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Diseases of camels

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Summary: The first part of this paper analyses the replies received from eleven African and Asian countries to a questionnaire concerning the general conditions under which camels are bred, and their principal diseases. The replies demonstrate a growing interest in these animals and in the effect of diseases on their productivity.

Gastro-intestinal helminthoses, mange and trypanosomiasis are by far the most widespread diseases. These diseases occur in eleven countries. Their economic impact is considerable because they result in high morbidity. They can be dealt with by therapy and chemoprophylaxis.

Pox is also widespread, occurring in seven of the eleven countries, including Pakistan, Chad, Jordan and Burkina Faso. Only the USSR has a vaccine and is conducting vaccination campaigns.

Other diseases appear to be more localised and their prevalence is variable. Contagious ecthyma and paratuberculosis appear to be the main diseases in Mongolia and Kazakhstan. The spread of foot and mouth disease virus by dromedaries has been investigated in Egypt. The role of dromedaries in the epidemiology of Rift Valley fever is of interest to several countries of East Africa.

Many countries stress the need for a better knowledge of the zootechnical potential of camelidae, in order to appreciate fully the economic importance of their diseases.

The second part of this paper provides a list of diseases recorded among the Camelidae of South America.

KEYWORDS: Africa - Alpaca - Animal diseases - Asia - Bacterial diseases - Bactrian camel - Camels - Dromedary - General account - Llama - Parasitoses - South America - Viral diseases.

INTRODUCTION

Domesticated representatives of the family Camelidae are an important part of the national livestock populations of numerous countries in arid and semi-arid regions of Asia and Africa, as well as the high mountains of the Andes in South America.

The family Camelidae comprises two genera:

– The genus *Camelus* (Linnaeus, 1758), includes two species. The first species is *C. dromedarius*, the dromedary or one-humped camel, the world population of

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which is estimated to be 15,368,000, with approximately 80% in Africa and 20% in Asia. The second species is *C. bactrianus* (Linnaeus), the bactrian or two-humped camel, of which there are some 1.7 million in their natural habitat in Asia.

– The genus *Lama* comprises *Lama glama* (the llama), *Lama pacos* (the alpaca), *Lama guanicoe* (the guanaco), and *Vicugna vicugna* (the vicugna). Only the first two have been domesticated. They are raised in herds in the Andes at altitudes above 2,500 m. Their population is estimated to be 7,165,000.

Well adapted to severe environmental conditions, the Camelidae are bred as working animals and for the production of meat and milk. Their hair and hide is used by craftsmen.

The socio-economic problems which have arisen during the past twenty years (population explosion, rural exodus, energy crisis, drought) have led to a revival of interest by national and international organisations in the breeding of these animals and in the improvement of their productivity. Pathological disorders limit productivity. For this reason the International Committee of OIE chose the topic of camel diseases for presentation at the 55th General Session.

In this connexion, a questionnaire was sent to the Delegates of Member Countries of OIE in order to compile up-to-date information concerning:

– the present situation in husbandry (population, husbandry methods and socio-economic role);

– the health status of the animals and control measures currently in force;

– current facilities for training and research.

Countries which replied to this questionnaire by 30 November 1986 were: Burkina Faso, Chad, Egypt, Ethiopia, Iran, Jordan, Morocco, the Sultanate of Oman, Pakistan, Saudi Arabia and the USSR, representing eleven of the thirty countries which have Camelidae.

Most of the information from South American countries came from documents provided by the Scientific Information Centre for Camelidae in South America (see references).

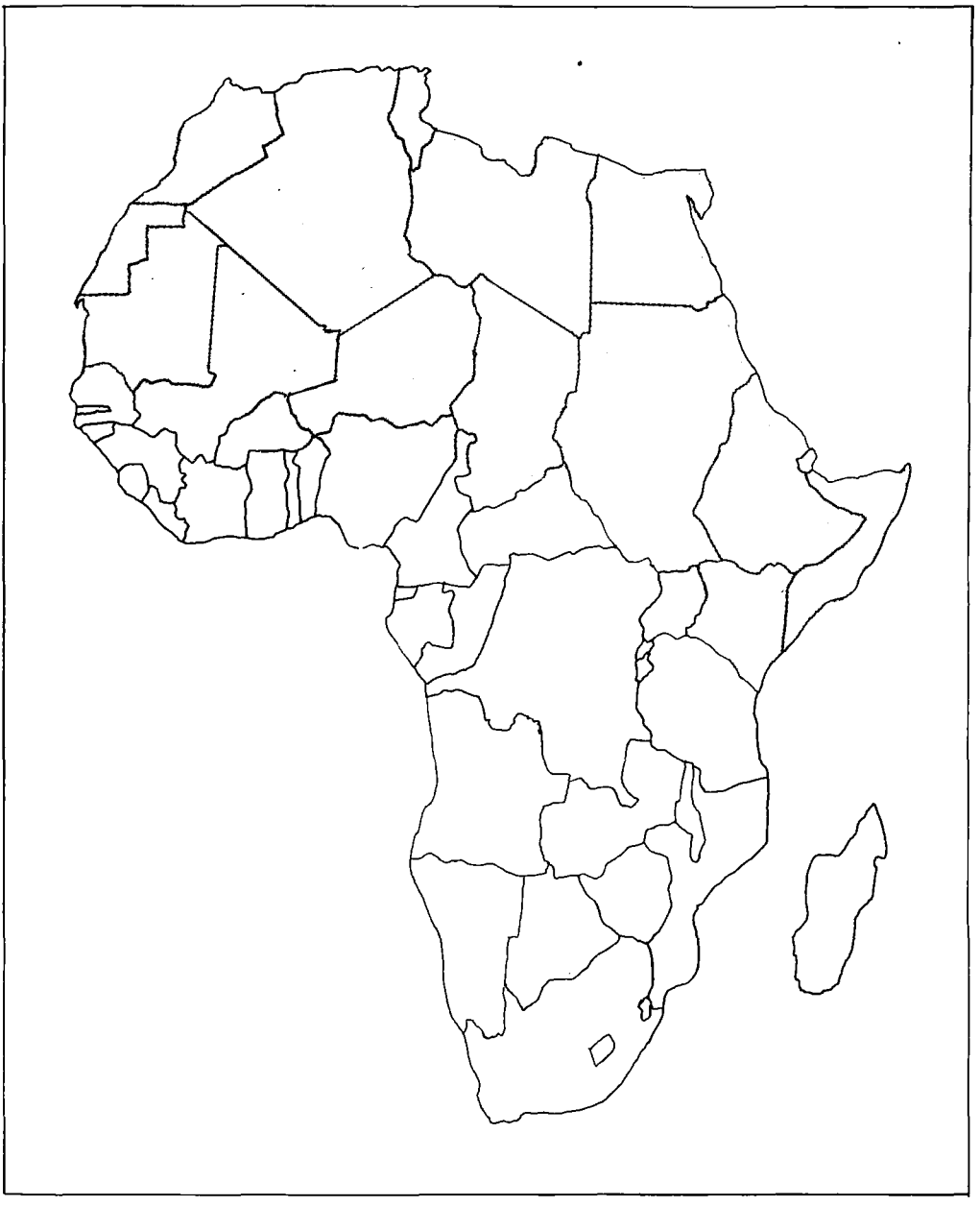
The diseases of Camelidae are closely related to their natural environment and the type of husbandry, which vary greatly between South American Camelidae and the representatives of Africa and Asia. For this reason, camel diseases are dealt with separately from those of llamas and alpacas.

