# Chapter 1

# THE IMPORTANCE OF ABORTIONS IN SMALL RUMINANTS

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Sheep and goats were among the first species of animals to be domesticated by man for the production of meat, milk, leather and fibres. Since then other small ruminants species, such as llamas, domestic deer and wapitis, have been domesticated. However, despite some recent attempts to adapt these latter species to new habitats (such as the rearing of llamas in the South of France), their utilisation by man remains geographically limited. In contrast, sheep and goats are reared throughout the world from the polar circle to the equator, evidence that these two species possess great adaptability to different climatic conditions. They are the most common species of small ruminants worldwide. It has, however, proved to be very difficult to accurately assess the total global population of small ruminants because their numbers fluctuate enormously. The number of animals in a flock can increase or decrease depending on the climatic conditions: a period of drought can reduce a flock to virtually nil; in contrast, when there is an overabundance of forage, flock sizes increase because of the low mortality rate in the young.

*Table 1.1 : Distribution of sheep and goats throughout the world*

| Geographical Area | 1979-1981 | 1992 | 1993 | 1994 |
|---|---|---|---|---|
| **Sheep** | | | | |
| Asia | 316 162 | 341 381 | 336 104 | 340 102 |
| Africa | 180 465 | 206 843 | 205 785 | 208 845 |
| South Sea Islands | 202 272 | 200 779 | 189 116 | 182 758 |
| Europe | 123 288 | 138 834 | 133 776 | 130 692 |
| South America | 102 944 | 101 540 | 92 876 | 94 054 |
| North & Central America | 21 073 | 16 270 | 16 168 | 17 529 |
| **Total** | **1 088 794** | **1 133 372** | **1 096 049** | **1 086 661** |
| **Goats** | | | | |
| Asia | 268 239 | 351 369 | 359 866 | 373 005 |
| Africa | 138 228 | 168 452 | 171 468 | 176 088 |
| South Sea Islands | 415 | 1 144 | 986 | 1 007 |
| Europe | 11 781 | 15 242 | 14 905 | 14 809 |
| South America | 18 538 | 22 593 | 22 679 | 22 819 |
| North & Central America | 13368 | 15 470 | 15 726 | 14 944 |
| **Total** | **456 380** | **581 317** | **592 874** | **609 488** |

*Source: FAO Production Yearbook 1994; 48: 192-194*

Additionally some owners tend to underestimate numbers in their flocks to avoid taxes and taxation, making estimations even more inaccurate.

FAO is attempting to establish accurate world statistics by collecting data as "non-official information" or "FAO estimations" from a maximum number of information sources. To date data has only been collected from 70 countries but shows that estimated number of small ruminants in Africa and Asia represents more than 50% of the world total of sheep and more than 90% of the world total of goats (Table 1.1).

Whether the purpose of rearing sheep or goats is production of milk, wool or meat, the process is dependent on the ability of the animals to reproduce successfully. Consequently any decrease in the total number of reproductive animals in a flock will cause important economic losses that could close the operation.

Failure of reproduction, that is the failure of the dam to produce live, viable young, is referred to as infertility when temporary and sterility when permanent. Reproductive failure results from two main sets of factors: non-infectious and infectious factors. Non-infectious factors include genetic, immunological, endocrine, nutritional and toxic causes. Apart from non-infectious nutritional causes, infectious causes tend to be easier to control.

In addition to heavy economic losses, the infectious diseases responsible for reproductive problems in sheep and goats can affect the health of humans associated with the animals since many of the disease-causing infectious organisms are transmissible to man.

## 1.1 THE ECONOMIC IMPORTANCE OF SMALL RUMINANTS

According to the geographical area, the economic reasons for keeping small ruminants can differ and may be:

- in response to the need for food;
- to serve as a safe investment;
- as the basis of an industry.

Small ruminants supply food to small communities in the form of milk and meat.

Milk can be consumed directly after purchase or after processing by one of a range of treatments which result in different levels of preservation and edible products of varying nature: it may be processed into cheese (fromage frais, soft cheeses, hard cheeses) or butter, used as fermented milk (yoghurt, "Doughe" in the Middle East, "Leben" or "Ajran" in the Far East) or caramelised milk ("dulces" in Central America, "cajeta" in Mexico, "geitost" in Norway, "Kurt" in central Asia). During the course of many infectious diseases such as brucellosis, tuberculosis, Q fever, listeriosis, massive excretion of infectious organisms occurs in the milk. Consumption of raw milk, milk that has been insufficiently pasteurised, or certain products produced from contaminated milk are therefore the origin of many diseases in man.

