of available diagnostic facilities, often being too far away to be reached and sometimes being unable to perform satisfactorily because of breakdown of equipment or absence of trained personnel. Also, during the past 5 to 10 years, economic, social and political changes have drastically affected the capability of many countries to maintain their rabies control programmes including diagnostic services and surveillance. This and the increasing density and mobility of populations (human and canine) has resulted in a considerable increase in rabies in quite a few countries, and some areas such as western Kenya, from which rabies had been eradicated, have now become reinfected again.

Wildlife rabies seems to play an insignificant and only secondary role in most African countries, and it is sometimes suspected that cases in wild carnivores such as jackals occur only in close association with rabies in domesticated or stray dogs. It appears, however, that the role of wildlife cannot be properly assessed until canine rabies is brought under control.

A different situation exists in the south of the African continent, namely in the South African Republic, Namibia and Zimbabwe (Table 1.4). In these countries wildlife animals (felidae, yellow mongoose and jackal) play an important role in the epidemiology of rabies, being apparently chief vectors of the disease in circumscribed areas. The involvement of dogs and cats differs markedly as to the area involved and the dog must be considered therefore to represent either the vector of the disease or to be the victim of wildlife rabies. The occurrence of rabies in Kudu antelopes (*Tragelaphus strepsiceros*) is worth mentioning. Of 541 wildlife cases confirmed since 1977 in Namibia, 267 were registered in Kudu. Exceptional is that Kudu rabies, unlike that in cattle and deer, is apparently not a dead end infection. Horizontal spread among Kudu and also between Kudu and cattle seems to occur due to direct transmucosal transmission. The situation is further complicated by the fact that rabies-related viruses were isolated in

Table 1.4: Reported Rabies cases of AFRICA by country and species*

Country	Period (years)	Dogs	Cats	Farm Animals	Wildlife	Human	Totals
Algeria	1964-67	130	10	5	4	70	219
Tunisia	1964-65 '77, '79	430	26	52	1	38	547
Morocco	1958, 65-67	856	15	219	1	132	1223
Egypt	1958, 64-66	188	16	19	7	64	294
Ghana	1970, 77+79	446	-	3	-	113	562
Kenya	1958-65 1968-75 1977+79	198	11	52	40	13	314
Nigeria	1928-78	2453	75	32	3	340	2903
Angola	1953-68	935	32	33	18	1	1019
Botswana	1977+79	54	4	68	9	5	140
Cameroon	1964-67	148	2	-	1	9	160
Chad & Cent.Afr. Rep.	1964-68, 1970, 75	326	4	10	6	72	418
Congo (Brazzaville) formerly Belgium Congo	1964-67 1935-58	173 563	2 19	- 8	1 3	7 8	183 601
Kinshasa	1964-67	581	3	7	1	-	592
Ethiopia	1965-66, 1977+79	330	7	18	2	81	438
Madagascar	1964-68	136	5	5	-	4	150
Malawi	1964-68	646	32	52	9	29	768
Mali	1967, 1977+79	41	-	3	-	19	63
Rwanda- Burundi	1954-61	356	9	49	5	19	438
Sierra Leone	1966-68	21	-	2	-	10	33
Sudan	1935-45	638	-	77	71	155	941
Tanzania	1966-68	236	1	1	3	25	266
Uganda	1965-66	78	1	3	4	22	108
Zambia	1964	48	1	3	-	6	58
South Afr. Rep. +Namibia	1967-76, 1977+79	283	109	664	1234	4	2299
Rhodesia/ Zimbabwe	1966-67 1977+79	392	14	125	279	36	846

* These data are not complete and may not reflect the actual situation.

several instances from fruit-eating bats and insectivores in the Natal province of South Africa and from a dog and cats in Zimbabwe. The virus isolates from bats were shown by monoclonal antibodies to be of different serotypes, one resembling Duvenhage virus, an isolate from a human rabies case of that region believed to be a victim to bat exposure. A similar virus was obtained from a cat from Natal which, although vaccinated against rabies a few months before, showed typical signs of rabies. Preliminary experiments indicate that the rabies related viruses are apparently as pathogenic to dogs as classical rabies virus and that these viruses are also excreted in the saliva of experimentally infected dogs. Field isolates of dogs from Natal were shown not to be of bat origin by monoclonal antibody analysis. However, the involvement of other animals and of man in rabies, being caused by different serotypes, could pose a serious problem to public health authorities as to the proper diagnosis and the requirement of different types of vaccines. A serotype differential diagnosis can easily be achieved by monoclonal antibodies today. The preparation of a specific vaccine, however, would be subject to further investigations.

1.2.5 Rabies occurrence in Asia

The rabies problem in Asia is one of the oldest in the world and its major characteristic is the almost inestimable number of human and animal cases on the one side and a minimum of animal control activities on the other. One reason for this is certainly that there are only a limited number of centrally-located institutes often based on the concepts of Pasteur institutes which deal mainly with the production of rabies vaccine as well as diagnosis and post-exposure treatment of humans. Surveillance activities beyond that are often non-existent. Attempts to establish national or even regional programmes for the elimination of canine rabies must fail in most of these developing countries due to the following reasons:

- low priority for law enforcement of canine rabies control
- lack of interdisciplinary coordination. Usually there is no particular government agency to take full responsibility for rabies control programmes
- lack of vaccine for mass vaccination of dogs
- failure to control stray dog populations:
 - (a) the percentage of stray dogs annually eliminated in large metropolitan towns is quite insignificant,
 - (b) for cultural reasons people are reluctant or totally object to such measures.

The rabies situation as described below for India and other countries of South East Asia are given as examples representative for many countries of the Asian continent.

Rabies in India

Human rabies is prevalent in all parts of India and occurs throughout the year. Though reliable figures do not exist, the available information on human rabies and animal bite cases clearly indicates the leading role played by dogs in the maintenance and spread of rabies to other animals and to man.

According to local Indian studies, including thousands of people receiving antirabies treatment, between 92% and 97% were exposed by dog bites.

The magnitude of the Indian rabies problem may be derived from the estimate that each year approximately 3 million people are subject to rabies post-exposure treatment consuming more than 35 000 litres of vaccine. Human mortalities due to rabies are not known exactly, but are estimated to be in the order of 12 000-20 000 cases each year, this would correspond to a mortality rate of 1.7-3.3 per 100 000 inhabitants.

Rabies vaccine produced for animals is in the order of 8400 litres/year but is mainly used for curative purposes (i.e., after exposure) in farm animals such as water buffalo and cattle, rather than for preventive immunization of dogs.

Pet dogs are limited in number, the vast majority of dogs is either community owned or unowned (stray). From studies made in certain areas, a dog to human ratio of 1:35 was estimated resulting in a total dog population of 20-30 million, a figure which in reality may be much higher.

Besides domestic animals, a certain though low proportion of wildlife animals such as jackals, wolves and mongooses are suspected of having rabies and of transmitting the disease to man.

Institutions responsible for a systematic surveillance of rabies in the country do not exist. Only some laboratories examine animal brains for evidence of rabies infection. Rabies control activities are mainly based on the clinical diagnosis of the disease.

Nepal

Canine rabies is endemic since decades and the dog is responsible for more than 95 per cent of all bite cases leading to post-exposure treatment. During 1979-1981 a total of 5111 post-exposure treatments were recorded by 7 hospitals, 45 of which had a fatal outcome. In a study in the Kathmandu valley, out of a total of 3330 exposures 3214 were caused by dogs, 69 by monkeys, 23 each by cattle and jackals and one by a tiger.

A dog to human ratio of 1:6.5, with a high proportion of stray dogs, is hampering control efforts aiming at a reduction of the dog population.

Sri Lanka

The island of Sri Lanka has a population of approximately 15 million people and a dog to human ratio of 1:10. More than 70 per cent are semi-owned or stray dogs.

Since early 1950, rabies has become a serious public health problem. Between 1960 and 1980 the average rabies mortality was 243.4 human cases and 492 animal cases recorded per year. The average human death rate was 1.6 cases per 100 000 inhabitants.

To get an idea of the magnitude of the human rabies problem one should imagine that if the same conditions existed in the Federal Republic of Germany, having four times the territory and the population of Sri Lanka, rabies would then take an annual toll of approximately 1000 human lives. In reality, Germany has experienced 15 human rabies deaths in 32 years (1951-1982), eight cases of which were "imported" from countries having canine rabies exclusively.

Little is known of the extent of animal rabies, since only one fully functioning laboratory exists in the capital Colombo. Canine vaccination has been intensified since 1977, but the capacity (135 266 vaccinations and 37 733 destroyed dogs in 1981) needs to be considerably increased.

Thailand

Canine rabies is the principal problem resulting each year in at least 300 human rabies deaths (mortality rate 0.7 cases per 100 000 population) and 50-60 000 post-exposure treatments. The majority of the population are living in close contact with dogs and cats which are rarely vaccinated against rabies due to lack of knowledge, low economic status and a considerable shortage of vaccine. For diagnostic purposes, 15 laboratories operate in different regions enabling a reasonable surveillance picture of the rabies situation within the country (Table 1.5).

Indonesia

An analysis of the 5-year period 1976-1980 shows that the incidence of rabies in animals and man was highest in certain parts of the major islands of Sumatra, Java and Celebes. Dogs, estimated at 9.1 million (dog to human ratio 1:16), proved the predominant animal species infected with rabies (98.6%). During this period, a total of 84 895 animal bite cases were reported, of which approximately 50% resulted in post-exposure treatment. 313 human rabies deaths occurred, and among the treated people 85 cases of post-vaccinal encephalopathy were recorded (ratio 1:500) of which 42.3% died. The vaccine was a monkey brain nerve tissue vaccine.

Rabies is ever-increasing since it was first recognized in 1884. Today, out of 27 provinces only 7 are still free from rabies. Based on human rabies mortality figures, the average occurrence of 1 human case between 1947 and 1972 was 1 every 26 days, between 1973 and 1976 1 every 9 days, and between 1977 and 1978 1 every 5 days (the average estimate for India: 1 human case every 20-40 minutes).

Rabies in dogs and cats has been known for years, it is increasing in farm animals, but negligible so far in wildlife. The control of canine rabies is hampered by the lack of animal rabies vaccines (450 000 doses were provided in 1977/78) and other factors including the reluctant attitude of people towards the catching and killing of dogs.

Philippines

Rabies is present in all regions of the Philippines with the dog as the principal vector and with an increasing tendency: the annual average for human rabies was 44.7 cases during 1902-1910, 209.7 cases during 1946-1951 and 253 cases during 1958-1968. The annual rabies death rate per 100 000 population was 0.5-0.6 cases during 1973-1977.

The limited supply of animal vaccine restricts national control efforts to priority areas such as metropolitan Manila. Even here, dog vaccination combined with impounding and elimination of stray dogs is practised only in some commercial centres but is objected to in other and in rural areas.

Malaysia

This country is one of the few examples from Asia where rabies has been brought well under control.

Rabies was endemic in the northern states bordering to Thailand until 1953. In 1952, an outbreak extending deep into the country and threatening the capital Kuala Lumpur gave rise to a national programme of compulsory vaccination of all dogs in rabies infected states and destruction of unowned and unvaccinated dogs. Three immune belts were created: (1) along the Thai-Malaysian border for a depth of 50 miles (2) in the south opposite Singapore, and (3) in the middle (around Kuala Lumpur). From these belts, the vaccination was extending north and south thus gradually filling the gaps. Following the first year of vaccination, there were for the first time no human cases. In 1954/55 the country was free of rabies. Since its initiation, the immune belt in the north has been maintained until today. During the period 1956-1980, sporadic and isolated outbreaks occurred but remained confined to the Malaysia/Thailand border. During this 25 year period, 26 confirmed cases of rabies occurred in dogs, 1 in a cat, 1 in a goat, and 10 in humans.

This example demonstrates the success of aimed vaccination campaigns coupled with strict control of dog movements and removal of unwanted dogs. Favourable conditions include three long borders represented by sea shore, few stray dogs due to well established census methods, excellent cooperation between Malaysian authorities and the public, strong legislation including heavy fines for violations.

Table 1.5: Reported Rabies cases of ASIA by country and species*

Country	Year	Dogs	Cats	Farm Animals	Wildlife	Human	Totals
Bangladesh ⁰⁾	1979	8	1	1	-	-	10
India ⁰⁾	1979	72	-	9	2	14	97
Indonesia	1976-80	3872	29	14	8	313	4236
Iran ⁰⁾	1965-67, 77+79	215	7	48	43	58	371
Iraq	1977	-	1	-	-	-	1
Israel	1964-68, 79	89	1	95	6	-	191
Jordan	1979	1	-	-	-	-	1
Korea	1977	9	-	-	-	-	9
Laos	1979	40	3	-	2	1	46
Lebanon	1966-68	28	4	1	2	-	35
Malaysia	1970-80	21	1	-	-	9	31
Pakistan ⁰⁾	1977	8188	-	1000	503	22	9713
Philippines ⁰⁾	1946-51	614	-	-	-	1258	1872
Saudi Arabia	1979	-	1	1	2	1	5
Sri Lanka	1960-80	10334 ¹⁾	-	-	-	5112	15446
Thailand	1975-81	16926	671	33	47	672 ²⁾	18349
Viet Nam	1977 + 79	33244	83	-	-	95	33422

⁰⁾ Data for parts of country only

¹⁾ Dogs, cats, farm animals

²⁾ Only 1979 + 1980

* These data are not complete and may not reflect the actual situation.

1.3 Canine rabies control measures and trends in their application

1.3.1 Target animals of control programmes

Measures leading to the elimination of canine rabies reservoirs concern predominantly dogs and to a much lesser extent jackals and cats. In wide areas of the world conditions are favourable for complete elimination of canine rabies. This is particularly true for areas in which reservoirs of this disease in other animal species are absent and the proportion of stray dogs or nonsupervised dogs is low.