DISEASES OF THE DROMEDARY AND BACTRIAN CAMEL

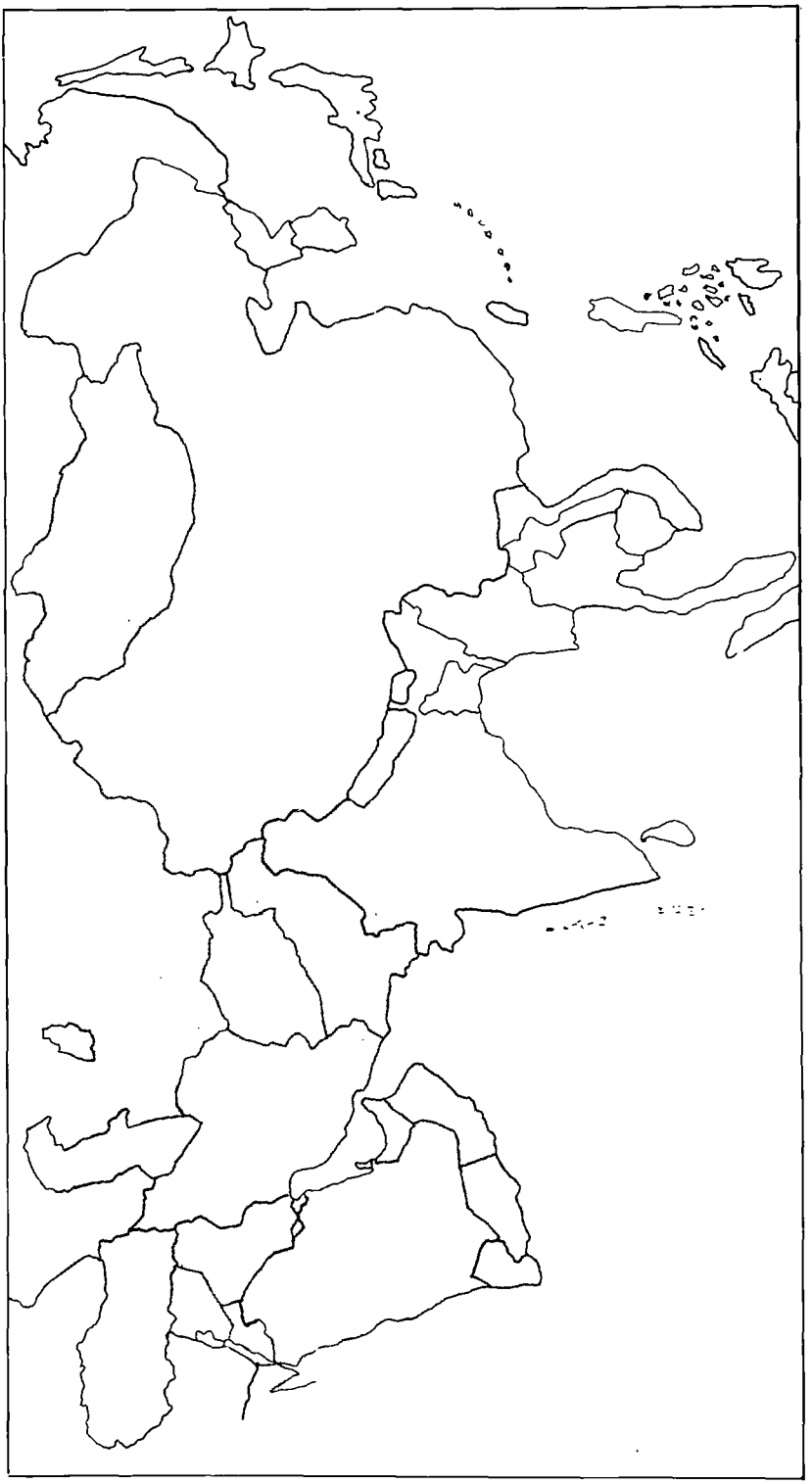
A. NATURAL HABITAT, POPULATION AND SOCIO-ECONOMIC ROLE

Maps 1 and 2 show the area of distribution of camels, which comprises the tropical and subtropical regions of the African and Asian continents, characterised by alternation of a brief rainy season with a long and dry hot season lasting for more than eight months.