Ovine and caprine meat is a major source of protein for many human communities. The small size of sheep and goats allows the meat to be consumed by a limited sized group of humans without need to preserve the carcass. During certain religious festivals, such as "Aid El Kebir", the slaughtered animal is divided between the family and their neighbours and the meat and offal of the animal is

completely consumed. The meat from infected animals may contain infectious organisms. Certain offal, for example the liver and the mammary gland, concentrate such organisms and their consumption can be the origin of diseases in man even though the meat is generally cooked before being eaten.

In certain countries, small ruminants can be considered as a "liquid asset" in case of need. They require less investment than other ruminants since the risk of financial loss is much lower if an animal should disappear. The capital return is faster because of early sexual maturity (from 7 months) and the resultant short interval between generations (of the order of one year).

Certain small ruminant rearing methods are aimed at specific production (meat, wool, milk). The main objective of rearing sheep in Australia is for the supply of wool for the textile industry. Goat hair in Cashmere and Tibet is also used by the textile industry: mixed with wool it is manufactured into light, warm fabrics and in a similar way fine wool is combined with the long fleece of the alpaca.

The meat of small ruminants is the origin of the meat industry. Certain abattoirs specialise in the preparation and packaging of meat from small ruminants. Sheep from New Zealand are exported for their meat as carcases. To export meat it is imperative that the sanitary conditions demanded by the exporting country are respected.

In the French Cevennes, sheep supply the milk used by the "Roquefort" cheese industry. Goats and sheep around the Mediterranean supply the raw material for the local cheese industry, for example for the production of Greek "Feta". The recent increase in export of these cheeses from the area of production has resulted in a massive expansion of the original "cottage" industry. Yoghurts made from goat and sheep milk have started to appear commercially on a large scale. Treatment of large quantities of milk requires a high level of vigilance particularly regarding the sanitary aspects of the supplying flocks.

The hides of sheep and goats are used in the leather industry for the manufacture of clothing, shoes and leather goods (bags, cases, gloves). During the handling of hides from contaminated animals, aerosols formed can be the origin of diseases in tannery workers (for example, Q fever).

## 1.2 METHODS OF REARING AROUND THE WORLD

The method of rearing is the combination of the practises used to ensure the upkeep of the animals so that they achieve the performance expected by the owner. Methods of rearing differ according to the climatic area in which the small ruminants are found. The availability of food is the main determinant of both the rearing method and the sizes of flocks. The actual method used depends on the technical means and the labour available and the best way these can be adapted to the prevailing environment. Adapting to the situation creates different approaches to the fight against diseases.

Different rearing methods vary in the degree of control of the animals, their reproduction and of the environment. The economic consequences and the risks of disease transmission between animals, and between animals and man differ according to the rearing method. Different rearing methods can either

control or aid the transmission of infection. Four types of small ruminant rearing methods exist in the world: tethering, two types of extensive rearing (nomadic and seasonal movement) and intensive rearing.

### 1.2.1 Rearing by tethering

This is a rearing practise undertaken in the countries of South-East Asia, Central America and Africa.

#### *1.2.1.1 The environment*

In the villages, small ruminants often wander freely but during periods of land cultivation they are tied up to prevent wandering (a posted animal) and to control the areas in which they graze. The animals are tied by a cord of two to three metres in length to a tree or a post sunk into the ground. They are moved each day and are grazed by the sides of the roads, on fallow land or on natural paths. The grazing can be supplemented by the feeding of domestic waste (for example, potato peelings) and/or small quantities of cereals or derived products.

The animals are watered when they return to the village. At night the animals are assembled in the village or the immediate proximity but they remain tethered.

#### *1.2.1.2 The flocks*

In this rearing method, each owner has a small number of tethered animals (between one and ten), often less than five. Such flocks tend to consist of family groups. Increases in and/or replenishment of the flock is carried out by retaining the young born to the flock or by acquisition of females either by purchase, if the owner has the means, or by exchange with, for example, poultry.