Control measures should be applied to canine rabies, irrespective of the presence or absence of rabies reservoirs in wildlife. Where wildlife rabies persists (e.g. in bats, mongooses, skunks, foxes or racoons), sporadic cases of canine rabies may continue to appear. Such spillovers of the infection from wildlife show, however, less tendency to spread within the canine population than outbreaks originating from a canine rabies reservoir. Rabies virus strains show a certain degree of adaptation to the principal reservoir species although this appears never to be absolute.

There may be exceptions to this rule in areas of widespread jackal rabies in Africa. The course of epidemics in eastern African states indicates that jackals easily establish chains of infection with virus strains from canine rabies and that jackals can thus become an integral part with full vector potential in a reservoir of canine rabies. Where such chains of infection, i.e., local epidemics, do occur in jackals, control of rabies in this species is indispensable for canine rabies elimination.

The role of wolves in areas of canine rabies reservoirs is less well understood. In view of the severity and magnitude of wolf bite episodes some countries take preventive measures against rabies in this species.

Felidae spp are more distantly related carnivores of the dog than jackals. This may explain why cats, although closely associated with dogs in urban ecosystems and often infected by rabid dogs, do not play an important role in the maintenance of chains of infection. In general cat rabies disappears as the disease is brought under control in the dog population. However, cats play a significant role as transmitters of rabies from its reservoir in dogs to man. Therefore preventive vaccination and other control measures should be applied to cats wherever possible.

1.3.2 Factors influencing epidemics and objectives of rabies control

In addition to the simple species composition of the canine rabies reservoir (see Section 1.3.1), other factors of rabies epidemiology, pathology and immunology favour the control of the disease in dog populations. With few epidemiologically insignificant exceptions, the virus is transmitted directly, the disease is always fatal, chronic cases or asymptomatic carriers do not exist, dog populations do not naturally establish a significant level of immunity, though mass vaccination establishes good protection, and specific diagnosis does not pose any difficulty. The bite and the aggression or paralysis of a dog is sufficient indication for man to react. In all these conditions canine rabies is comparable to smallpox and it is therefore not by accident that both diseases could be eliminated under various socio-economic conditions by applying classical measures reducing contact rates and by mass vaccination.

Canine rabies control programmes are therefore based on the following principles:

- a) Notification of suspected cases of canine rabies, killing of animals showing clinical signs or having been in close contact or bitten by a rabid or suspectedly rabid animal. In some countries "contact animals" can be exempted from destruction if they have been duly vaccinated prior to exposure. Post-exposure treatment of animals is prohibited in all effective control programmes, since this measure is considered inefficient and thus in conflict with all principles of control and the prevention of the risks for man.
- b) Reduction of contact rates between susceptible dogs. Classical procedures of veterinary control include quarantine measures, movement restriction (e.g., prohibition of free movement outside houses and farms, leashing, muzzling), surveillance of animals into and out of infected areas, etc. Spread between susceptible animals is greatly reduced by mass vaccination and possibly by stray dog control (see below).
- c) Mass immunization. Vaccination campaigns (annual or bi-annual) may be combined with continuing vaccination schemes for young dogs or be carried out as the only measure of mass immunization. Such campaigns can be extended to supervised as well as stray dogs. Marking of vaccinated dogs may be permanent (collar and tag, or tattooing), or temporary (paint, simple plastic collar) in order to facilitate removal of non-vaccinated animals throughout the year or for a limited period following the vaccination campaign.
- d) Stray dog control. Irrespective of the difficulty of defining the term stray dog under various anthropological and ecological conditions, special control measures are extended to dogs not in compliance with the regulations (e.g., not vaccinated or not confined to farm or house, not on leash). Most control programmes call for destruction of such dogs (unless the owner is prepared to pay a fine, etc.).
- e) Dog registration. This measure is often considered a basis for mass immunization and dog population control. In some countries, particularly where fees or taxes are associated with registration, this measure counteracts the desired community participation in rabies control. The application and efficiency of this measure depend, therefore, on many other factors.

On the other hand registration fees have influenced positively some national programmes, because they have promoted responsible ownerships of dogs and solved the financial part of stray dog control projects, as for instance in Cyprus, Portugal and Spain. A considerably heavier fee for female unsterilised dogs is a practical idea.

- f) Rabies diagnosis and surveillance. An epidemic surveillance system is, without doubt, an important instrument in rabies control, particularly for the effective and economic application of control measures in animals and post-exposure treatment in man.
- g) Mobilization of community participation. Public education and cooperation are essential for a wide range of activities in canine rabies control programmes.

- h) Technical cooperation at the international level is essential in resource mobilization and coordination of control activities (canine rabies elimination in border areas and measures governing the import of dogs, cats and other animals able to spread rabies, etc.).

1.3.3 Global review of canine rabies control

Dog rabies control up to the mid-century

Until 1950 dog rabies elimination was limited to countries in central and northern Europe. In the last century and the beginning of this century large areas of central, western and northern Europe became free of rabies. Scandinavian countries had already successfully brought the disease under control in the 19th century by destroying stray dogs and placing domesticated dogs in quarantine (1a). The veterinary services of Hungary showed, by first field trials in 1937 and a nationwide campaign from 1939 to 1944, that canine rabies can be eliminated in a well planned programme based on the mass vaccination of dogs in addition to the classical measures of movement and contact restriction and of stray dog control (5).

Since then mass vaccination of dogs has led to considerable success in many countries and territories, although such areas became reinfected from time to time and had to be freed again of the disease with enormous efforts, work and psychological burdens. Therefore worldwide and regional surveillance systems have been established and much attention has been given to international regulations for the transfer of animals.

Mass vaccination as a tool for dog rabies control: 1950-1970

From 1950 to 1970 a number of countries throughout the world brought rabies under control. In the nineteen fifties dog rabies elimination programmes were strengthened, in particular by the swift mass vaccination of dogs (following the example given by Hungary). Sporadic reappearance of dog rabies following a successful campaign was due to reintroduction from infected neighbouring areas or to spillover from rabies reservoirs in wildlife.

Malaysia (6, 7) was reported free of rabies in 1956, Japan (1a) in 1956, Hong Kong in 1956 (12), Province of Taiwan (China) (1a) in 1961, Portugal (1a) in 1961. Zimbabwe (8) became virtually free of the disease with only sporadic cases at its borders in 1961 (only two canine cases versus 129 recorded cases in dogs in 1952). Similarly, Uganda (9) reported a drop in the number of recorded cases from 55 in 1952 to 2 cases in 1961, and Israel (10) from an average of 64 cases annually for the years 1950-1959 to an average of 14 cases annually for 1960-1969. Only sporadic cases in dogs have been reported from the entire USA (1, 11, 21) since about 1968 (in that year 296 cases) so that the dog rabies reservoir, which was still the cause of over 5000 cases in dogs in the USA in 1953, can be considered as eliminated.

The latest decade of dog rabies control

Since 1970 new successful programmes of dog rabies control have become rare and have been limited mainly to Latin America and Europe. During the last decade, progress of countrywide programmes was mainly reported from South America where canine rabies was reduced to a border problem in Chile (2d). Many other areas in that region showed an improvement due to well designed national and regional projects. For example, the number of animal rabies cases dropped in the Province of Buenos Aires from 4759 in 1976 to 714 in 1979 (2c, 13).

Remaining foci of canine rabies were eliminated in European countries, namely in southern Italy 1971 (14), in Greece 1979 (15), and records from 1979-82 indicated that the dog rabies epidemic was close to its elimination or actually eliminated in the south of Yugoslavia (15).

Apart from these recent successes in Latin America and certain areas of Europe, very few reports have been received from other continents of successful dog rabies control programmes. Local efforts such as the project in Manila and in some islands and provinces of the Philippines (16) are exceptions and have been of transient success or have been restricted to limited areas due to the lack of extended national programmes.

Rabies control in reinfected areas

Outbreaks of dog rabies in previously rabies-free areas or countries always cause much public concern, activate great control efforts (and surveillance) and lead to considerable socio-economic consequences. It has taken months or even years for reintroduced rabies to be completely eliminated in several countries. Thus in the north-eastern part of Austria canine rabies was a problem for several years following the second world war (1a). A short epidemic of dog rabies caused four human deaths in Amsterdam in 1962 and almost all dogs in the country had to be vaccinated in a swift campaign (17).

On the island of Guam (18) an outbreak involving 90 cases of animal rabies was brought under control during 1967. An epidemic in the region of Malaga in Spain (15) lasted from 1975 to 1978. In Laredo, USA (19), on the Mexican border, energetic measures had to be taken to bring an outbreak involving at least 55 cases in dogs from November 1976 to June 1977 under control. Recently Hong Kong has been confronted with rabies in dogs and man due to an imported rabid dog.

Suspected cases or outbreaks called for extended programmes of containment and elimination in Belgium in 1961 (1a), in French Somalia 1962 (1a) and in Malaysia 1966 (1a) and 1970 (4). In two episodes in the United Kingdom in 1969 and 1970 (20) rabies was diagnosed in two dogs after release from quarantine. Unfortunately, most episodes of this sort are not detected so early, since services and population are often unaware of the risk. In such cases dog to dog transmission occurs covertly and regrettably the index case is often a case of rabies in man.

Conclusions for national programmes and international technical cooperation

Unfortunately, a negative conclusion must be drawn from the foregoing analysis, namely that country-wide and effective programmes of dog rabies elimination have become rare, with existing programmes lapsing and much needed programmes not being developed during the past 15 years, in spite of the availability of improved methods of surveillance and control and in spite of the increasing health significance of this disease.

Four coincidental reasons for this lack of progress may be identified, namely:

- a) the rapid scientific development in virology attracting and absorbing scientific resources in research on the virus, improved laboratory procedures (24, 26, 27), on more potent and safer vaccines for man (22, 23, 26, 27) and

on the epidemiology and control of wildlife rabies (24, 25). The fact that this trend led also to improved, inactivated and relatively thermostable vaccines for animals (23, 27) it has remained almost unnoticed in the developing countries and has had little or no impact on dog rabies elimination in these countries. Research and progress have mainly been directed towards conditions in the developed countries where most of the scientific institutes are located.

b) the satisfaction of experts and national authorities by the obvious effectiveness in some countries, of the classical instrument of "veterinary police" supplemented by mass vaccination. Thus, in 1972 the WHO Expert Committee on Rabies (23) did not see a special research problem with respect to dog rabies elimination. It has, however, now become apparent that only a limited number of countries were able to eliminate the disease, namely those in which the recommended standard procedure of dog rabies elimination could be applied without great difficulty. At a certain point, progress came to a standstill in most countries (perhaps with the exception of some countries in Europe and South America).

c) regulations are generally not fully observed in the daily work of health and veterinary services where coordinating principles and the frameworks and specific budgets of programmes are missing. Under such circumstances, vaccine potency or vaccine application may be inadequate or stray dog control ineffective. All this must be seen in the light of an enormous annual turnover of dog populations which calls for continuing efforts if rabies control is to be successful.

d) socio-economic analyses of the increasing expenses and other burdens of human post-exposure treatment and the effectiveness of the counteracting policy of eliminating the infection in its canine reservoir have not been made.

National programmes of dog rabies elimination will need our particular attention in view of the increasing costs of human post-exposure treatment. The offer of more potent and safer vaccines and of immunoglobulins is a temptation to place even more weight on the human post-exposure treatment (which may now be given almost indiscriminately) and to neglect animal rabies control. Such actions do nothing to reduce human exposures to rabies. The high cost of the current products for post-exposure treatment call for a critical assessment of this trend and of national investments in the different components of rabies prevention and control.

The current trend to deal with rabies by concentrating on human post-exposure treatment rather than dealing with the disease in the increasing dog population must be reversed without delay. There seems to be nothing more urgent in the field of rabies than the development of national programmes of dog rabies elimination and strategies and procedures for international cooperation.

It must therefore be the purpose of the following guide to re-orient research, to strengthen managerial processes of programme planning and execution, to ensure community cooperation, intersectoral cooperation and international technical cooperation and to improve, accordingly, legislation and international control procedures.

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1.4 Prevention of spread of canine rabies to rabies-free areas

1.4.1 Measures within infected countries

The spread of rabies was successfully prevented within infected countries by enforcement of classical methods of veterinary control, i.e. licensing of dogs, destruction of rabid and stray dogs, reduction of contact rates by movement restriction (leashing) and muzzling, and by ban, quarantine and/or veterinary observation for dogs from an area of higher level of risk of infection.

Thus large areas of Central, Western and Northern Europe became free of canine rabies in the last century and the beginning of this century. Even today countries still base the principles of their legislation and control operations on these early traditional methods of control. The veterinary services of Hungary showed, first by field trials in 1937 and then by a nationwide campaign from 1937 to 1944, that control operations can succeed even under difficult conditions if the classical measures are supplemented by mass vaccination of dogs.

In modern times the complex of classical measures, mass vaccination and public cooperation has to be considered as an integral part of national health plans. However, the international aspect has become most important because canine rabies control can only be effective and feasible if reintroduction of the disease across the borders of the country is prevented. National plans of rabies control, therefore, require coordination of control operations with neighbouring countries and enforcement of appropriate import regulations. Thus regulations and management of rabies control within a country, regulations and measures controlling the import of animals able to carry the disease national schemes of research, education and training (including programmes of public awareness) form a comprehensive programme for the prevention of the spread of the disease.