Camels are better adapted than any other domestic animal to the very hot and very dry desert or subdesert regions. By contrast they are poorly adapted to moist



MAP 1
Area of distribution of Camelidae in Africa



MAP 2
Area of distribution of Camelidae in Asia

climates and marshland. The limit of their distribution is approximately that of the isohyet of 400-450 mm rainfall.

Table I shows the population in each country, expressed in "tropical livestock units" (TLU). In absolute figures, the countries which have the most camels are, in descending order: Somalia, Sudan, Ethiopia, India, Pakistan, Mauritania.

TABLE I

Changes in the camel population between 1980 and 1985 by country

(in thousands of TLU)

Country	1980		1985	
Somalia	5,450	(44)	6,500	(56,4)
Sudan	2,500	(11,8)	2,500	(11,1)
Ethiopia	980	(4,2)	1,020	(3,4)
Kenya	608	(5,9)	630	(5,3)
Djibouti	26	(14,5)	59	(23,3)
Mauritania	740	(25,6)	800	(26,1)
Mali	190	(3,4)	219	(3,0)
Niger	353	(7,9)	412	(8,3)
Chad	418	(9,8)	459	(12,2)
Senegal	4	(0,1)	6	(0,2)
Nigeria	17	(0,1)	18	(0,1)
Burkina Faso	6	(0,2)	22	(0,7)
Morocco	230	(3,1)	81	(1,3)
Algeria	150	(3,8)	164	(3,8)
Tunisia	170	(9,0)	177	(10,4)
Libya	134	(9,4)	135	(10,7)
Egypt	99	(2,0)	432	(10,5)
Arabian Peninsula	69	(4,4)	549	(23,0)
Jordan	5	(1,3)	15	(5,6)
Iraq	246	(5,2)	55	(1,9)
Iran	27	(0,2)	283	(1,9)
Pakistan	850	(3,9)	930	(4,3)
Afghanistan	300	(4,0)	270	(4,0)
India	1,150	(0,7)	1,100	(0,6)
USSR	220	(not calculated)	240	(not calculated)

Sources: FAO Production Yearbook and replies to the questionnaire

1 camel = 1 TLU 1 sheep or goat = 0.15 TLU 1 bovine = 0.80 TLU

The populations are expressed as thousands of "tropical livestock units" (TLU). The percentage of the camel population in relation to the population of cattle, sheep and goats (in TLU) is shown in brackets.

Countries having a camel population of less than 1,000 units are not listed.

Dromedaries and bactrian camels feed on a natural vegetation composed of grass and spiny plants (e.g. acacia, cactus) which are not eaten by sheep, goats or cattle. Thus they rarely compete with other species for feed.

Camels are essential for a nomadic life in which transhumance is dictated by the search for grazing. They are used as pack animals (transport of water, cereals, wood, salt), riding animals, for traction, and as a source of meat and milk. For example, annual camel meat consumption is estimated to be 21,500 tonnes in Saudi Arabia, 6,000 t in Chad, 2,000-4,000 t in Niger and 300 t in Djibouti. Camel meat accounts for 5% of meat consumed in Pakistan. Their hair and hides are used for making various goods.

Camels are raised in herds which range in size from a few head to many dozens (ranging from 12 to 24 in Saudi Arabia, 50-80 in Oman, 60-70 in Iran, 100-150 in Mongolia and Kazakhstan); in Somalia and Ethiopia a herd may comprise several hundred animals.

Camel raising is nearly always coupled with the keeping of sheep and goats, and sometimes cattle (rarely asses and horses).

Apart from fluctuations in numbers arising from different methods of counting, the camel populations are changing. Table I shows that there have been increases in Somalia, Saudi Arabia, Egypt, Djibouti, Chad, Jordan and Iran, with stability of numbers (or a slight increase) in Mauritania, Ethiopia, Libya, Tunisia, Sudan, Algeria and Nigeria. Numbers have diminished in Iraq, Morocco and Senegal. This situation has resulted from various factors, as follows.

In camel-breeding countries which do not produce their own petroleum, the oil crisis undoubtedly reduced the motorisation of transport as costs increased considerably. Animals were kept for transport, though this role had begun to decline.

Adoption of a sedentary lifestyle, notably in oil-producing countries, has not been accompanied by a change in the eating habits of the population. Sedentary populations have continued, by habit or because of purchasing power, to show preference for camel meat and milk. This has given rise to permanent semi-sedentary herds in the vicinity of centres of consumption, a tendency seen in Saudi Arabia, Oman, Iran, Pakistan, Mauritania, Mongolia and Kazakhstan. There is also export movement of live animals from producing countries to consuming countries (e.g. from Mali and Tunisia to Libya; from Somalia and Ethiopia to Saudi Arabia; from Sudan to Egypt; from Mauritania to Morocco).

The drought prevailing in the Sahel region during the 1970's and early 1980's, which generated considerable losses of cattle and sheep, had a less severe effect on camels. For example, losses attributable to drought in Mauritania between 1981 and 1983 were put at 5% for dromedaries, 15-30% for sheep and goats and 20-50% for cattle.

Drought has resulted in increased movement of camels from the Sahel zone to the Sahelo-Sudanese zone (from Mauritania to Mali and Senegal, from Niger to Nigeria and Cameroon, from Chad to the Central African Republic and Nigeria).

B. IMPORTANCE AND LIMITATIONS

In a recent publication, Wilson *et al.* (1983) collected some 3,100 bibliographical references concerning Camelidae (anatomy, physiology, reproduction, nutrition,

breeding, anthropology, economics, sociology) published between 1840 and 1985. Whatever the degree of precision of this number, taking into account the fact that numerous articles appear in local publications having a limited distribution, there is no doubt that, among domestic animals, Camelidae are among the least studied. Only 25% of the references concerned disease, while less than 20% concerned breeding. Such a situation may be due to economic considerations and certain material constraints.

Thus until twenty years ago, the dromedary and bactrian camel were considered essentially as transport animals in marginal zones, produced for consumption on the spot (subsistence economy), with no place in the market economy.