#### *1.2.1.3 Labour*

The size of the animals combined with low total numbers minimises handling and allows rapid adaptability to the available resources. The quantity of work involved in this rearing method is small in comparison with other jobs such as the growing of cereals. The care of the goats and sheep requires little training in techniques and therefore demands little specialised labour (in comparison with grazing animals), often met in the form of unpaid family labour (women, children). In Africa, small ruminants are allowed a certain autonomy by the chief of the village.

#### *1.2.1.4 Reproduction*

Reproduction will be affected by the rearing practises in force at the time, for example, whether ewes are tethered or wandering, the number of ewes the males have already covered. Only certain owners in the village keep entire males (one or two), the other owners can obtain them on loan from the breeders or they can simply release their females in the direction of the best males in the village making any control of reproduction relatively difficult.

#### *1.2.1.5 Consequences for transmission of infections*

The close proximity of the small ruminants and humans is often the origin of zoonoses acquired by direct contact with sick animals or by removal of contaminated products from the animals.

### 1.2.2 Nomadism

This rearing method predominates in the Middle East and North Africa.

#### *1.2.2.1 The environment*

This rearing method necessitates adaptation to a difficult environment and,

above all, requires a good knowledge of the surrounding area in which the flock is moved. The animals graze on large areas of marginal ground unsuitable for cultivation. They are moved according to the climatic conditions. In the Near East, the low humidity level has led to the traditional system of exploitation of lands with sparse vegetation of poor quality. During the dry season the animals are maintained close to watering places.

#### *1.2.2.2 The flocks*

In this situation, small ruminants constitute the principal source of subsistence for the rearers and the size of the flocks is therefore usually larger than in flocks reared by tethering. A nomadic flock can contain about fifty head in suburban areas but can increase to more than 200 animals in rural areas. Very often a flock will belong to a nomadic human tribe and move with it. Reproduction is usually sufficient to assure the replenishment of the flock.

#### *1.2.2.3 Labour*

The life of the owning community of the flock depends directly on this flock and close observation of the flock is therefore assured by members of the group, generally unpaid, including children.

#### *1.2.2.4 Reproduction*

The nomadic flock is mainly composed of females with entire males present in limited numbers. With the exception of choosing the males to be maintained as entire, the rearers have no other means of intervention in the control of reproduction.

#### *1.2.2.5 Consequences of transmission of infections*

The spread of infectious diseases in this rearing method occurs through direct contact with infected animals or indirectly by contamination of the environment, for example, of watering points where successive groups of animals go to drink. In addition, the close contact between humans and the animals aids transmission to man.

### 1.2.3 Seasonal movement or semi-nomadic

This method of rearing is used in five continents.

#### *1.2.3.1 The environment*

Seasonal movement is characterised by alternation according to the season between a settled period and the use of variable areas of grazing. During the moving period a shepherd has the responsibility for animals belonging to several owners (collective flocks). Seasonal movement can take many forms according to the geographical location :

- In mountain regions alternation occurs between enclosed winter grazing in the plains and valleys which are not cultivated during this season and extensive summer grazing on the pastures of the mountains that are clear of snow at this time.
- In desert regions winter grazing takes place in the desert and summer grazing close to the oases and cultivated areas.

Seasonal movement can also be affected by sanitary conditions: grazing on the plains and valleys may be abandoned because of flooding during the humid season but also because of the risk of diseases (glossina, parasites). The movement of flocks from one region to another often follows the same route from year to year but can vary according to the availability of food. Grazing areas are usually collective lands which belong to tribes or families. This rearing method

exploits the forage resources of natural paths or of fallow land with residues of cultivation, and allows manuring of the land especially where animals are assembled at night.

### *1.2.3.2 The flocks*

The flocks are collective during seasonal movement but can be divided into individual groups again during the settled period. The replenishment of individual groups either occurs by acquisition of animals from outside the group or by the maintenance of young which are selected according to certain criteria with the remainder being sold.

### *1.2.3.3 Labour*

The flocks are moved under the responsibility of one or a group of shepherds who have a good knowledge of both the environment and the animals. They are paid by the owners when they return the animals at the end of the seasonal movement.

### *1.2.3.4 Reproduction*

Characterised by movement and management of the often collective flocks managed completely in the open air. This rearing method does not allow any control of reproduction unless the sexes are segregated.

### *1.2.3.5 Consequences of transmission of infection*

The mixing of flocks during seasonal movement aids the transmission of infectious diseases.