Legislative aspects are discussed in Chapter 4 and other components of national programme management in Chapter 3. The complexity of a programme is considered in particular in Section 3.4. Lack of one or more of the components of a national programme are often the reasons for the failure of disease control, despite all other efforts and the availability of services and materials.

Also, in respect of the international transfer of animals and the risk of the spread of the disease from country to country, often over long distances by air, sea, rail or road, direct measures through specific import regulations should only be considered as part of a comprehensive plan which also includes public cooperation, professional training, and, in some rabies-free countries, continuing compulsory vaccination of indigenous dogs and removal of unsupervised dogs. Recommendations for international transfer should therefore be understood as one of the components of a complete defence programme. Examples of such comprehensive programmes may be given by many countries, of which only Malaysia and the United Kingdom are mentioned in this manual for further reference (see Section 6.3).

1.4.2 Measures between countries

There are several principal measures used in preventing the spread of rabies into a country, namely:

- complete ban on import
- ban on importation from infected areas or countries

- licensing of import in each individual case
- vaccination of the animal prior to or on entry
- examination of health status of the animal in the country of origin
- certification of rabies-free status of country of origin or of area of origin
- quarantine
- veterinary surveillance and movement restrictions in the importing country
- vaccination of susceptible animal populations and destruction of non-vaccinated animals (dogs and cats or only dogs) in the importing country.

The specific measures depend on the epidemiological situation in the country of origin of the animal and neighbouring countries, the intensity of rabies surveillance in the country of origin and in countries visited prior to entry into the country of destination. Moreover, the animal's health and immune status has to be taken into consideration as well as the epidemiological situation and the possibilities of quarantine and veterinary surveillance in the country of destination.

The various conditions of risk, surveillance, control and prevention in both the country of origin and country of destination resulted in a great number of different national regulations which are even further modified by the preservation of archaic requirements, special bilateral agreements, economic considerations (e.g. of tourism), and a certain distrust in international disease reporting (ACHA and HUBBARD^{*}).

Exceptions are made in some countries for certain vaccine types or animal species. Alternatives are sometimes permitted for quarantine, vaccination and/or certification of health and origin. Requirements are even more complicated by limitations or extensions to a varying number of animal species: carnivores, domestic animals, wildlife, laboratory animals, bats, etc.

The lack of uniformity in the regulations controlling animal movement among various countries derives, therefore, from different origins. Although these have led to the present divergence or multiplicity of national requirements, there may yet be a reasonable basis for harmonization and simplification (see Section 6.5).

The "International Zoosanitary Code" of the International Office of Epizootics (OIE) and the "International Certificate of Vaccination against Rabies", as well as the specific recommendations of the WHO Expert Committee on Rabies try to harmonize and to provide all desired safety requirements facilitating the international transfer of animals (see Chapter 6). An attempt has been made by ACHA and HUBBARD (*) to introduce a new approach to the international management of rabies through animal movement:

^{*}International Management of Rabies, Chapter 17, in The Natural History of Rabies, G. Baer Edit., ACADEMIC PRESS, London 1975.

"Modifications of the present importation and quarantine laws are needed to permit an animal to enter a country without undergoing lengthy confinement in a quarantine station, provided the following requirements are met:

(a) The animal was vaccinated not less than 30 days and not more than one year prior to entry or disembarkation.

(b) The animal is accompanied by an acceptable vaccination certificate, which includes the name of the vaccine manufacturer, type of vaccine, control lot number, expiration date, and pertinent identification information of the animal, as stated by the World Health Organization Expert Committee on Rabies (1973).

(c) The certificate is affixed to the immigration documents of its owner until removed by the proper authorities.

(d) The animal is under house or leash confinement for a minimum of 120 days and under surveillance at least twice monthly by local health or law enforcement authorities nearest the place of residence of the owner.

Specific details governing the critical provisions of the regulations can easily be spelled out, including the use of acceptable vaccines (and quality control of the vaccines), use of the vaccination certificate and adequate surveillance procedures by local officials.

Recommendations for most of these criteria are now available in reports by expert committees of international agencies or in the scientific literature, as expressed by the World Health Organization Expert Committee on Rabies (1973)."

The attachment of the certificates to the personal travel document and the 4 months restriction and observation of the animal in the country of destination are the two new elements of this proposal, which is considered in the requirements recommended in Section 6.6.

WHO issues biennially an update of the "Animal Import Regulations with Regard to Rabies."*

Ban on import

Non-infected countries, particularly if their geographical situation as an island facilitates and justifies strict measures of epidemiological defence and if resources and services do not permit the establishment of quarantine and surveillance, tend to apply a complete ban on import of dogs, cats and sometimes other carnivores from all infected countries or from specified infected countries.

Transfer is generally easier from non-infected to non-infected country. The list of countries of origin which are fully recognized by the country of destination as being free of the disease is often very limited and sometimes

* WHO unpublished document WHO/Rabies/78.185, Geneva.

depends on mutual agreements and special trans-shipment regulations to ensure safety. In fact, the definition of what should be called a rabies-infected or rabies-free country does not always follow the International Zoosanitary Code (Section 6.3.2). A country may be considered free from rabies if no case of rabies was recorded for at least 6 months, 2 years or even 10 years prior to the export of animals.

Some non-infected countries impose a ban only on import from infected areas, i.e. if a case of rabies was recorded during a period of 6 or 12 months prior to export at a distance of less than 25 or 100 km from the place of origin of the animal.

Also a number of infected countries ban import from infected areas if rabies cases have been observed during 6 weeks or 6 months prior to export, whereas the transfer of animals between infected countries is nowhere completely prohibited but subject to certain requirements.

Quarantine

General principles

Certain principles can be seen in the application of quarantine measures:

- (a) Quarantine may supplement a partial ban on import. In this case quarantine periods extend up to 6 or even 12 months. These measures are mainly taken by rabies-free countries.
- (b) Quarantine is often imposed where a prescribed minimum interval between time of vaccination and entry has not yet elapsed. Animals not vaccinated in due time prior to entry, or non-vaccinated animals, may thus be subject to quarantine for periods which are often relatively short (several weeks) and depend also on the area of origin of the animal. These measures are mainly taken by rabies-infected countries. Some countries offer vaccination in due time prior to entry as an alternative to quarantine.
- (c) Quarantine may have to be imposed if required certificates of health and epidemiological status of area of origin are not produced at entry. Length of quarantine in this case depends on the implications of this lack of information for (a) and (b) above.
- (d) Quarantine may be imposed for a combination of reasons, considering also the epidemiological situation and the traffic with countries from which most animals come.
- (e) In general, quarantine measures are most stringent for dogs and cats, though in some countries they are less stringent or not required for cats and other animals. A number of countries require quarantine also for other animals.

Depending on the geographical situation and epidemiological conditions in neighbouring countries, quarantine has been established by some rabies-free countries as the most forceful measure. The United Kingdom and Ireland require 6 months' quarantine for animals from all countries combined with vaccination on entry into quarantine and again 1 month later. They do not, therefore, require vaccination prior to entry or any certificate of health or origin of the exporting country.

This procedure is considered safe by other countries or territories which rely on quarantine in the United Kingdom or other rabies-free countries before export to themselves because they cannot provide these facilities (e.g. islands of the West Indies, except Granada which is infected and Barbados). In fact, the complete ban by these countries on import, with the exception of import from the United Kingdom, indirectly recognizes and endorses the quarantine measures taken in the United Kingdom (e.g. by countries not specifically imposing quarantine such as Ireland, Australia and New Zealand). The requirements set up between these countries and regulations of other countries permitting free importation from such countries (e.g. St. Lucia, Guam, New Caledonia, Barbados and Gibraltar) without quarantine or with relatively short periods of quarantine on arrival (e.g. 30 days in New Zealand, at least 10 days in New Caledonia for dogs and cats imported by air from the United Kingdom) form a network of interlinked countries which base their safety on the rabies-free status of United Kingdom and Ireland (New Caledonia requires rabies-free status for at least 10 years) and the quarantine measures instituted by the United Kingdom and Ireland.

Other rabies-free countries with their own facilities permit importation under varying conditions which are listed below, from infected countries and from rabies-free countries which are not especially recognized:

- 6 months' quarantine without any pre-requisite (no vaccination, no certificate of health or rabies-free status or area of origin)
- 6 months' quarantine and vaccination prior to entry
- 6 months' quarantine and vaccination not less than 2 months prior to entry as well as certificate of health and rabies-free status of area of origin or vaccination as an alternative to quarantine
- from less than 12 hours' to 12 months' quarantine, depending on the country of origin, vaccination status, certificate of health and rabies-free status of area of origin
- special import permit and 4 months' quarantine (with exceptions), followed by 2 months' restraint on leash at destination
- 4 months' quarantine (with exceptions) without pre-requisites or requiring vaccination in due time (e.g. 3 months) prior to entry
- 30 days' quarantine and certificate of health, or 20 days' quarantine as an alternative to vaccination prior to entry, and certification of health and rabies-free status of area of origin.

A few rabies-free countries do not require quarantine but only valid vaccination or vaccination combined with a health certificate or, in addition, a certificate of rabies-free status of area or origin.

Many infected countries take measures to ensure that properly immunized animals enter the country from areas which are rabies-free. If one of these two requirements is not met, or conditions are difficult to verify, quarantine periods are generally prescribed. These can be listed in the following categories:

- (i) 2-6 months' quarantine with proper vaccination before entry if the dog or cat comes from an infected area or country. As an alternative to quarantine, vaccination may be offered by some countries if the animal is accompanied by a health certificate and a certificate stating that the country of origin is free of rabies.

- (ii) up to 2 months' quarantine: such relatively short quarantine periods are common in infected countries and are often related to lack of vaccination or too short a period between the time of vaccination and entry.

Vaccination

Most countries and territories which permit the import of rabies susceptible animals require vaccination against the disease. Quarantine serves in many countries as a relatively safe alternative to vaccination.

Some rabies-free countries do not insist on vaccination if the import of animals is limited to those coming from rabies-free countries which have also established a ban on import or stringent quarantine measures.

Some rabies-free territories require vaccination prior to departure although the import is only permitted from selected countries belonging to the network of "safe" rabies-free territories. Protection during travel seems to be the reason for this additional safety measure. Some rabies-free countries or territories combine vaccination prior to entry with quarantine. This combination can be variable, so that lack of periods of valid vaccination prior to import can be compensated for by corresponding extension of the length of quarantine, particularly if the animals come from infected countries.

Extended intervals of 2 or even 6 months between the time of vaccination and entry are, however, required by some infected, or occasionally infected, countries which do not impose quarantine.

Most infected countries permit import if the animal has been vaccinated at least 1 month prior to entry. Few countries permit shorter intervals of 15 or 21 days.

The vaccine type used to immunize the animal is specified in some national regulations, though most of them follow the International Zoosanitary Code (Section 6.2.2) and the recommendations of the WHO Expert Committee on Rabies*. The long-lasting immunity conferred on dogs by live attenuated viruses (Flury, SAD or Kelev) is reflected in the validity period of vaccination certificates of 2 or even 3 years. One country recognizes for 2 years a specified inactivated tissue culture vaccine. Periods of less than 12 months between time of vaccination and import (maximum 6 or 9-10 months) are required by some countries for certain inactivated vaccines, especially those containing phenolized nervous tissue.

Certificate of health and of origin/rabies-free status of country or area of origin

A certificate of health is required by most countries, a certificate of origin is required by fewer countries. However, in the latter case, the certification of the rabies-free status of the country or area of origin is often replaced by other requirements considering the epidemiological status of the country or area of origin. It is often the importing country which determines the status of the country of origin under the stipulation of individual import licenses and requirements of quarantine and vaccination for animals originating from specified countries.

* WHO Technical Report Series: Seventh Report of the WHO Expert Committee on Rabies (in press).

In general, certificates of health and origin are required if animals come from rabies-infected countries or from countries which permit import from infected countries. Some countries adapt measures to the epidemiological status of the country and/or area of origin, whereby the rabies-free status and size of the area of origin are defined by time (e.g. 6 or 12 months) and radius around the place of origin (e.g. 20 kms, 24 kms or 100 kms). Certificates of both health and origin are generally required in conjunction with vaccination. A number of countries link vaccination only with certification of health, in others both certificates may substitute for vaccination prior to entry.

Some countries combine quarantine with certificates of health, others with certificates of origin, and others with both certificates.