In addition, the high degree of dispersal of the herds and their considerable mobility over vast distances, render access and supervision difficult. Thus 17 million head are distributed across 20 million km² of territory, with densities less than 1%, except in Somalia (8.9%), Djibouti (2.4%) and Kenya (1%). The problem is aggravated by the fact that technical training is generally poor.

Finally, the diseases of Camelidae are often difficult to deal with, having very similar and non-specific signs. A further disadvantage arises from imperfect knowledge of normal physiological values and their variations.

Such constraints have shaped the methods on which our current knowledge is based, namely:

– observations, usually limited in scope, made on a restricted number of animals under special conditions (e.g. abattoirs, army animals, veterinary clinics);

– systematic investigations, either in a defined area or at an abattoir (longitudinal study of nomadic animals is very rare);

– experiments on animals which, though necessary, are performed only exceptionally because of their cost.

C. DETAILED REVIEW

A classification of 770 bibliographical references dealing with the diseases of dromedaries and bactrian camels shows that:

– 52% of the articles dealt with parasitic diseases;

– 42% dealt with infectious diseases;

– 2% dealt with deficiencies, nutritional disorders and plant poisoning;

– 4% dealt with various conditions, including surgical interventions.

In line with this distribution, we shall describe the dominant diseases and illustrate them by examples.

1. Internal Parasitic Diseases

1.1. Gastro-intestinal helminthoses

These diseases of Camelidae have received the most attention by pathologists, on account of the high morbidity rate, the wide distribution of the parasites and the simplicity of methods of investigation.

An inventory of parasites with reference to ecological conditions has been prepared in many countries, notably Chad, Egypt, Ethiopia, India, Iraq and Niger.

Among the **nematodes**, some appear to be practically specific to the dromedary (*Haemonchus longistipes, Nematodirus mauritanicus, Nematodirus dromedarii*) or for the bactrian camel (*Chabertia reshati*), but most of them are also common to sheep and goats (*Trichostrongylus prololurus, T. vitrinus, Ostertagia mongolica, Marshallagia mentulata, Nematodirus spathiger, Oesophagostomum venulosum*).

Infection by larval stages usually takes place during the rainy season, when grass is the main feed instead of shrubs and trees.

Massive infestations and combinations of parasites (combination of species of nematodes, or of nematodes and cestodes) occur frequently and are accompanied by high morbidity.

Most of the species of **cestodes** are common to dromedaries, sheep, goats and cattle (*Moniezia expansa, M. benedeni, Stelesia globipunctata, Avitellina centripunctata, A. woodlandi*). Cestodes are transmitted by the ingestion of mites carrying cysticerci.

Numerous anthelmintics have been tried in dromedaries, and some have been adopted for treatment of helminthoses.

Infestations with **larval cestodes** (hydatidosis, cysticercosis) have been observed frequently at abattoirs.

Hydatidosis is caused by the larvae of *Echinococcus polymorphus*, and is a zoonosis. All the surveys carried out to date have shown a relatively high rate of infestation: 45.4% in Sudan, 37.5% in Chad and 32% in Morocco. In Mauritania, 4,795 livers and lungs were condemned because of hydatid cysts during 1985, while in Egypt 10,580 organs were condemned in the same year for the same reason.

Cysticercosis is caused by *Cysticercus dromedarii, C. bovis and C. tenuicolis,* which are the larval forms of *Taenia hynea, T. saginata and T. hydatigena,* respectively. Cysticercosis is widespread, particularly in Saudi Arabia, Ethiopia, Somalia and Egypt (resulting in 1,042 condemnations in 1985).

Fascioliasis due to *Fasciola hepatica* has been reported from the Nile Delta, India and Iran, occurring in regions where there is sufficient moisture for the aquatic intermediate host (mollusc) to live.

1.2. Other helminthoses

The geographical distribution of other helminthoses is restricted and their incidence is low:

– Schistosomiasis caused by *Schistosoma bovis* and *S. indicum* occurs in the Nile Delta and in India, where there is sufficient moisture for the mollusc intermediate host (Bulinus) to live.

– Parasitic bronchitis: the development of larvae of *Dictyocaulus viviparus* requires moisture. This nematode can cause respiratory disease.

– Filariasis is due to *Dipetalonema evansi*, a parasite of the pulmonary arteries, mesentery and lymph vessels. Microfilariae are present in peripheral blood. Infection may result in orchitis.

– Onchocerciasis is caused by *Onchocerca armillata, O. fasciata* and *O. gutturosa*, which are localised in the aorta, subcutaneous tissue of the neck, and cervical ligament, respectively.

– Thelaziasis due to *Thelazia leesei* (intermediate host *Musca lucidala*) is responsible for parasitic ophthalmia in Turkmenia.

1.3. Protozoal infections

Trypanosomiasis (*Trypanosoma evansi* infection): the trypanosome which infects camels also infects cattle, horses and dogs. Because of this wide host range, there has been much research on the pathogenicity of different strains, their biochemical and antigenic properties, and sensitivity to trypanocidal drugs. Among camels there are reports of clinical observations, epidemiological surveys and therapeutic trials.

Trypanosoma evansi infection occurs wherever camels are kept (Saudi Arabia, Burkina Faso, Egypt, Ethiopia, India, southern Iran, around the Caspian Sea, Jordan, Morocco, Mauritania, Niger, Oman, Pakistan, Chad), but its incidence varies enormously from one area to another. It is high in marshy territory and along rivers, where conditions are suitable for the vector flies (*Tabanus* and *Stomoxys*). In Africa, infestation is rare and sporadic in northern Sahel, becoming endemic with high rates of infection (30-35%) in southern Sahel and in the Sudano-Sahelian zone, where rainfall is in excess of 500 mm.