## 1.2.4 Intensive rearing

Intensive rearing is characterised by the number of animals raised per unit area and by the control of food and reproduction. This rearing method is predominant in Europe and North America.

### *1.2.4.1 The environment*

The animals are held in a restricted space with provision of feed. Intensive rearing can be:

- outdoors;
- partly housed / partly outdoors;
- permanently housed.

The method of using forage resources is therefore:

- solely by grazing;
- by grazing and distribution;
- solely by distribution.

This rearing method uses techniques of intensive production and use of forages.

### *1.2.4.2 The flocks*

In this type of rearing, the breeder chooses his animals according to the available forage resources and the type of production (meat, milk). He may either manage his natural forage resources using animals adapted to the environment or he may create a new forage environment using more productive animals with the flock held under artificial living conditions (housing usually with mechanisation of food distribution). In intensive rearing the flocks are almost exclusively comprised of females with very few selected males retained for mating.

### *1.2.4.3 Labour*

The intensive rearing method leads to specialised production often combined with other forms of animal or vegetable production. Specialisation may be very restricted, for example, certain rearers may only carry out breeding whilst others may only fatten lambs. Such specialisation can lead to the creation of

chains of production, such as those which exist in Britain, in which individual participants may be "cottage" industries, semi-industrial or wholly industrial. Intensive rearing can therefore be considered as the partnership of two sectors:

- a "plant sector" for production of primary feed materials;
- and a "animal sector" for transformation of these primary materials to milk, wool, hide and especially to meat.

Such rearing methods require shepherds to have good technical knowledge and may demand heavy and expensive equipment. For this reason the labour for intensive rearing is highly specialised with shepherds skilled in one or other field.

### *1.2.4.4 Reproduction*

According to the chosen specialisation, meat, milk or wool, rearers select their reproductive animals not only according to appearance but also according to performance criteria such as fertility, proliferacy and lamb survival rates. To replenish the flock, rearers retain young from females that are fertile and prolific, giving birth to at least two lambs or kids, that produce viable offspring, and that are good milkers and mothers. Reproduction can be controlled at the level of both the females and the males. This control can be variable:

- selected males can be released into the flock without any control: the young are born of unknown paternity;
- a group of ewes remain with the same ram for the duration of mating: the paternity of the offspring is known, therefore selection is very effective;
- the ewes are artificially inseminated which allows complete control of reproduction as breeding stock are chosen on precise criteria. Thereafter the pregnant ewes are grouped together.

### *1.2.4.5 Consequences for transmission of infection*

The concentration of a large number of animals into a limited space aids the transmission of infections and exposure to certain diseases, but it also allows for better surveillance and sanitary conditions. Artificial insemination can allow control of transmission of infections from the male to the female. Similarly, synchronisation of ovulation can aid the control of abortive diseases: the females can be grouped together in batches according to their stage of gestation. If abortions occur at the end of gestation, excretion of abortive organisms does not occur in the vicinity of more susceptible animals at the beginning of gestation.

## 1.3 THE IMPORTANCE OF ABORTIONS AMONG THE DISEASES OF SMALL RUMINANTS

It is very difficult to assess the incidence of any disease among small ruminants. From published material it should be possible to ascertain if a specific disease could be encountered in a given country at a given time and this type of information does exist in certain official documents (the zoo-sanitary situation in the member countries of the International Office of Epizootics, Annual of Animal Health edited by FAO/WHO/OIE). However, it is impossible to know the incidence of a given disease for at least two reasons:

- Firstly, there is the problem of the quality of diagnosis of a disease. Before diagnosing the cause of an abortion, the clinical signs must be observed. In small

ruminants such observations are easy if reproduction is controlled but this is not the case in extensive rearing (tethering, nomadic, seasonal movement). For satisfactory confirmation of abortion it must be known which females are pregnant and the date that each one began its gestation. When there is no control of reproduction abortions will only be detected at the end of gestation when the foetus is large enough, previous abortions will pass unnoticed and will not be distinguishable from a low fertility rate. The precision of diagnosing abortion is therefore directly related to the rearing method.

- Secondly, even if the cause of abortion is correctly diagnosed, the owner may be reluctant to impart this information.