SUMMARY OF HUMAN RABIES DATA, WORLDWIDE

A. Human Rabies Case Mortality; Annual Averages (based on Tables 1.1-1.5)

Continent	Cases Annual Average	Range of Cases/Country + year
Latin America	251.4	0 - 105
North America	2.1	0.09 - 2
Europe	2.8 ^{x)}	0 - 0.8
Africa	9.8	0.3 - 44
Asia	86.4 (263) ^{xx)}	0 - 336

x) without Turkey and imported cases

xx) data in brackets for Philippines, Sri Lanka + Thailand

B. Human Rabies Case Mortality by Reported Animal Cases and Species Based on Tables 1.1-1.5

Continent or Country	Human Mortality/ 1000 animal cases	% involvement of main vector species
Europe	0.3/1000	78.8 % wildlife
Turkey (30-50 human cases/year)	20-30 /1000	60.5 % dogs
North America	0.5/1000	76.5 % wildlife
Latin America	10.7/1000	76.5 % dogs
Africa	82.7/1000	68.6 % dogs
Asia	35.8/1000	92.6 % dogs

C. Estimated Annual Human Rabies Mortality Rates per 100 000 InhabitantsEurope

Austria	0.003	Switzerland	0.009
GDR	0.001	Turkey	0.07 - 0.17
Romania	0.003	Yugoslavia	0.004

America

Brazil	0.10	Honduras	0.13
Ecuador	0.27	Mexico	0.10
El Salvador	0.24	USA	0.001

Asia

India	1.7 - 3.3	Philippines	0.5 - 0.6
Indonesia	0.05	Sri Lanka	1.62
Nepal	0.12	Thailand	0.71

Africa

Algeria	0.10	Mali	0.11
Botswana	0.36	Morocco	0.25
Cameroon	0.04	Sudan	0.08
Congo (Brazzaville)	0.14	Tanzania	0.06
Egypt	0.04	Tunisia	0.16
Ethiopia	0.07	Uganda	0.10
Ghana	0.38	Zambia	0.12
Malawi	0.11	Zimbabwe	0.14

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2. THE DOG POPULATION IN URBAN AND RURAL AREAS

2.1 Introduction

Any decision made by responsible authorities concerning dog rabies control should be based on cost-benefit analysis. Cost and benefit of particular control strategies cannot be estimated without knowledge about the involvement of different species in the epizootic, the size and turnover of the dog population concerned, the degree of supervision of owned dogs, the proportion of unowned animals in the dog population, the origin of unowned dogs, the accessibility of dogs for control and vaccination campaigns and the public attitude towards dogs and control measures. Also of great importance is an understanding of the habitat with its man-made resources (food, water, shelter) supporting a variable number of unowned and owned unsupervised dogs. Part of the information can be gathered by simple means (e.g. questionnaire surveys) but the majority of data needs establishing by time-consuming field observations using wildlife techniques. These efforts are not purely academic; on the contrary, they will lead to the selection of optimal strategies of disease control. Before discussing more complex studies a few suggestions will be made in the following section on how some information on the dog population parameters can be obtained by simple means.

Information collected by these simple methods may suffice for administrative purposes and possibly for the planning of rabies control campaigns. More precise knowledge is not easy to obtain. Nobody expects that the biology of rabies virus can be elucidated by anybody except a virologist. The genome of a dog is about 100 000 times bigger than that of a rabies virus. The dogs morphology, physiology and behaviour are correspondingly more complicated. Unfortunately zoologists have been slow to study domestic animals. The following pages are intended to stimulate their interest. Suggestions are made concerning how several different and fascinating questions can be tackled by using methods of wildlife research and field anthropology. The acquisition of new knowledge concerning the abundance, habitat requirements, movement, dynamics and behaviour of dogs, along with sociological data regarding dog-human relationships, will result in a significantly better understanding of:

- a) the incidence and persistence of dog rabies in urban and rural communities in relation to dog population densities and demography
- b) the parameters of physical environments responsible for variable dog population densities, the conditions under which susceptible dog populations occur and the ecological requirements necessary to sustain these populations
- c) the relationship between dog movement, dog social interactions, and rabies transmission between individuals within populations and the spread of the disease into new areas
- d) regional or local sociological and cultural practices that result in the presence of dog populations susceptible to rabies and cultural activities leading to endemic dog rabies situations
- e) dog demography, ecology, behaviour and human cultural practices as related to the effectiveness of dog control and rabies vaccination programmes.

Very few urban or rural dog population studies have been published, and none have had as major objectives the relationship between dog ecology and behaviour, human cultural attitudes and the occurrence of rabies in dogs. However, several describe methodologies for the collection of data relating to density estimates, demography, movement, social interactions and behaviour, and sources of food and shelter. Most of the methods used to obtain these data were adapted from previously developed techniques for the study of wildlife species in natural habitats. Many wildlife techniques may be used or modified for studying urban or rural dog populations. Publications and journals that summarize or publish wildlife techniques and indexed wildlife bibliographies are available in many university or public libraries and at biological research centres. Because the study of dog populations has received little attention, virtually no standardized field techniques are available that have been proved, through replication, to reliably measure various population parameters. Thus, a great need exists to develop and evaluate such techniques using pilot studies that can later be expanded upon and applied in a number of areas where dog rabies is a problem. For these reasons, it is not feasible to present specific and detailed outlines for conducting population studies. The following guidelines are therefore intended to serve as a basis for the design of field studies that will hopefully result in practical protocols for future use.

The following sections on the different aspects of dog ecology include a short introduction, a summary of available techniques to investigate the respective aspects and a brief review of the actual knowledge. In the introduction the problems are defined. A few indications of their significance for practical dog or disease control are given. Information on the subject is usually gained by two different types of approach. One approach uses the techniques of wildlife biology, the other the methods of anthropological or sociological inquiries. The methods for investigating wildlife populations and wildlife habitats are continuously improved. The fourth edition of the "Wildlife Techniques Manual" (Schemnitz, 1980) covers the present state of the art. Comprehensive guidelines for the elaboration of questionnaires and their use in surveys do not exist so far. Useful hints can be found in the "Interviewer's Manual" published by the Institute for Social Research in Ann Arbor (1969) and in Sellitz et al. (1976). Questionnaires for gathering dog population data and for assessing human attitudes towards dogs have to be designed very carefully in order to get interpretable answers and to minimize ambiguity. Questions should be formulated so that people are not tempted to answer what they think the interviewer would like to hear. The majority of studies published on ecological aspects of dog populations were done in North America. Some cultural aspects of dog-man relations were also recorded in other areas, e.g., in Africa (Frank, 1965), Australia (Meggitt, 1965), and Polynesia (Luomala, 1960).

2.2 A short programme for the collection of information on dog populations and some general considerations

The most important items of information on dog populations for planning and surveillance of rabies control measures are as follows:

a) Abundance

Where the number of owned dogs is not registered by licensing, it may be estimated by questionnaire surveys. An example of an abbreviated survey questionnaire is in Annex 2.4. Care has to be taken that randomly selected respondents from representative human populations are interviewed. A minimum number of unowned or unsupervised dogs can be estimated by street counts. In

order to do that representative districts of the areas under study have to be chosen. These can be a number of streets, or quadrants. In these sample districts all dogs must be counted during the time when the maximum number of individuals is active and visible. If a known number of dogs wearing collars or tags is in the sampled sections, a much more precise census can be made. For details see Section 2.3.1 of this chapter.

b) Ratio of owned versus unowned dogs

It is important to know the ratio in order to estimate the percentage of dogs accessible for vaccination. A ratio can be calculated if the number of owned dogs is established and the total population is reasonably well estimated by comprehensive investigation (e.g. by marking and recapture). Another most simple procedure estimates the two classes of owned and unowned dogs in an area through enquiry.

One might assume that people are well aware of the dog situation in their neighbourhood. Selected respondents may be asked the following questions:

- how many dogs are in your neighbourhood?
- how many of them are owned by yourself, how many by your neighbours?
- how many are unowned?
- (or: what percentage of dogs you see in your neighbourhood are unowned dogs?).

c) Dog population turnover

This information is important for determining the frequency of vaccination campaigns. Facts on reproduction and longevity of owned dogs can be gathered by questionnaire (see Annex 2.3 for example). Some (possibly biased) data on the age structure of stray dog population can be obtained by examining the tooth wear of killed or impounded stray dogs.

2.3 Abundance

Dog abundance is related to different epidemiological situations, to different culture areas, to different rural and urban habitats, to areas of different human settlement patterns and also to different social strata of human rural and urban populations. Dog population density is commonly indicated as a dog to human ratio, occasionally also as dogs per household. In many situations it would be more meaningful to express it as the numbers of dogs per unit area, or to have it related to both surface area and human population.

The practical importance of investigating dog population sizes seems clear. The knowledge of the numbers of owned dogs and of the abundance of unowned dogs is a prerequisite for the planning of animal control and vaccination campaigns and for epidemiological and ecological studies.

2.3.1 Techniques

The numbers of owned dogs may be established by questionnaire surveys, or from the records of licensing of dogs (Schurrenberger et al., 1961; Marx and Furcolow, 1969; Kelly, 1980; Nassar and Mosier, 1980; Rangel et al., 1981; WHO studies in the Philippines, in the US-Mexico border area, and in North Africa) or during dog vaccination campaigns (Beran et al., 1972). If there is any indication that a sizeable proportion of a dog population escapes these censusing procedures, the techniques used for estimating wildlife abundance have to be applied. Various methods are available for estimating the number of free-roaming carnivores, all of which are based on two assumptions (Caughley, 1977; Davis and Winstead, 1980):

- that mortality, emigration and recruitment into the population are minimal during the period of census, or that corrective factors can be incorporated into resultant estimates.
- that all individuals within the population to be estimated have an equal chance of being counted.

Techniques that can be used to obtain estimates of dog densities include:

a) Total or direct counts. This method simply consists of making direct visual counts of individual dogs in a defined geographical area and within a limited period of time in order to meet the assumptions mentioned above. Direct counts are not practical over large geographical areas nor in sizeable cities but can be used in small communities and rural situations where dog populations are small (Gipson, 1982). Under certain conditions, estimates of density may also be obtained by counting dogs along stratified samples of randomly selected streets or in quadrants. These data can then be extrapolated to the entire study area. If this technique is used, it is important that statistical expertise be obtained to determine appropriate sampling procedures and data analyses. In some circumstances, data derived from this technique (and several others discussed below) may also be used to compare dog densities between areas when expressed, for example, as the mean number of dogs observed per unit of land area (e.g. dogs/hectare).

b) Estimates from rate of capture. Assuming certain constraints such as a closed population, equal intensity of capture effort and probability of capture, and unvaried environmental conditions, estimates of dog populations can be obtained by plotting on graph paper either the sum of daily captures, the cumulative sum of captures, the probability of

capture or the catch-effort required. Plots can be smoothed and/or extrapolated to provide estimates of dog population size. More complete explanations of these procedures and examples of each are shown in chapter 14 of a wildlife techniques manual published by the Wildlife Society (Schemnitz, 1980; Davis and Winstead, 1980; see also Caughley, 1977, and Annex 2.3). Studies are needed to determine if these techniques could be used in conjunction with stray dog elimination programmes.

c) Estimates from recaptures. The reliability of these techniques are dependent upon the same constraints as mentioned in (b) above. They are commonly known as the "Peterson-Jackson" or "Lincoln" index and are based on the use of a simple ratio obtained by capturing a number of individuals, marking or tagging them, and releasing them back into the population. The population is subsequently sampled again by trapping and the total dogs caught and the numbers that are marked are determined. The population estimate is then obtained as follows:

$$\begin{array}{rcl}
 \text{Estimated dog population} & = & \frac{\text{No. dogs subsequently caught}}{\frac{\text{No. dogs caught, marked and released}}{\text{No. marked dogs recaptured}}} \\
 \text{or} & & \\
 \text{Estimated dog population} & = & \frac{\text{No. dogs initially trapped, marked and released} \times \text{Total no. of dogs subsequently caught}}{\text{No. marked dogs recaptured}}
 \end{array}$$

The statistical procedure currently described as the most suitable for analysis of capture-recapture data should be consulted (Jolly, 1965; Caughley, 1977).

Dogs in urban areas do not have to be physically captured in order to mark them. Studies in Baltimore, MD and Newark, NJ, USA (Beck, 1973; Heussner et al 1978; Daniels, 1980) used a method whereby dogs were "marked" by photographing them. Subsequent sampling then determined the number of "recaptures" on any given day based on the number of dogs that had been photographed previously. In these studies a modification of Schnabel's statistical analysis for multiple recaptures (Day et al., 1980) was used (Hanson 1967, 1968; Beck, 1982; see also Annex 2.3). This technique has the advantage of reducing sampling error since capture ratios are averaged.

The Baltimore study (Beck, 1973) employed several alternate methods for estimating dog abundance and compared the numerical values derived from each as a measure of their validity (Annex 2.3). Such comparisons are recommended when uncertainty exists as to which method of population estimation is most suitable for a given situation. While the photographic multiple recapture method may be suitable for smaller areas where the dog population consists of mixed breeds and individuals can be distinguished on the basis of colour, identifying markings and size, native dogs in some geographic areas are more physically uniform in appearance and distinguishing individuals would be difficult or impossible. In such areas, physically marking individuals may be

necessary. Depending upon local acceptance, this can be done in urban areas, where dogs are less wary, by using a commercially available livestock-marking pistol that fires paint balls containing different colour paints. CO₂-activated rifles that fire a dart containing a marking paint are also available. Tree marking paint can be propelled in a stream for considerable distances using a hand-held squirt can. Another way to mark dogs for later derivation of population estimates is to place permanently affixed coloured collars on dogs at the time rabies vaccination programmes are implemented. Subsequent observations can be made to gather data for calculating density estimates and these data can also be used to determine the percent of free-roaming dogs that have been vaccinated (i.e., programme efficacy). A number of other techniques for permanently or temporarily marking wild mammals have been described and summarized (Day et al., 1980), some of which could be used to mark dogs captured in rural habitats. The semi-permanent marking of claws and hair by oral ingestion of a bait containing rhodamine B (Johns and Pan, 1982), and marking the blood with oral (via baits) administration of an iodine compound (iophenoxic acid) or mirex (Larson et al., 1981) have been described for wild canids but not for domestic dogs. The latter two techniques may have application providing that the number of dogs consuming treated bait is known.

d) Indices. These techniques involve establishing a relationship between the numbers of animals present in an area in relation to some measureable environmental factor. So far the only published attempt to establish relative figures of dog abundance and distribution in a city used the number of sightings of dogs at large by school children in Bristol, United Kingdom (Harris, 1981). Examples of indices used for wild canids are the number of dens observed per unit of land area (dens/hectare), the number of tracks counted crossing roadways (tracks/kilometer), and the number of canid visitations to odour or "scent" stations placed out at regular intervals and checked daily for tracks left at stations (station night/visit) (Roughton and Sweeny, 1982). While such techniques were developed for application in rural areas, modification for urban use to obtain indices of relative dog abundance may be feasible. For example, the removal or marking of all dog faeces along sample roadways and subsequent counts of fresh or unmarked deposits for a set number of days (no. faeces/km/day) immediately before and after an intensive stray dog elimination programme, may be a feasible technique. The difference between the number of old and new deposits should be directly proportional to the reduction in street dogs and thus provide an indicator of the percentage of dogs removed, even though the size of the original population was unknown. Another index which could possibly be used is the widely recorded frequency of reported dog bites in relation to the dogs present in an area. But this figure depends on a great variety of factors (Marr et al., 1979). Indices of relative abundance generally require less effort to obtain than actual densities and are particularly valuable for determining changes in population size over time or for comparisons between environmentally similar areas. As with all other techniques previously discussed, certain assumptions must be made in order to obtain valid indices.