In certain countries (Iran, Jordan, Morocco, Niger, Kazakhstan) camel trypanosomiasis is a notifiable disease. Chemoprophylactic campaigns have been organised in the eleven countries which replied to the questionnaire.

Dromedaries are susceptible to *T. brucei* and *T. congolense*, the infection resulting in an acute, fatal illness. Various species of tsetse fly (*Glossina*) are responsible for transmission. These infections are a limiting factor in the extension of dromedary breeding in tropical zones of Africa.

Coccidiosis (*Eimeria cameli* infection) has been reported from Turkmenia, India, Oman and Chad. The level of infestation in Niger was put at 29%. Coccidiosis, which is frequently accompanied by other intestinal parasitic diseases, causes few symptoms and lesions. Little is known about the pathogenicity of *E. cameli*.

Toxoplasmosis: serological surveys have been performed on slaughter animals in Afghanistan, Turkmenia, Egypt and India. The proportion of serologically positive animals is generally quite high (around 10%). Naturally occurring infection does not result in illness.

Sarcosporidiosis (*Sarcocystis cameli* infection): lesions of sarcosporidiosis are often found in the muscles and in the heart. It has been investigated in Egypt, Jordan and Sudan, where the infestation rate was put at 4.5%.

2. ECTOPARASITOSES

Camel mange due to *Sarcoptes scabiei* var. *cameli* is widespread. In Mongolia and India it is particularly common during the cold, damp season. By contrast, the incidence in the Middle East is highest in summer. Malnutrition and nutritional deficiency (particularly vitamin A deficiency) favour its development.

Transmission occurs by direct contact with an affected animal, and the disease may affect an entire herd.

The acute form is easy to diagnose (pruritic lesions with loss of hair and hyperkeratosis on the neck, axilla, inguinal region, around the tail and around the eyes). Subacute and chronic forms are much less easy to diagnose. There is a latent form where the parasite is in a quiescent state (reduced feeding and oviposition), and this form may be responsible for new outbreaks. Camel mange is transmissible to man.

Tick infestation: this is quite common. The ticks found most often are *Hyalomma dromedarii*, *H. rufipes* and *Rhipicephalus pulchellus*. These ticks may carry bunyaviruses and rickettsias.

Myiasis: this occurs widely. Wounds become infested by larvae of *Wohlfahrtia magnifica* and *W. nubae*. The rhinopharynx may become infested by larvae of *Cephalopsis titillator*.

Mycoses: among the fungi which seem to have a certain pathogenic role in camels are *Trichophyton schoenleinii*, *Microsporum gypseum* and *Penicillium vinaceum*.

3. Infectious Diseases

Apart from camel pox, which is specific for dromedaries and bactrian camels, all other bacterial and viral diseases also occur in other domesticated ruminants. Most of these infections have been demonstrated by serological tests, but it is rare for the causal agent to be isolated from camels. These infections are not accompanied by clinical signs nor lesions, and in most cases little is known of the role of camels in the diseases.

Information gathered from eleven countries is shown in Tables II and III.

Table II

Principal bacterial diseases of dromedaries and bactrian camels

Country	Anthrax	Blackleg	Salmonellosis	Brucellosis	Tuberculosis	Pleuropneumonia	Q Fever	Pasteurellosis	Tetanus
Burkina Faso	...(*)	...(*)	...	...(*)	+(*)	...(*)	...	...	...
Chad	+(*)	+(*)	−	+	+(*)	...(*)	+	+	...
Egypt	−(*)	−(*)	−	−(*)	...	−(*)	−(*)	...	+(*)
Ethiopia	+	...	...	+	−	...	...	+	+
Iran	−	−	−	...	...	−	−	...	−
Jordan	−	...	...	...	...	...	...	...	...
Morocco	+(*)	...	...	...(*)	−(*)	−	−	...	...
Oman	...(*)	...	...	+	...	−	...	...	...
Pakistan	+	+	...	...	...	...	...	...	+
Saudi Arabia	...	+	+	+	+	+	...	...	...
USSR	+(*)	−(*)	+	+(*)	−(*)	−(*)	−(*)	...	−(*)

(*): disease notifiable when it occurs in camels; +: the disease exists; −: the disease is absent; ...: no information

TABLE III

Principal viral diseases of dromedaries and bactrian camels

Country	Camel Pox	Rinderpest	FMD	Rabies	Parainfluenza 3	Bluetongue
Burkina Faso	...(*)	...(*)	...(*)	...(*)	...	...
Chad	...	+(*)	...(*)	−(*)	+	...
Egypt	+(*)	−	+(*)	−(*)	...	...
Ethiopia	+	+	−	−	...	...
Iran	+(*)	−(*)	−(*)	+(*)	...	...
Jordan	−	...	−	...	...	...
Morocco	+	−(*)	−(*)	+(*)	...	...
Oman	+(*)	−(*)	−(*)	−(*)	...	+
Pakistan	...	...	...	+(*)	...	...
Saudi Arabia	+	+	...	+	...	+
USSR	+(*)	−(*)	−(*)	+(*)	...	...

(*) : disease notifiable when it occurs in camels
+ : the disease exists
− : the disease is absent
... : no information

3.1. Bacterial infections

Brucellosis: there are very few clinical observations of brucellosis in camels. Most reports mention abortion and lesions in the joints. By contrast, there have been many serological surveys, often in conjunction with the occurrence of the disease in cattle, sheep and goats. Such surveys are justified by the risk of human infection, particularly from milk.

A wide range of infection rates for brucellosis has been reported: 1.6-5.2% in Ethiopia, 1.75% in Sudan, 1.2-10.75% in Chad, 10.4% in Somalia, 8.3% in Niger. In general the infection is less prevalent than in cattle, but more prevalent than in sheep and goats.

Camel brucellosis is caused by *Brucella abortus*, although in fact there are few reports of strains of camel origin having been isolated, except for a report of an isolation of *B. abortus* in Kenya. Such studies would be valuable for a better understanding of the epidemiology of the disease.