The density and distribution of dogs, whether in urban or rural areas, will vary depending upon environmental factors, availability of food, water and shelter, and human cultural practices and customs. Because of these variations, the selection of sampling "units" or methods of stratification of study areas, the results of which are later extrapolated to estimate total densities, must be carefully considered.

For example, the commonly used procedure of sampling to obtain a dog to human ratio and applying it to the total human population in a city to estimate total dog numbers, does not take into account variations in the frequency of dog ownership as a result of such factors as economic status. Sampling procedures are therefore an extremely important component of population estimation techniques.

While a number of methods are commonly used to estimate wildlife population densities in natural habitats, similar procedures for dog populations have not been adequately evaluated. Thus, further research is needed to devise standardized procedures that can be used in a wide variety of situations.

2.3.2 Observations

Reliable estimates for dog populations are still rare. In general, American and European countries report a dog to human ratio between 1:10 and 1:6. But there is no doubt that the abundance of dogs varies considerably from country to country and within geographical regions within countries. A striking example is given by Ezeokoli et al. (1982) for Kaduna State in Nigeria. In northern Kaduna State there is less than 1 dog per 1000 inhabitants, while in southern parts of the same state the dog to human ratio lies between 1:27 and 1:3. In different areas of Mexico City the ratio varies between 1:10 and 1:1 (Rangel et al., 1981). In developed countries the variation of the pet dog population is usually directly related to the income and the vigour of the economy (Franti et al., 1974; Purvis and Otto, 1976). As a general rule, the ratio of owned dogs to people is greater in the more rural regions of a country.

In urban areas of North America and Europe the breeding success of ownerless dogs is very low (Beck, 1973). In these cities the stray dog populations are the product of released, lost, and abandoned owned animals (Beck, 1973, 1974, 1975). In the same cities, most dogs found free ranging are owned, but unsupervised, animals. As a general rule in urban areas straying or loose pets are more common in low-income higher density areas, while ownerless stray dogs are more common in lower human density areas (Beck, 1973, 1974; see also Rangel et al., 1981; Harris, 1981). In study areas of Baltimore, Maryland, USA (Beck, 1973) and of Newark, New Jersey, USA (Daniels, 1980) the density of street dog populations (stray dogs plus loose pets) were estimated to be approximately 150 per square km. The density and origin of street dogs in cities of subtropical and tropical areas may be different from the situation described above.

Very little is known about the abundance of unowned stray and feral dogs in rural areas. A few reports indicate that unowned dogs in rural areas are found wherever they are looked for (McKnight, 1964).

2.4 Habitat

Dogs inhabit a great variety of different habitats. An analysis of these habitats should reveal the abundance, distribution and predictability of resources (shelter, water, food) for dogs. Once the resources determining the carrying capacity of a habitat are known, it might become possible to influence dog abundance by habitat control e.g., by removing an important food resource.

Considerable effort has been devoted to defining and quantifying wildlife habitats and relating habitat quality or "carrying capacity" to animal densities and distribution (Gysel and Lyon, 1980). However, similar parameters and techniques for evaluating dog habitats are lacking. One obvious difficulty, at least in urban areas, is that one segment of the dog population may be ownerless and completely free-roaming, thus relying entirely on the availability of shelter, food and water found on the street; whereas these needs are wholly supplied to another segment of the population by their owners. Ranging between these two extremes is a third component of the population whose requirements are met in varying degrees by both street and owner. Another problem complicating habitat analysis is that cultural practices may also vary widely, even within the same city, and this factor will greatly influence the quality and quantity of habitat, food and shelter.

Some of the more specific elements that comprise dog habitat in urban areas are

- Shelter. Number of vacant buildings accessible to dogs; land fills, dumps, parks, open space (including types of vegetation and percentage vegetated); streets, alleyways, parking lots; percentage of land area comprising private residences, apartments, retail businesses and industrial sites; number of resting or loafing areas (i.e., porches, stoops, stairs, passages, garages, yards, roofs, loading areas, etc.).
- Water. Number and extent of naturally occurring sources of water (springs, streams, rivers, lakes, standing rain water); man-made sources (fountains, piped sources, leaking hydrants, livestock watering tanks or wells, water placed out for dogs).
- Food. Number and size of garbage dumps and land fills, garbage piles left in street or in containers accessible to dogs, frequency of garbage collection, commercial open food markets, food handouts by humans.

2.4.1 Techniques

A great number of systems for the classification of natural and rural wildlife habitats has been published (Gysel and Lyon, 1980). The growing need for an understanding of the urban environment has also stimulated first inventories of urban wildlife habitats (Matthews and Miller, 1980, Annex 2.5). None of the classification systems has universal application and none of them has been tried for dog habitats. While no attempts have been made to quantify urban dog habitats, the guidelines and steps suggested for wildlife habitat analysis will be helpful (Flood et al., 1977; Gysel and Lyon, 1980). Detailed maps of the area must be obtained or drawn; those prepared by urban planners are particularly useful. Based on aerial photographs (where available) and ground reconnaissance, major land use types are delineated, plotted on maps and area sizes encompassed by each are determined and their occurrence expressed as a percentage of the total available habitat. The location of other important elements of habitat such as large vacant buildings, water sources, dumps, open markets, etc., are also shown. Where open areas occur, type, height and density of vegetation should be determined and placed on maps. Use of colour codes, symbols or keys are helpful when mapping various features of the habitat. The information shown on maps can then later be organized and arranged in tables and graphs, and statistically analyzed manually or by computer. Such maps can be used as a basis for selecting sample roadways, plots, or quadrants within the entire

urban area for intense studies of more specific features of the habitat (as well as for representative analysis of dog population parameters). As previously mentioned, the collection of data from large areas is frequently impractical because of limited funds or manpower. Detailed habitat maps permit the systematic selection of similar (or dissimilar) sampling units so that quantification and statistical analysis of data are possible. Their use also enhances the potential for extrapolating the data to the entire study area which, in turn, permits generalizations concerning habitat and dog population parameters to be formulated.

2.4.2 Observations

Some major components of the environment that are determinants of dog habitat (and thus their density and distribution) are:

- a) Climate. Harsh climates and particularly cold, winter weather, but also extreme heat, tend to make survival more difficult, resulting in lower free-roaming dog densities (Daniels, 1980).
- b) Shelter. The urban environment contains numerous areas where dogs can find cover and protection against adverse weather conditions, people and other animals, while resting, sleeping or whelping. The availability of shelter in urban areas appears to be determined in large part by the economic status and density of the human population. As mentioned under Section 2.3.2, dog densities are generally higher in densely populated areas where incomes are low. Sites offering complete cover include vacant buildings and garages, as well as those under construction, and passages and common areas of occupied structures (Fox et al., 1975). There are also numerous topographic features that offer some protection against the elements including disused densely vegetated areas, woodlots, dumps, building structures, porches and other overhanging structures. Parked cars and trucks are also routinely used (Beck, 1973, 1974, 1980a; Daniels, 1980). The rural environment contains many similar structures as well as larger woodlands and fields and natural caves and dens; Scott and Causey, 1973). It should be remembered that the general social acceptance of dogs permits them to use areas which are not available to wild animals or pest species (Beck, 1973, 1980a).
- c) Water. While availability of water in most areas is not a limiting factor, water in arid habitats may be so limited that dogs are forced to either move elsewhere or numbers are limited.
- d) Food. Availability of food for free-roaming dogs is probably one of the most important factors influencing density. In urban as well as in rural areas garbage from individual homes, at market places, or at centralized dumps is a major source of food for dogs.
- e) Cultural practices and customs. Human affection for, or tolerance of, both owned and unowned dogs, religious beliefs, use and disposal of natural and man-made resources, and living conditions, to mention only a few factors, directly or indirectly influence the quality and quantity of shelter, food, and water required to support dog populations.

- f) Dog interactions. The densities of many wild canids are regulated, at least in part, by social interactions between individuals, family groups or packs. To what extent such relationships limit dog densities in relation to available habitat is unknown.

2.5 Dog movements

The analysis of the use of space by a mammal includes the investigation of actual individual movements to feeding places, shelter, breeding places, females in heat, etc. Daily movements within a home range or territory must be distinguished from dispersal movements. In mammals, most dispersal activity occurs in a short period before or at sexual maturity. The dispersal movement leads away from the place of birth or from the parents to another place or group. This is much more complicated in dogs. Daily movements of dogs may be directly influenced or controlled by man through part or full time confinement to buildings, fenced yards, etc., and through transportation and conduct by leash and obedience. The dispersal of owned dogs is entirely directed by man or dependant on human migratory movements. Owned, but also unowned dogs may follow human nomads. Knowledge of these movements is important for the understanding of the epidemiology of dog diseases and of diseases transmitted from dogs to man and to livestock. These observations have their practical application when considering quarantine measures.

2.5.1 Techniques

Owned dogs and urban stray dogs are often individually recognizable, mostly diurnal, and relatively tolerant of human proximity. The movements and the use of space of such dogs can be tracked by direct observation (Beck, 1973; Fox et al 1975, Daniels, 1980; Rubin and Beck 1982). The use of spotlights and dog collars made of light-reflecting materials, or collars carrying battery-operated "pin" lights or beta lights, can be used to facilitate night-time observation of dog activity and movement. Unowned dogs, especially feral dogs in rural areas, are often more secretive. For secretive wild canids radio telemetry is commonly used to obtain movement, home range and activity data (Amlaner and MacDonald, 1979; Cochran, 1980). This procedure consists of placing battery-powered radio transmitters affixed to collars on individual animals. Signals emitted by transmitters are received on small, portable or fixed-location receivers equipped with a receiving antenna. The animal's location is fixed by triangulation. The technique has been used to study feral dogs in rural areas (Scott and Causey, 1973; Nesbitt, 1975; Gipson, 1982), but not for investigating space utilization by urban dogs. However, red foxes in an urban area have been studied in this manner (Harris, 1980). Telemetry equipment is commercially available from a number of sources and, while costly, it offers certain advantages over direct observations. Locations of a large number of instrumented individuals can be easily determined at frequent intervals, both night and day, and small home ranges would permit the use of small size transmitters concealed in collars. Transmitters can be constructed so that changes in animal activity result in different transmitter signal pulse rates. Thus, periods of resting and movement can be distinguished. Some countries have regulations for the use of telemetry equipment, frequency bands and power output of transmitters.

Other methods exist for studying dog movements. A number of distinctively coloured non-toxic dyes and reflective and fluorescent pigments for the marking of animals can be placed in edible dog baits (Day et al., 1980; Johns and Pan, 1982). Baits can also be loaded with coloured plastic

markers or metallic paint particles, which do not disintegrate and are resorbed during the intestinal passage (Wandeler et al., 1975). Baits containing these markers could be placed at central feeding sites (e.g., dumps, open food markets, etc.) or within small quadrants, and dog faeces subsequently recovered from outlying areas. The occurrence, location and frequency of marked faeces within given time periods would indicate movement and distribution. If individual baits contain distinct markers, a more complex bait lay-out pattern may be chosen. The use of baits containing markers has been investigated for assessing the potential effectiveness of control by toxicants and chemosterilants, and the oral administration of rabies vaccine (Larson et al., 1981).

2.5.2 Observations

In a study in Baltimore, Maryland (USA), 40 percent of all dogs observed were in alleys, 21 percent in the street and 19 percent on steps or sidewalks.

The home range of North American urban dogs has been estimated using continuous observation and plotting methods; a range of 26 hectares has been reported in Baltimore, Maryland (Beck, 1973; 1975), 52 hectares in St. Louis, Missouri (Fox et al., 1975), 4 hectares in New York (Rubin and Beck, 1982), and only 0.7 hectares in Newark, New Jersey (Daniels, 1980). The home range of partially restrained dogs, that is dogs permitted freedom for only a small portion of the day, is smaller than for pets that are permitted freedom continuously. The home range of unowned dogs in rural areas appears to be considerably larger. Packs composed of 2 to 5 adult feral dogs in Alabama (USA) used home ranges between 444 and 1050 hectares (Scott and Causey, 1973). The range of a feral dog pack in Illinois (USA) included nearly all of a 2850 hectare portion of a wildlife refuge (Nesbitt, 1975). Another pack of feral dogs ranged over an area of about 7000 hectares in Alaska (Gipson, 1982).

As a general rule, home range appears to be smaller in more favourable habitats, especially ones with more plentiful food. The smaller range in urban areas may be indicative of the increased food resources represented by human feeding; both owners and urban garbage are important food sources for dogs.

There is little evidence that dogs are strictly territorial, i.e., keeping all intruders out of their range. Individual dogs superficially protect the borders of their range.

2.6 Population structure and turnover

The structure and turnover of a dog population is determined by a great number of different factors. Its analysis depends on vital statistics such as sex and age ratios, natality and rearing success, and survival and mortality rates. Since dog populations are more heterogeneous than populations of free-living wild animals, it might be necessary to evaluate data for separate subpopulations of owned and unowned dogs, of confined and free-ranging dogs, of dogs kept for different purposes, etc. The information on dog demography can be related to the incidence and spread of density-dependent diseases such as rabies and as a basis for predicting the strategy and anticipated results of dog immunization and control programmes. For example, if a knowledge of annual population turnover and survival rates can be obtained, it should be possible to calculate the percentage of the population that needs to be vaccinated or eliminated in a given time period to reduce the probability of dog-to-dog transmission of rabies, providing the

essential raw population data can be acquired. Techniques are also available for reconstructing populations to estimate recruitment and mortality and to relate such functions to population trends and sizes (Downing, 1980). Similar data will also permit construction of predictive models that will be helpful in understanding the epizootiology of rabies and the probable effect of dog rabies immunization and control programmes. Sampling, statistical procedures, derivation of estimates and interpretation of results can be complex and assistance of demographers and biometricians should be solicited.

2.6.1 Techniques

Detailed procedures for collecting and analyzing wildlife (Caughley, 1977; Downing, 1980) and carnivore (Dixon, 1981) population statistics are available. These methods are commonly used to determine the status of populations by wildlife biologists. However, with few exceptions, such information is lacking for dog populations.

The intensity and frequency of sampling dog populations for vital statistics is dependent on both the objectives of the study and the dynamics of any given dog population. If populations are stable with little change, infrequent surveys (every 3-5 years) should be adequate to characterize their dynamics. However, when individuals within the population are short-lived, with rapid rates of changes in reproduction, mortality and immigration, then more frequent data collection and analyses are needed. Of equal importance is the question of how many data are needed to characterize populations. This determination is, in turn, dependent on the number of parameters to be measured and the variation within these parameters. Until more demographic studies have been made, answers to these questions are difficult to provide; however, the basic principles of statistical sampling apply and appropriate statistical assistance is recommended before data collection is initiated.

The data needed for the analysis of dog populations structure and demography are very diverse. So are the methods to be used to collect the information. Any system of sampling may be subject to bias. For example, young dogs are more easily captured than older animals and the economic status of owners is related to the probability of dog vaccination. The greater the probability of bias and variation, the larger the sample size required. Sampling bias should be minimized when possible or at least acknowledged in reports and publications.

Major components of demographic analyses and a brief explanation of each is as follows:

- a) Sex ratios. Data on sex ratios are needed in order to understand and interpret other vital statistics that are frequently expressed separately for each sex (Downing, 1980). Sex ratios are also used to calculate other statistics such as change-in-ratio indicators. Variation in dog/sex ratios may significantly influence productivity in the population. Sex ratios are commonly expressed as the number of males per 100 females (e.g., 150 males : 100 females, or 1.5:1), or more conveniently as a percent $150/250 = 60\%$ males). It should be noted that the sex ratio in different samples of sub-adult and adult dogs may be different from the sex ratio at birth.
- b) Age ratios and age determination. Analyses of age ratio data, or the number of animals that occur in each age class, can provide important information regarding the population. For example, young

to adult ratios are an indication of natality and productivity of the populations and of the pattern of mortality (Downing, 1980). The number of animals in each age class is needed to calculate mortality and survival values. Methods of age determination for various domestic (Habermehl, 1975) and wild species, including canids (Larson and Taber, 1980), have been developed. But an appropriate method for the domestic dog is still lacking. Tooth eruption and replacement of deciduous teeth by permanent teeth can only be used for animals under one year of age. Age-related tooth wear patterns are described for dogs (Habermehl, 1975), but they are unreliable criteria for age determination. Tooth wear is different in different breeds and depends heavily on nutrition and general living conditions. Tooth wear is therefore very variable in owned dogs, although it might be more uniform in populations of free-living dogs of similar stature. Annular structures in the dentine and in the cement of tooth roots are widely used to determine the age of wild mammals (Klevezal and Kleinenberg, 1967; Grue and Jensen, 1979) and this technique should be studied in dogs. Other methods of age determination for dogs, using a combination of criteria already developed for wild carnivores (e.g. skull suture closure, epiphyseal closure in long bones, tooth wear, relative pulp cavity width in canine teeth, eye lens weight/body weight ratios, etc.), may prove feasible and should also be investigated. Any method proven applicable in one area may need some re-evaluation in a new study area. The lack of an appropriate method of age determination has limited the analysis so far to the owned segment of the dog population whose owners know their dog's year of birth. Age ratio data are most useful when two or more data collection periods (at annual intervals, for example) are available. Changes in these ratios over time permit inferences to be made regarding changes in the population.

- c) Natality and rearing success. Measurements of natality and rearing success are indicative of population health and permit inferences as to how much annual mortality can be sustained before population declines occur. They are also indicators of the maximum rate at which populations recover following control efforts or decimation (Downing, 1980). Data needed to determine natality and rearing success include the number of adult females breeding, the number of young born per adult female and the number of young that remain alive to adulthood. Such data can be collected during dog elimination programmes or at dog pounds by making juvenile/adult counts and by removing reproductive tracts and examining uteri and ovaries for embryos, placental scars and corpora lutea (Kirkpatrick, 1980). Data on the reproduction in the owned segment of a dog population can be collected by an inquiry of owners. By questioning dog owners information concerning the following should be collected:

- age structure of reproducing population
- age dependent fertility
- frequency and incidence of oestrous and gravidity
- litter sizes
- litter survival/litter mortality (diseases, predation, killing of puppies, etc.)

- human control of canine reproduction (for population control, breeding purposes, etc.)

See Annex 2.4 for an example of a questionnaire on these prints.

- d) Mortality and survival. Dogs may be killed by disease, by traffic, by other dogs and predators, and by man by population control, disease control or the elimination of animals with undesired peculiarities, etc. There is a wealth of information on dog diseases in veterinary literature (Jones and Hunt 1983). Besides the information gathered from dog owners and veterinarians, the data collected by government administrations on dog control can be used for mortality studies. It should be borne in mind that the number of dogs killed becomes meaningful only when this figure can be related to dog population size. Four types of methods have been commonly used to calculate mortality and survival; catch-effort techniques, and life, survival and mortality tables. Detailed procedures regarding the collection of mortality and survival data are needed; procedures for estimating values, and examples of each, have been described in detail (Caughley, 1977; Downing, 1980; Nassar and Mosier, 1980).

An analysis of dog mortality should not only include the number and causes of deaths (diseases, traffic casualties, etc.), but also their differential importance in different segments (owned supervised, owned unsupervised, unowned) of a dog population.

- e) Phenotype frequency. While a thorough analysis of the genetic structure of a dog population is hardly ever realizable, it is appropriate to collect information on the frequency of different breeds, size classes, shapes, etc. These are related to ecological conditions, and human needs and preferences. Kennel clubs recognize about 200 different breeds, all of which are described in numerous publications (e.g. American Kennel Club, 1979). In areas with little or no controlled breeding it is useful to differentiate between different size and shapes of mongrels such as German Shepherd-like, Husky-like, Beagle-like, Greyhound-like dogs, etc.
- f) Sources of dogs. The sources of owned dogs can be established by asking owners if their animal was purchased from an occasional or commercial breeder, received as a gift, if it was an adopted stray dog or the offspring of their own bitch, etc. (see Annex 2.4 for questionnaire). At the same time the age at which dogs were acquired should be investigated. The important question as to whether unowned dogs are predominantly escaped and abandoned pets or whether they are the offspring of feral dogs needs careful assessment of human attitudes, of individual dogs' behaviour and of reproductive success of unowned dogs.

2.6.2 Observations

- a) Sex ratio. The sex ratio at birth is 1 to 1. In one survey in the central Philippines the sex ratio of sub-adult and adult dogs was also found to be close to equal (Beran, 1982). But in many surveys on predominantly owned dogs there was a preponderance of males noted. The ratio of females to males on five areas was found to be as follows:

Mexico City	1:2.3 (Rangel et al., 1981)
Sacramento County, California	1:2.4 (Westbrood and Allen, 1979)
rural Ohio	1:1.7 (Schnurrenberger et al., 1961)
Baltimore, Maryland	1:1.8 (Beck, 1973)
Newark, New Jersey	1:3 (Daniels, 1980)

Observations on sex ratios are vulnerable to bias; they heavily depend on the sampling procedures. Females are most often involved in bites that get reported to health departments, i.e., they bite passersby more than males (Beck, 1975; Beck et al., 1975; Harris et al., 1974). Males are most often involved in intra-family aggression; males are far more commonly seen by behaviourists and trainers for aggression problems.

- b) Age structure. The mean age of populations of owned and well supervised dogs in the USA is approximately 4.5 years (Schnurrenberger et al., 1961; Beck, 1973, 1981a; Nassar and Mosier, 1980). In these studies more than one third of the observed dogs were older than 5 years. In a similar study in Mexico City only 12 per cent of the animals were found to be older than 5 years (Rangel et al., 1981). Ageing studies of pets found on the street (captured by animal control agencies) in USA cities had a mean age of 2.3 years. Females were slightly older and had a slightly longer life expectancy (Beck, 1973; 1981a).
- c) Reproduction and natality. There is quite a large volume of information concerning dog reproduction. Reviews on current concepts are published sporadically (e.g. McDonald, 1975; Jochle and Andersen, 1977; Stabenfeldt and Shille, 1977; Shille and Stabenfeldt, 1980). Young dogs become sexually mature at an age between 6 and 12 months, and some shortly after reaching adult size. Females usually reach puberty earlier than males, smaller breeds earlier than larger breeds. In most breeds there is an even distribution of oestrous cycles throughout the year. Intervals between oestrous cycles average between 7 and 8 months. There are considerable breed differences and geographic differences within the same breed. The intervals may be lengthened by 1 to 3 weeks by the occurrence of pregnancy. The average length of the gestation period is 63 days, ranging from 59 to 68 days. The mean litter size is about 7, but there is considerable variation. Small breeds have smaller litters than large breeds.

In contrast to the comprehensive information on the physiology of dog reproduction is the meagre knowledge of dog breeding and reproductive success in canine populations. There is obviously very little breeding success among unowned dogs in urban areas in the USA (Beck, 1973; Fox et al., 1975). Feral dogs in Alabama (Scott and Causey, 1973) and in interior Alaska (Gipson, 1982) reproduce with varying success, rearing at least some of their pups to adulthood. Reproduction among owned dogs was found to be very low in Manhattan, Kansas (Nassar and Mosier, 1980). The percentage of spayed female dogs in this city was about 12 per cent before 1973, but had increased to 66 per cent by 1979.

- d) Mortality. Causes of mortality include traffic accidents and a wide variety of different diseases. However, in North America, Japan and Europe the greatest number of animals die at the hands of man (Carding, 1969; Beck, 1973, 1981c; König, 1979). A conservative

estimate is that many millions are killed annually after being delivered to animal shelters as unwanted pets.

- e) Phenotypes. The urban environment appears to support a wide variety of sizes and breeds without any selection for any one physical or behavioural attribute. The morphological and behavioural variations observed in urban areas are either a real biological phenomenon serving some adaptive function at the population level or a fortuitous result of man's capricious manipulation of inherent canine variability (Beck, 1973). But there are no meaningful statistics available. Dogs observed in the rural environment of North America often tend to be larger and there appears to be some selection (human or natural) towards the darker shepherd/collie-like dog (Smith, 1966; Perry and Giles, 1970; Scott and Causey, 1973; Nesbitt, 1975). Owned and unowned dogs in urban and rural areas of Africa and Asia are more uniform in size and usually of lighter colour than American and European breeds.
- f) Sources of dogs/dog population turnover. There is little evidence that urban stray dogs in the USA successfully breed (Beck, 1973; Fox et al., 1975). Urban stray dog populations appear to be continuously "seeded" from owned, home-bred populations through abandonment, release or escape. Presumably, feral dogs in the rural environment of North America replace their numbers, at least in part, through successful breeding (Gipson, 1982), though even in a truly rural area in Alabama, half the free-roaming dogs captured turned out to be owned animals (Scott and Causey, 1973). Similar studies from other areas with different cultural and climatic conditions are still awaited.

The sources of owned dogs are numerous. A survey in the USA of 918 dogs owners at 13 animal control agencies conducted by the National Animal Control Association reported the following sources of dogs (Dow, 1982):

Professional breeder	47.0 per cent
Neighbour or friend	23.5 per cent
Pet shop	11.7 per cent
Animal shelter	0.0 per cent
Stray	0.0 per cent
Born in home	1.9 per cent
Advertisement	9.8 per cent
Other	5.8 per cent

Although this particular survey found no one who obtained their dog from a shelter, shelters do supply animals, though a review of the numbers indicates that it is rarely more than 6 per cent of the total population. The figure quoted for 'pet shops' is consistent with trade estimates. This survey also found that the more an animal costs, the longer it remained in the home, hence the bias towards breeders (Dow, 1982).

A study of the owned dog population in Manhattan, Kansas (Nassar and Mosier, 1980) revealed that the age distribution and thus the population size was stable. When only age-dependent birth and survival were considered, the population would be expected to decline rapidly, but a high net rate of immigration of young dogs from outside the city was responsible for maintaining a stable population.

The population turnover can be exacerbated by animal control activities. Surveys were conducted in 1975 along the US/Mexico border tabulating the extensive questionnaire data that was generated by the local animal control agencies. In general, the mean age of household dogs in cities that had aggressive dog capture programmes was lower than comparable areas with little capturing activities (CDC, 1976). The dog population in the US appears to be decreasing both in numbers and biomass (smaller breeds are again becoming more common) (American Kennel Club, 1975; Wilbur, 1976). This reduction may be due to a decrease in fecundity as well as to increased mortality. The actual fecundity and mortality of dogs (as opposed to sales and survey data) are not known.