Tuberculosis: surveys conducted in Egypt, Sudan, India, Somalia and Kazakhstan have shown that tuberculosis is rare, although some cases have been observed in Saudi Arabia, Chad and Burkina Faso. The commonest form is miliary or nodular tuberculosis of the lungs caused by *Mycobacterium bovis*.

Salmonellosis: numerous serotypes of Salmonella have been isolated from camels, some of them associated with enteritis (*Salmonella typhimurium, S. enteritidis, S. dublin*) or with abortion (*S. dublin, S. bovis morbificans*).

Most of the serotypes are ubiquitous. Certain serotypes particularly pathogenic for human beings (*S. typhi, S. paratyphi C*) have been isolated occasionally from camels.

Respiratory diseases and *Pasteurella* infection: respiratory disease is common among camels, as shown by the reports of bronchopneumonia and pneumonia lesions at abattoirs, but little is known of the complex aetiology of these diseases. *Pasteurella multocida* type A may be important. Three serological surveys of dromedaries conducted in Chad (1968), Ethiopia (1975) and Niger (1985) showed that the average percentages of camels serologically positive for *Pasteurella multocida* were 80.5%, 64.6% and 59.85%, respectively. These percentages become even higher during the rainy season. *P. multocida* type A is considered to be a common inhabitant of the upper respiratory tract and it may cause disorders, in association with other micro-organisms such as parainfluenza type 3 virus, in animals weakened by exposure to cold, malnutrition or gastro-intestinal parasitism.

Infections with **pyogenic bacteria**: such infections are common in dromedaries, particularly in the form of lymphangitis. Accompanied by suppurative lymphadenitis of cervical and sciatic lymph nodes, sometimes with visceral abscesses as well, lymphangitis is often seen in adult camels more than 4 years old. Bacteria isolated are *Corynebacterium pseudotuberculosis, C. pyogenes,* group B streptococci and staphylococci.

Q fever (*Coxiella burnetii* infection): serological surveys have been conducted in Morocco (1954), Egypt (1954), Kenya (1956), Chad (1967), Sudan (1962 and 1972), India (1972) and Niger (1985). The percentage of serologically positive camels was variable, averaging 12% in Sudan, 4.8% in Chad and 1.95% in Niger. It seems that dromedaries may act as a reservoir of *C. burnetii*, providing a source of human infection.

Other bacterial infections: paratuberculosis is rare. It has been reported in Turkmenia, where it was responsible for episodes of diarrhoea in young camels. **Leptospirosis** is rare and very localised. **Botulism** due to *Clostridium botulinum* type C has been reported from Chad.

3.2. Viral infections

Camel pox: this is the most widespread viral disease and the easiest to identify clinically. Outbreaks have been investigated in Egypt, India, Iran, Kenya, Somalia, Turkmenia and Yemen. The disease is also known to occur in Saudi Arabia, Ethiopia, Oman, Morocco and Niger.

The virus responsible for pox in bactrian camels and dromedaries belongs to the same group as vaccinia and smallpox viruses. All the strains studied so far have had identical properties. They can be propagated on the chorio-allantoic membrane of chick embryos and are easily adaptable to cultures of kidney cells from young camels and lambs, as well as the BHK 21 and Vero cell lines. It does not possess haemagglutinating properties. The virus is pathogenic for mice by intracerebral inoculation, and is resistant to the action of ether and chloroform. Sheep, goats and cattle are refractory to experimental infection.

Camel pox is notifiable in certain countries (Iran, Oman, Burkina Faso, USSR).

There is no commercially available vaccine, although a vaccine is available in the USSR, where vaccination campaigns have been undertaken. Chemotherapy is used to prevent complications.

Contagious ecthyma: this disease was identified in bactrian camels and dromedaries for the first time in Kazakhstan in 1972. Outbreaks have been reported in Mongolia (1982, 1984), Somalia (1983) and Kenya (1986).

It is manifested by papules, which develop progressively into pustules, on the lips. The lesions may extend to the buccal and nasal mucous membranes. A generalised form of the disease may be confused with pox.

A virus having the morphological and cultural properties of a parapoxvirus has been isolated.

Rabies: many cases have been reported in Mauritania, Saudi Arabia, Iran and Pakistan. The source of infection has not always been identified definitely, but infection is usually attributed to bites from rabid dogs.

Rinderpest: the dromedary is susceptible to rinderpest virus. This has been verified by serological surveys undertaken particularly in Saudi Arabia, Ethiopia and Chad. Up to 15% of camels tested have been serologically positive. However, there has been no report of clinical infection, backed up by virus isolation. Thus the infection must be inapparent.

This supposition has been confirmed by experimental infection.

It is believed that dromedaries play a negligible part in the propagation of the virus, but further research is required on the possibility of spread of the virus by this species, and its localisation, frequency and duration.

Foot and mouth disease: as in the case of rinderpest, the dromedary seems to be susceptible to foot and mouth disease, but the infection remains inapparent. However, there have been fewer serological surveys and infection experiments than in the case of rinderpest.

Recently a strain of type O FMD virus was isolated in Giza (Egypt) from a camel with vesicular, ulcerative stomatitis. The strain was not very pathogenic when inoculated into calves, sheep and goats, though it did elicit the formation of neutralising and 'virus infection-associated' antibodies. In camels, inoculation of the virus into the skin, buccal mucosa, nose or eye failed to produce symptoms or lesions. The virus was recovered from blood plasma and lymphocytes between 4 days and 5 weeks after inoculation, but no antibody formation was detected (including 'virus infection-associated' antibody). This suggests that the virus persists in camels for a few weeks, without multiplying.

Despite the interesting nature of these results, the role of Camelidae in the epidemiology of foot and mouth disease remains to be elucidated.

Bluetongue: many serological surveys have shown that the dromedary is susceptible to bluetongue virus. The agar gel diffusion test has shown that 73% of camels in Chad were positive, and 17.8% in Niger. There is no account of the actual disease, confirmed by virus isolation, in camels.

Apart from reports from Saudi Arabia and Oman, there is no information from any other country.

Rift Valley fever: it was not until the most recent outbreak in East African countries, commencing in 1977, that the dromedary was included in serological surveys.

Complement fixation, haemagglutination-inhibition and cell-culture neutralisation tests have given quite high rates of positive results: 22.2% in Sudan, 31.4% in Aswan (Egypt), 6.2% in Giza (Egypt) and 22% in Kenya. Despite the high frequency of positive tests, the disease has never been reported in dromedaries, and it seems that the infection is inapparent.

The role of dromedaries in the propagation of Rift Valley fever remains to be elucidated. A recent survey in southern Mauritania showed that most of the serologically positive human beings were camel keepers.

Infection with **parainfluenza virus type 3**: serological surveys conducted in India (1967), Chad (1968), Somalia (1979) and Niger (1985) have shown that this infection is very common.

The virus has been implicated in respiratory disease of camels.

Other viral infections: **mucosal disease** has been reported from Saudi Arabia. Various viruses have been isolated from ticks (*Hyalomma dromedarii*) and other insects collected from camels, such as the bunyaviruses Dhori (India, Thogoto) and Wanovric (Egypt), and the flaviviruses (mosquito-borne) West Nile and Wesselsbron.

4. Deficiencies And Nutritional Disorders

These have been suspected often, but investigated little. A deficiency or nutritional disorder has been suspected of being involved in bone diseases, myopathy of young camels, and urethral urolithiasis.

Sodium chloride deficiency seems to be quite common. The salt requirement of the dromedary has been put at about 20 g per 100 kg body weight, and it is essential for the camel to resist dehydration. Most of the plants of subdesert regions are poor in sodium chloride. Deficiency is manifested by skin lesions and lameness.

There are some bone diseases which may be associated with phosphorus deficiency.

5. Plant Poisoning

There are reports of poisoning following the ingestion of *Perralderia coronipofolia* (Cosson), *Ornithogalum amoenum* (Batt), *Lotus jolyi* (Batt), *Commiphora africana, Ipomoea verticillata* and *Cornulaca monacontha.*

D. OVERALL VIEW AND OUTLOOK

Although not exhaustive, this review amply reflects the fragmentary and superficial nature of our present knowledge about the diseases of Camelidae. Certain aspects have been barely touched on here, such as reproductive disorders (abortion, infertility, neonatal mortality) and diseases of the digestive and respiratory tracts, and of the mammary glands.

Consequently, it is rare to find a complete and coherent system of health care, apart from chemoprophylaxis for trypanosomiasis and treatment of internal and external parasites. There are many reasons for this situation.

For a long time, interest in these diseases has been confined to the epidemiological role which camels might play in infections of cattle, sheep and goats, and in the

zoonoses. This role is an important one since such infections are of an asymptomatic, inapparent or even enigmatic nature. But there has also been a common failure to appreciate the economic and socio-cultural importance of camels. In addition, only a few pathological conditions have been identified to date which are likely to interest pathologists.

On the basis of information received, Saudi Arabia does have an institution which specialises in the study of breeding, feeding and diseases of dromedaries, and a similar institution also exists in Egypt (Desert Research Institute). Many universities and laboratories have special research units, such as the Camel Research Unit of Khartoum Veterinary Faculty, the Camel Research Project of the Somalian Institute for Animal Husbandry and Veterinary Medicine, and an integrated arid zone project at Nairobi University.

Every country which returned the questionnaire expressed a wish for more research, particularly on zootechnical subjects (husbandry methods, nutrition, reproduction, improvements in the production and use of camel milk and meat). This choice reflects a desire to explore the zootechnical potential of Camelidae, which is justified by socio-economic factors (population explosion, drought, rural exodus, search for self-sufficiency in food).

A better knowledge of the zootechnical possibilities in the widest sense is a starting point for the integration of Camelidae into a dynamic economic framework, thus stimulating greater interest in related disease problems.

DISEASES OF LLAMA AND ALPACA

A. NATURAL HABITAT, POPULATION AND SOCIO-ECONOMIC ROLE

By contrast with camels, the raising of llamas and alpacas is confined to the high plateaux and mountains of the Central Andes, at altitudes above 2,500 metres (Map 3). The original breeding ground is the Lake Titicaca region.