2.7 Feeding habits

Studies on feeding habits of dogs overlap with habitat studies. Spatial and temporal distribution, predictability and availability of food are properties of the habitat. But investigations on dog feeding focus also on nutritional requirements, on food quality, on feeding strategies, on resource partitioning with other species, on food chains and on energy flow. Food quality, distribution and availability are heavily dependent on cultural practices and on human attitudes towards dogs. Dog feeding habits have public health implications (hygiene, spread of parasitic diseases, etc.). They can be of ecological importance through garbage removal in one habitat, and through predation on wildlife in another situation.

2.7.1 Techniques

Nutritional requirement of dogs and nutrient content of foods need to be investigated by the methods of animal physiology. These will not be dealt with here. But in order to understand the feeding strategies of dogs some information on these subjects can be gained by consulting respective literature (Ferrando, 1973; Gaines Dog Research Center, 1974).

Questionnaire surveys should reveal information on whether owned dogs are fed regularly or not, on the proportion of food dogs have to find on their own, on the feeding of other people's dogs and on the feeding of unowned dogs (see Annexes 2.4 and 2.5).

Field observations may serve to record the uptake of different types of food items and their distribution. Thereby it should also be noted how much food dogs receive through regular feeding by man, through occasional handouts, through scavenging in garbage and waste or through predation on rodents, game, domestic animals, etc. Field investigations need the same training and equipment (binoculars, night viewing devices) as used for behavioural studies (see Lehner, 1979, and Section 2.9.1).

Tagging of food items with markers excreted with the faeces should give indications on the exploitation of resources (see also Section 2.4.1).

Information on the diversity and the importance of different food items can be gained by post mortem examination of dogs killed by traffic or during population control operations. The stomach content of freshly killed dogs should be examined within 24 hours. If this is not possible, the unopened stomachs or the weighed contents should be preserved in a 5 per cent to 10 per cent solution of formalin. The analytical procedures for stomach contents comprise several steps (described in detail by; Korschgen, 1980). The identification and classification of food items needs training and

experience. Collections of reference preparations of hair, feathers, arthropods, seeds, etc. may be needed. Some information may also be gained by analyzing dog scats in a similar way.

It is important to analyze data on nutrition relative to season and to the sample segments (unowned, unowned unsupervised, owned supervised) of a dog population.

2.7.2 Observations

In urban USA dogs find food at home, eat garbage, and receive handouts (Beck, 1973; 1975). The frequent occurrence of unsupervised dogs in alleys where there are garbage containers and in parks at evening indicate that they easily learn to find food in the urban environment. Dogs shift within their home range and vary their feeding activity according to varying distribution of food (Beck, 1973; Daniels, 1980). Water is available in gutters and sidewalk puddles filled by rain, car washing, leaking fire hydrants and air conditioning units, and from people putting out water for their pet dogs and cats and even for stray dogs. Urban fountains, streams and lakes are also used. In North American cities sick animals are often seen, but starving stray dogs are only very seldom observed. Although there are no studies of the quantity and quality of the garbage available to urban stray dogs, it appears adequate to sustain the population.

While the availability of garbage may be similar in many cities in other parts of the world, the sources and abundance of water depend more heavily on climatic and cultural conditions.

In a publication on dog ecology in the central Philippines (Beran, 1982) it is stated that owned dogs scavenged garbage, received leftover human food and frequently ingested human faeces. A survey in rural Tunisia (unpublished data) revealed that only a small proportion of the owned dogs were chained up all the time. Only these animals were fed by their owners. The dogs permitted partial or total freedom had to look for food, consisting mainly of garbage, rodents and insects.

Feral dogs in rural USA seem to depend very heavily on litter and garbage, and also on carrion, small mammals, insects, fruits and some green vegetation (Scott and Causey, 1973; Nesbitt, 1975; Gipson, 1982).

In North America and Europe unowned and unsupervised owned dogs are considered to be a major enemy of wildlife and small livestock (Barick, 1969; Feldman and Carding, 1973; Caras, 1973, 1974), although some investigations do not confirm this opinion (Progulske and Baskett, 1958; Sweeney et al., 1971; Nesbit, 1975). There is no doubt that the introduction of dogs on previously vertebrate-predator free islands had disastrous effects on the ground-dwelling wildlife (e.g. on the Galapagos Islands, see Thoruton, 1971; Lewin, 1978).

Urban dogs in the USA have been observed chasing cats, squirrels and deer, although a capture appears very rare (Fox et al., 1975). Predation is probably not a significant source of food for city dogs. Unsupervised rural dogs may rely more heavily on both wild game and small livestock, although most reports of livestock kills do not report eating of the animals killed (Smith, 1966; Perry and Giles, 1970). The same is reported of dogs killing zoo animals, even when there was ample time for feeding. On the other hand truly feral dogs in Alabama returned to a carcass until it was consumed (Scott and Causey, 1973). Sixty-five chases of white-tailed deer by hunting dogs over distances of 0.3 to 22 km lasted 3 to 155 minutes, and resulted in not a single catch (Sweeney et al., 1971).

2.8 Activity patterns

The behaviour of dogs varies on a daily cycle. The daily pattern of different activities (behaviour) of a dog is influenced by internal and external factors. Internal factors causing variation are age, sex, phase of breeding cycle, health, etc. External factors are season of the year, weather conditions, other dogs, temporal pattern of food availability, constraints imposed by owners, etc. Activity studies usually rely on the recording of a limited number of rather unprecisely defined activities (behaviour). Some knowledge of the activity pattern of dogs in a given area is essential for investigations of dog abundance, for more detailed behavioural studies, and for planning and executing control and vaccination campaigns.

2.8.1 Techniques

The analysis of dog activity cannot really be separated from other behavioural studies nor from investigations on home ranges and movements. The activities of urban dogs and of owned dogs in rural areas can be followed by direct observation with the aid of binoculars and night-viewing devices if needed (Beck, 1973; Fox et al., 1975; Daniels, 1980). The behaviour of individual animals may be recorded continuously or at regular intervals. Ad libitum sampling may also provide information. The different sampling techniques are described best by Lehner (1979). Less precise sampling techniques should not be applied. The method of observation (direct or by telemetry) and the experience of the observer limit the number of different behaviour patterns which can be recorded. These have to be defined and data forms have to be prepared before the actual field study is initiated. The classification of behaviour might be as simple as resting as opposed to being active or moving, or it might segregate an animal's activities in numerous gestures, behavioural acts and their component parts. Scott and Fuller (1965) suggested a scheme by classifying behaviour as ingestive, investigative, shelter-seeking, eliminative (excretory), sexual, epimeletic (giving care), et-epimeletic (soliciting care), allelomimetic (imitating, etc.), and agonistic. This system is also recommended by Westbrook and Allen (1979) for the study of urban dogs. The majority of Scott's behaviour categories are functional units. Therefore the function of a particular observed behaviour has to be determined before it can be classified in Scott's system. Instead of using this system of behaviour classification it might be easier to apply purely descriptive terms, such as sleeping, resting, walking, running, defecating, urinating, etc. For studies on dog activity it is strongly recommended that the advice of field ethologists should be sought. Good basic information on methodologies, statistics and pitfalls is given in Lehner's "Handbook of ethological methods" (Lehner, 1979).

2.8.2 Observations

Several studies on the activity of dogs in North American cities indicate that daily cycles may vary according to environmental conditions. In Baltimore, Maryland (Beck, 1973), in St. Louis, Missouri (Fox et al., 1975), and in Newark, New Jersey (Daniels, 1980), the observed number of free-roaming dogs peaked in early morning and in late afternoon hours. In Newark the pattern changed in winter, the highest number of dogs being observed in the late morning (Daniels, 1980). Westbrook and Allen (1979) report that in Sacramento, California, the greatest activity of free-roaming dogs occurred during the midday period. In the same area the number of observed dogs increased during the weekends. A pack of 3 stray dogs in St. Louis, Missouri, was predominantly nocturnal (Fox et al., 1975). The number of

freeroaming dogs counted in the streets of a city depends on the activity cycles of unowned dogs and on the human cycle of temporal release of pet dogs. For North American cities the following generalization may hold true: urban stray dogs are active in the early mornings, late afternoons and sporadically throughout the night. Owned pets appear on the streets well after sunrise, which is when the two populations interact. Strays are often active, later during winter months than summer ones: in addition, extreme heat in general lessens the activity.

Feral dogs in rural areas of North America appear to be more nocturnal. However, pack movements occurred at all times of day and night in a study in Illinois (Nesbitt, 1975). Feral dogs in Alabama showed an increase in daytime activity during the cool season (Scott and Causey, 1973).

Beck (1973) classified the behaviour of free ranging dogs in Baltimore, Maryland, as resting (19.2%), moving (68.0%), feeding (11%), socializing (0.9%), and mating (0.9%). Of 65 dog groups observed in Newark, New Jersey, 9.2% were engaged in foraging, 27.7% in walking and standing and 33.8 per cent were lying down (Daniels, 1980). Westbrook and Allen (1979) attributed the activities observed in dogs of Sacramento, California, to 36.0% investigation, 20.2% elimination, 17.4% social interaction, 8.9% shelter seeking, 5.5% ingestion, 5.5% self-grooming, 3.5% agonistic behaviour and 3% sexual behaviour.

2.9 Social organization of dog populations

Dogs are gregarious. They aggregate in groups that are not random, but indicative of social organization. Depending on the cultural setting, man restricts contact between the individual animals of a varying proportion of a dog population.

The social behaviour of dogs in the context of physical contact with other individuals, or groups of dogs within the population, as well as their contacts with humans, has important implications in connexion with the transmission of rabies and other density-dependent diseases. Such behaviour also becomes important when dogs are in contact with other pet species in urban environments, with livestock on the fringes of urban areas, and with wild carnivores, especially wild canids and feral dogs, along the urban-rural interface or in wholly rural habitats.

A catalogue of topics to be studied in the context of social behaviour should include the following:

- the frequency of occurrence of single dogs and social groups in relation to season of the year
- age, sex, breed and phenotype composition of social groups
- the stability (i.e., persistence over time) of dog groups
- behaviour displayed between groups of dogs
- the percentage of time single dogs spend within groups of two or more dogs
- the probability of encountering another dog at either home or at various distances from home

- the frequency of dog encounters with familiar or "known" dogs and with strange dogs, and behavioural responses during encounters (grouping or avoidance)
- whether humans react to dog encounters with responses beneficial (food, shelter, etc.) or detrimental (physical abuse) to dogs
- feeding behaviour and social interactions during feeding
- behavioural responses to humans (agonistic or friendly) as a function of group size
- social patterns in response to fluctuations in food availability
- behavioural responses to sick (rabid) dogs.

2.9.1 Techniques

Some information on dog social organization may be gained by simple recording of group size and composition in relation to time and area. An applicable definition of the term "group" is important for this kind of data collection. A "group" is a set of dogs remaining together temporarily or permanently while interacting with one another to a greater degree than with other dogs. Daniels (1980) used a more operational definition for actual recording of dog group sizes in a field study defining a group as the number of dogs that remained together for at least one minute of observation and did not show any agonism or avoidance.

Most of the epidemiologically important questions about spatial relations and frequency of interactions among the individuals of a dog population need to be solved by labour intensive field operations. For this purpose, the majority of all dogs of a study area should be known individually. Every dog in the study should be given a short designation (name, number, letter or other). For identification he has to be photographed, and sex, size, shape or breed, age (pup, juvenile, subadult, adult), colour, and other distinguishing marks have to be recorded. By this way urban dogs and owned rural dogs can be individually recognized (Beck, 1973; Fox et al., 1975; Daniels, 1980). The behaviour and the interactions of the dogs in the study area can then be recorded on previously prepared data sheets using the sampling methods of field ethology (see Lehner, 1979).

2.9.2 Observations

Several publications summarize what is known about dog social behaviour and also provide knowledge concerning both interspecific and intraspecific relationships (Fox, 1965; Scott and Fuller, 1965; Scott, 1967; Fox, 1971; Fox, 1975; Bekoff, 1977; Fox, 1978; and others). Most of these publications are primarily descriptive, or they focus on ontogenetic or evolutionary problems. Only a few studies examine the quantitative aspects so important for epidemiology. Morning surveys in Baltimore, Maryland, on a quarter square mile study plot revealed the following group sizes (N=28 surveys) (Beck, 1973):

GROUP SIZE	PERCENTAGE OF DOGS INVOLVED
1	50.6
2	25.9
3	16.3
4	5.3
5	1.9
6	isolated events

Female pairs were never observed; groups rarely had more than one adult female. Similar observations were made in Newark, New Jersey (Daniels, 1980). In both studies unowned dogs and loose pets did interact, though the groups appeared to be transient. Loose pets interacted among themselves, but again for only short periods of time, often encouraged by some desirable resource like garbage or a novel object.

Groups of unowned dogs in rural areas of North America are much more stable. Packs of 2 to 5 dogs were observed in Alabama (Scott and Causey, 1973). Packs of usually 5 to 6 dogs are reported for a wildlife refuge in Illinois (Nesbitt, 1975). In Alaska the size of a pack of feral dogs ranged from 3 to 11 (Gipson, 1982). In these studies individual dogs stayed for up to several years with the observed packs, and pack size and composition remained unchanged for up to 6 months. The activities of a trio of unowned dogs having a similar coherence in St. Louis, Missouri, was described by Fox et al (1975).