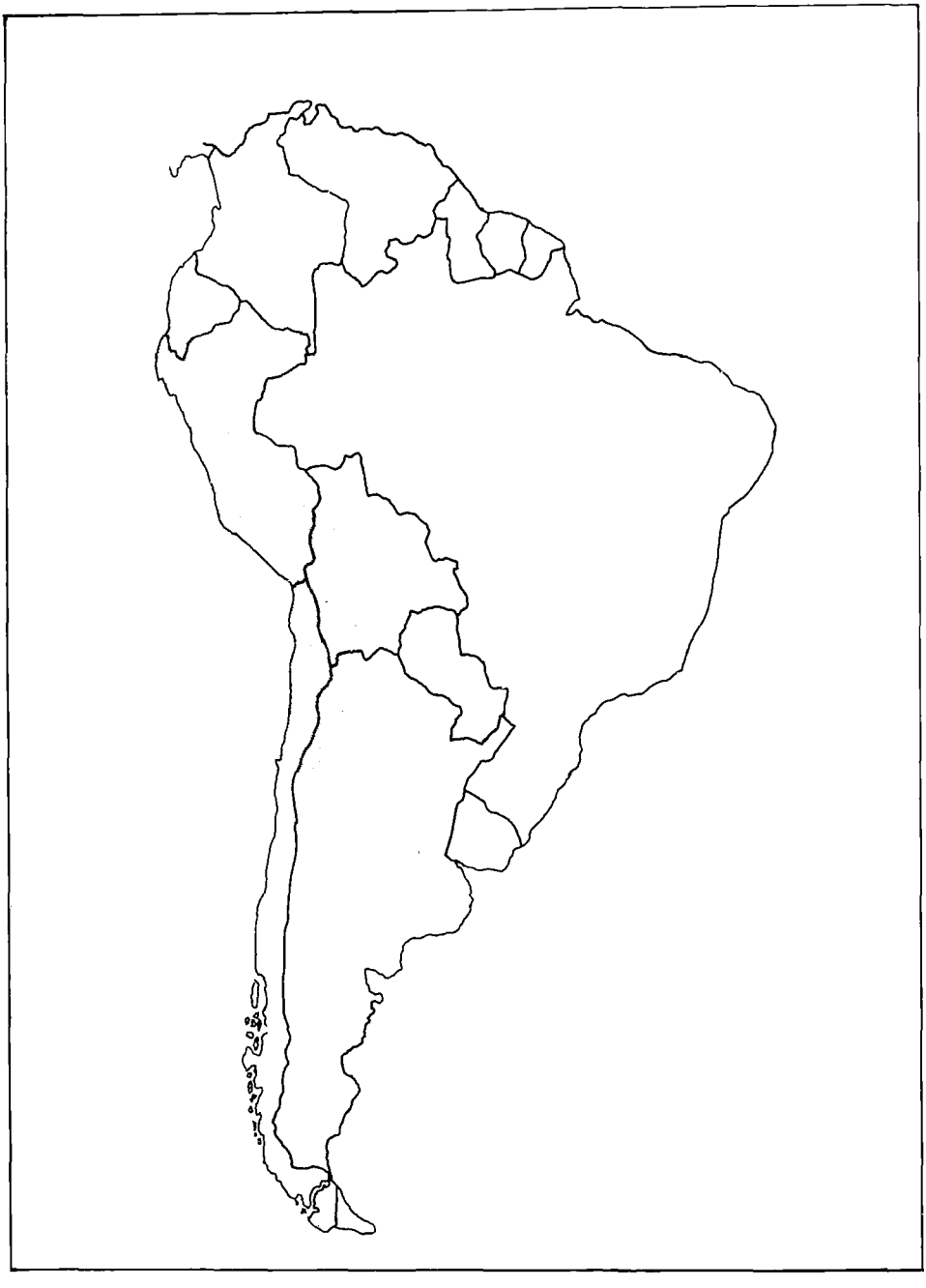
These regions are characterised by low seasonal rainfall and much sunlight.

The vegetation consists of natural pastures of grasses in the humid zones, with shrubs and herbaceous plants, and tundra in the highest zones.

Table IV shows the number of animals in each country. They tend to be grouped in small flocks belonging to villagers or to associations of breeders.

TABLE IV
Population of alpacas and llamas by country
(in thousands)

Country	Alpaca	Llama
Peru	3,200	950
Bolivia	300	2,500
Chile	30	60
Argentina	20	105
Ecuador	–	2
Other countries	1	18



MAP 3
Area of distribution of South American Camelidae

Llamas and alpacas are kept for their wool and hides, raw materials used by craftsmen and the local textile industry, as well as for export. They are also an important source of meat. Moreover, llamas are used as pack animals (for supplying villages and for transport of minerals). More than 100,000 people are directly involved in the raising of Camelidae.

The South American Centre for Scientific Information on Camelidae, in collaboration with the Research Centre of the San Marcos National University (Peru) and the International Research and Development Centre (Canada) has collected 2,400 publications (journal articles, internal reports, notes) dealing with the South American Camelidae, published during the past sixty-five years. The current interest in these animals is demonstrated by the fact that 30% of these publications have appeared since 1980.

B. BRIEF REVIEW

Publications dealing with health represent 16% of the total, and are divisible into the following subject areas: parasitic diseases (38%), bacterial and viral diseases (34%), pharmacology, therapeutics and toxicology (13%), clinical cases and surgical techniques (14%).

1. Internal Parasitic Diseases

1.1. Gastro-intestinal helminthoses

These are important because of the illness they produce, and over twenty-two species of parasite have been identified. Certain parasites are confined to llamas and alpacas, such as *Nematodirus lamae, Spiculopteragia peruviana, Lamanena chavezi, Graphinema aucheniae.* Polyparasitism is the rule. Conventional antiparasitic agents are used for treatment.

1.2. Other helminthoses

- **Taeniasis** (*Moniezia benedeni* and *M. expansa*)
- **Hydatidosis** (larvae of *Echinococcus granulosus*)
- **Fascioliasis** (*Fasciola hepatica*)
- **Dictyocauliasis** (*Dictyocaulus filaria*).

1.3. Protozoal infections

- **Coccidiosis.** Among the coccidia which have been identified are *Eimeria lamae, E. macusaniensis, E. alpacae* and *E. punoensis.* Little is known about their pathogenicity.
- **Sarcosporidiosis** (*Sarcocystis aucheniae*)
- **Toxoplasmosis** (*Toxoplasma gondii*)

2. Ectoparasitoses

- **Mange** (*Sarcoptes scabiei* var. *aucheniae*)
- **Ectoparasites**: *Damalinia aucheniae, Microthoracius minor, Macrothoracius proelonyceps.*

3. Infectious Diseases

3.1. Bacterial diseases

- **Brucellosis**
- **Tuberculosis**
- **Tetanus**
- **Enterotoxaemia** due to *Clostridium perfringens* types A and C
- **Diarrhoea** due to enteropathogenic *Escherichia coli*
- **"Alpaca fever"** or **streptococcal infection.**

Bacteriological research has also been conducted on the respiratory tract flora, and it has been found that many animals carry *Pasteurella multocida* (47% of those sampled). The bacterial flora associated with metritis, mastitis and keratoconjunctivitis is also under study.

- **Anaplasmosis** (*Anaplasma marginale*).

3.2. Viral diseases

- **Contagious ecthyma**
- **Rabies**
- **Vesicular stomatitis.**

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REFERENCES

(See p. 333)