2.10 Dog functions in human societies

The sizes of different segments (owned, unowned) of a dog population depend very heavily on the proportion of the human population keeping dogs, tolerating dogs, or rejecting dogs in their neighbourhood. Dogs can be kept as pets and companions, for hunting, as guard dogs, draught animals, for food or for commercial buying and selling, etc. For certain tasks special breeds are raised. Besides the duties dogs are kept for, they may also fulfill beneficiary functions in other ways. Dogs can also be rejected because they are unclean (in a religious or a hygienic sense), because they bite, or because they are disease vectors, pests or nuisances. There are qualitative and quantitative differences in what people think the functions of dogs are and what dogs really do. In different cultures dogs are regarded as supernatural or related to supernatural powers, either as divine beings or as evil spirits. Dogs bear human names, specific dog names or no names according to local tradition. Functions and values attributed to dogs and other aspects of the cultural and ecological setting determine the conditions in which dogs are kept, how much they are cared for and the degree of supervision. Popular beliefs concerning dogs also influence the acceptance of governmental regulations and disease control measures.

2.10.1 Techniques

The analysis of dog functions in human societies requires a multidisciplinary approach. Anthropological or sociological questionnaire surveys need complementary behavioural field studies. Examples of questionnaires are given in Annexes 2.4 and 2.5. These questionnaires have to be adapted to local conditions. The questions have to be formulated so that the respondents are not tempted to tell what they think the interviewers would like to hear. The difficulty in getting correct information is indicated by the following example. If the possession of dogs is subject to tax, respondents may be reluctant to indicate the correct number of dogs they own. Under these circumstances the question: "How many dogs do you own?" might be replaced by "How many dogs do you feed?" The second question again does not give any information on dog ownership in regions where owned dogs have to find food of their own. Observational field studies may have to replace questioning under these conditions.

For the design of questionnaires the advice of anthropologists or sociologists experienced in field surveys should be solicited. Information on field survey methods can also be found in the "Interviewer's Manual"

published by the Institute for Social Research in Ann Arbor (Interviewers Manual, 1969) and in Sellitz et al. (1976). Questionnaires which could be used for collecting information on attitudes concerning dogs and dog ownership in industrial societies were published by Westbrook and Allen (1979).

The amount of time owned dogs are supervised, or are fulfilling certain duties (e.g., guarding), the proportion of food they receive from their owner, from other people and find on their own, and related questions need to be investigated by observational data sampling methods mentioned in Sections 2.5.1, 2.7.1, 2.8.1 and 2.9.1.

2.10.2 Observations

Observations on dog functions in human societies are relatively abundant in the anthropological and ethnographical literature, but most accounts concerning the cultural and economic values attributed to dogs are relatively short and incomplete. A few more detailed accounts concern dingos in Australia (Meggitt, 1965), dogs in Polynesia (Luomala, 1960), and in Alaska (Nelson, 1969, 1973). A comprehensive review of publications treating cultural aspects of dog keeping in Africa was published by Frank (1965). Papers on psychologic aspects of pet ownership and on attitudes toward pets in urban societies of industrialized nations (e.g. Westbrook and Allen, 1979; Fogle, 1981) are becoming quite numerous.

Dogs fulfill a variety of cultural and economic functions. The ethnographical literature abounds with remarks that dogs are also kept at a certain place and that they are used for such and such. Frank (1965) cites close to 600 publications in her review of the role of the dog in African cultures.

Dogs may constantly clean up and permanently guard a settlement, but other duties (e.g., hunting, pulling vehicles, etc.) may be performed only during relatively short periods. The reason for the association of people with dogs is frequently not so obvious (see Meggitt, 1965). Their importance and efficiency for hunting is often overstated. Dogs or dingos are obviously not of great help to hunting parties of Australian aborigines (Meggitt, 1965). South African bushmen use dogs only to hunt certain game species; but the owners of well trained packs are more successful than those without (Washburn and Lancaster, 1968; Yellen and Lee, 1976). Hunting dogs are highly esteemed in most cultures, even by people who do not primarily depend on game as a resource.

In some areas of Eurasia and North America dogs are used to carry goods and to pull sledges, travois or carts. This cultural trait is becoming especially widespread in the northern circumpolar region (Graburn and Strong, 1973). The high dependence of man on dog teams as means of transportation evoked especially detailed consideration in accounts of arctic cultures (e.g., Gubser, 1965; Oswalt, 1967; Balikci, 1970; Nelson, 1973). It has to be mentioned that dog traction is relatively young in the arctic and that dogs were also used for other purposes, e.g., for hunting and as a meat source (Lantis, 1980).

Despite the obvious importance of dogs for herding cattle, sheep and goats over large areas of the old world, very little attention has been paid to dog-pastoralist relationships. A large proportion of the older breeds in Eurasia and Africa were raised to guard livestock, but other guarding functions in premises and plantations have not yet been the focus of ethnographical studies.

Dogs are eaten by many tribes and in many cultures on all continents. Frank (1965) describes the tribal distribution of ritual killing and eating of dogs in Africa. She suspects that dog eating is originally a West African agricultural trait, but she gives no explanation for this association. Dogs are castrated by a few African tribes for the purpose of making them fatter for eating (Frank, 1965). The complicated relations in Polynesia between dogs as food, as gifts and offerings and as other items of value are described by Luomala (1960).

The fact that dogs eat refuse and human faeces is recognized and their cleaning function is often esteemed. In some places they are even left to clean and guard babies and small children (Frank, 1965).

More often than is expressed in the literature, dogs are kept as pets. The pet function is not so easy to define. In many languages (Spanish, French, German, etc.) a precise translation of the English term pet does not exist. Pets in industrialized societies have been reported to serve the following functions:

A pet is a companion

- something to care for
- something to touch
- something to keep one busy
- a focus of attention
- a reason for exercise
- something to make one feel safer.

It seems probable that pet dogs help to offset some of the pathological effects of social isolation (Katcher and Friedmann, 1980). The psychological importance of owning a pet becomes well documented for industrialized societies (Fogle, 1981). To own a pet as a companion might also be more important in hunter-gatherer and simple peasant societies than recognized so far (Luomala, 1960; Frank, 1965; Meggitt, 1965). From Frank's (1965) monograph on the role of dogs in African cultures it becomes clear that the attitudes toward dogs vary from tribe to tribe. Dogs are despised and mistreated by some African tribes. In others the dog is a venerated culture hero as the bringer of fire or grain. In a few areas it is an offence to kill a dog. But quite often the way they are treated is not in accordance with the merits of their mythical ancestors. Some muslim people believe that djinns (ghosts) may take the shape of a dog (Zbinden, 1953). In these areas unknown dogs are treated with respect or contact with them is avoided. In complex societies the attitude toward dogs may be different in different social strata and may vary according to professional occupation, subsistence level and economic status (Franti et al., 1974; Rangel et al., 1981).

Ideas about ownership and responsibilities are also quite variable. In western societies the law and public attitude gives people the right to own dogs, but also the obligation to care for them. Care of an animal has to include, but must not be limited to, adequate shelter and wholesome food and water. The owner is responsible for ensuring that his dogs do not damage public or private property other than his own, that they do not defecate on public or private property other than his own, that they do not cause unsanitary, dangerous or offensive conditions, they they do not cause disturbance by excessive barking, that they do not chase vehicles, or molest, attack or interfere with persons or other domestic animals.

In other cultures the obligations put on dog owners are often considerably less restrictive. But ownership and responsibilities may still be regulated by more or less complicated rules. In the Tlingit Indian tribe of north west North America dog ownership is an individual matter, but responsibility is controlled by the clan. If a dog bites a person, the owner of the dog has to compensate only if the injured person belongs to another clan (Oberg, 1934). In another north west American tribe, the Bella Coola Indians, the dog names are clan property, and no two canines may bear the same one at the same time (McIlwraith, 1948).

To terminate this brief account of dog functions in human societies, it should be stressed that a systematic and comprehensive review does not exist. Investigation is still required into the epidemiologically important questions concerning the number of dogs kept, the treatment and care of dogs, and the amount of freedom permitted in relation to dog utility, folklore, beliefs, economy and ecology.

2.11 Dog diseases and public health

As in all other vertebrates, dogs harbour a great variety of macroparasites, microorganisms and viruses. Some of the more pathogenic ones may be important factors of mortality in dog populations. A good proportion of the infectious agents disseminated among and carried by dogs are also harmful for man. Rabies and hydatidosis are among the most important diseases transmitted from dogs to man. Dog bite accidents are also of considerable importance for man. The amount of dog faeces deposited on public or private property becomes a hygiene problem in many cities. On the other hand there are the beneficial effects of garbage and waste removal through dogs. The psychological importance of owning pet dogs has only been recognized quite recently.

2.11.1 Methods

The occurrence of dog diseases and their demographic importance have to be studied using the methods of veterinary parasitology, microbiology, pathology and epidemiology. The techniques for rabies diagnosis and surveillance are described in chapter 5 of these guidelines, those for hydatidosis in the FAO/WHO Guidelines for Surveillance, Prevention and Control of Echinococcosis/Hydatidosis (1981). For many other dog diseases the diagnostic features are described in handbooks and numerous special publications. The diagnosis of dog diseases should be made by trained pathologists, parasitologists and microbiologists. Administrators involved in disease and dog control should be familiar with medical statistics and with surveillance procedures. To those not familiar with epidemiological definitions and calculations the consultation of relevant literature (e.g., Halpin, 1975; Schwabe et al., 1977) is highly recommended.

The frequency and the implications of dog bites have to be investigated by questionnaire surveys. Information on some aspects of dog bite accidents may be gathered at public health centres for those bites for which medical consultation is requested. Reporting forms should include questions about date and time of the accident, age and sex of the person bitten, part of the body bitten, type of activity in which the victim was engaged, place of occurrence of the bite accident, type and breed of dog, and whether the biting dog and his owner are known to the victim. Valuable information on the design of questionnaires can be found in Payne (1951), Oppenheim (1966) and others.

No method has been proved so far for the estimation of the percentage of available garbage and waste removed by dogs. Such studies should be undertaken in connexion with the habitat analysis described in Section 2.2 of this chapter.

Consultation of the relevant literature (Levinson, 1972, Friedmann et al., 1980) is recommended for those wishing to learn about the types of social and epidemiological investigations needed for the study of the potential health value of pets.

2.11.2 Observations

There is a wealth of information in veterinary literature about the occurrence and age, sex and breed dependent frequency of different dog diseases (e.g. in Jones and Hunt, 1983). Unfortunately this knowledge is largely limited to the well-cared-for dogs owned by city-dwellers. Very little is known about the mortality factors of unowned dogs or of owned dogs in rural areas of Africa, Asia and Latin-America.

A review of the epidemiological knowledge on rabies is given in Chapter 1. Information on hydatidosis epidemiology is summarized in the FAO/UNEP/WHO Guidelines for Surveillance, Prevention and Control of Echinococcosis/Hydatidosis. Rabies and hydatidosis are only two of the most important of more than 100 zoonotic diseases transmitted from dog to man (Hull, 1963; Van der Hoeden, 1964; Carding, 1969; and others). Dogs are also involved in the epidemiology of Rocky Mountain spotted fever in South America, Chagas disease, visceral leishmaniasis, diphyllbothriasis, trichinosis, dirofilariasis, strongyloidiasis, larva migrans of Toxocara canis and of Ancylostoma brasiliense (Hubbard et al., 1975; Acha and Szyfres, 1980).

Very little is known about the recognition of different specific dog diseases and zoonoses in different cultures. The anthropological literature gives no indication of whether dogs with signs of disease are cared about or if they are confined or killed. Cultural practices greatly influence the occurrence of zoonotic diseases, as demonstrated by Lantis (1980) in the case of echinococcosis and Haskan Eskimos.

Increasing recognition is given to the importance of dog bites. Epidemiological features of the occurrence of dog bites are described for several areas, mostly urban or suburban (Berzon et al., 1972; Harris et al. 1974; Beck et al., 1975; Lockwood and Beck, 1975; Hervey, 1977; Moore et al., 1977; Winkler, 1977; Marr et al., 1979; Nixon et al., 1980; Beck, 1981c). The mean annual animal bite rate per 100 000 total population varied between 20 in South Carolina and 927 in Arizona in a survey conducted in the USA by Moore et al. (1977). Robinson (1976) puts it at 500 per 100 000 in Liverpool (UK), and Nixon et al. (1980) recorded a mean annual dog attack rate of 184 per 100 000 total population in Canberra, Australia. Many of the authors point out that rabies is not the main disease transmitted by dog bites - tetanus, pasteurellosis and other diseases are also transmitted in this way. Bite wounds are vulnerable to a great variety of infections. Dog bites are certainly of greater importance in developing countries than officially recognized. This is suggested by the great discrepancy between the high number of people receiving post-exposure treatment against rabies and the low figure of actually diagnosed rabies cases in humans and in dogs.

The educational value of pets has long been recognized (Levinson, 1972; Fox, 1975b, 1979; Frucht, 1980). Pet dogs may also be of value for the health of their owners (Katcher and Friedmann, 1980). There is growing evidence that companion animals have potential health benefits. Loneliness per se is bad for health; people who are alone have increased rates for most diseases and injuries. It seems likely that pet dogs help offset some of the pathological effects of social isolation. Animal owners have been shown to have a higher rate of survival from coronary heart disease - an effect independent of other social support systems. The relationship between animal ownership and survival one year after myocardial infarction was as follows (Friedmann et al. 1980):

Patient Status	Number of patients with:	
	no pets	pets
Alive	28	50
Dead	11	3

There is an evergrowing field of pet-facilitated therapy utilizing a wide variety of animals for many special populations of people; elderly, autistic, depressed and imprisoned. Dogs often play a leading role in this work (Corson et al., 1975; Beck, 1981b; Curtis, 1981).

The human/companion animal bond, especially with the dog, is a real one, that affects the health of both parties. Good animal management comprises the same factors that enable animals to fit well into human society (Beck, 1980b, 1981a). It is possible for people and animals to live together in health and happiness.

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