### 1.3.1 Importance of research work on small ruminants

Is it possible to use the published articles on the diseases of small ruminants to estimate the incidence of a disease? Awareness of the existence of a disease always originates in an article, scientific or not. A large number of articles illustrates the importance that a disease has in the community. It is therefore possible to estimate the importance which specialists give to ovine abortions by consulting the reference database. In the largest four biological databases the mean number of references per annum is of the order of 20 for Agris, 40 for Biosis and Medline and 80 for CAB Abstracts (Table 1.2). Three-quarters of the references deal with at least one infectious abortive disease. Articles dealing with brucellosis and chlamydiosis are the most numerous (always more than 50 percent of references in each database) then come articles on salmonellosis, toxoplasmosis, Q fever, infections by Campylobacter and listeriosis (Table 1.3).

## 1.4 PATHOLOGY OF ABORTIVE DISEASES OF SMALL RUMINANTS

The placenta, the foetal organ in contact with maternal endometrium at the level of the cotyledons on the placentome, assures :

1. exchange of nutrients;
2. hormone balance;
3. immunological competence;
4. protection against possible infective organisms, micro-organisms in particular.

If one of these functions, normally controlled with high precision, is altered it may result in premature expulsion of the foetus. The foetus may be live or dead, infected or uninfected. In sheep rearing consideration is given to the flock rather than the individual. "Abortive disease" - without inference of the cause - is said to occur when the threshold of abortions exceeds 1% since below this level the causal factors are uncertain.

Abortions can be classified, in a somewhat academic way according to the principal cause, into three categories :

1. genetic (malformations);
2. nutritional and/or toxic;
3. infectious.

Infectious abortion occurs most frequently and is the subject of the current work. However, initial mention will be made of the other causes to avoid any error in the preliminary careful diagnostic examination being systematically directed towards an infectious cause.

### 1.4.1 Genetic causes

Malformations of the foetus leading to its death or premature expulsion can be due to abnormalities of the genome.

*Table 1.2 :Number of references concerning abortive diseases of small ruminants presented in the four largest bibliographic databases*

| Period of Publication | Agris March 1974-1996 | Biosis August 1969-1996 | Cab Abstracts July 1972-1996 | Medline October 1966-1996 |
|---|---|---|---|---|
| 1976-1980 | 107 | 211 | 577 | 204 |
| 1981-1985 | 134 | 241 | 599 | 248 |
| 1986-1990 | 142 | 313 | 625 | 281 |
| 1991-1995 | 110 | 260 | 386 | 216 |
| *Total number of references selected* | *504* | *1274* | *2628* | *1352* |

*Source of information : Dialog, Knight-Ridder information, Mountain View*
*Selection criteria for references: (ovin? + sheep? + ewe? + lamb + lambs + ram + rams + caprin? + goat?)*abort?*

*Table 1.3 : Distribution of references concerning abortive diseases of small ruminants according to the nature of the infectious organism.*

| Infectious Disease | Agris March 1974-1996 | Biosis August 1969-1996 | Cab Abstracts July 1972-1996 | Medline October1966-1996 |
|---|---|---|---|---|
| *Total number of references selected* | **504** | **1274** | **2628** | **1352** |
| Brucellosis | 86 | 432 | 646 | 167 |
| Chlamydiosis | 136 | 163 | 552 | 132 |
| Salmonellosis | 76 | 140 | 351 | 50 |
| Toxoplasmosis | 54 | 91 | 276 | 46 |
| Q Fever | 26 | 20 | 110 | 26 |
| Campylobacter Infections | 28 | 40 | 174 | 21 |
| Listeriosis | 18 | 35 | 132 | 12 |
| Border Disease | 7 | 20 | 55 | 15 |
| Leptospirosis | 11 | 12 | 91 | 7 |
| Rift Valley Fever | 5 | 16 | 43 | 12 |
| Yersiniosis | 5 | 12 | 30 | 11 |
| Mycoplasmosis | 7 | 7 | 39 | 3 |
| Corynebacteriosis | 2 | 16 | 32 | 6 |
| Mycosis | 3 | 2 | 29 | 1 |
| Others | 148 | 214 | 717 | 412 |

*Source of information: Dialog, Knight-Ridder information, Mountain View*
*Selection criteria for references: (ovin? + sheep? + ewe? + lamb + lambs + ram + rams + caprin? + goat?)*abort?*

*One reference may refer to more than one infectious organism and may appear in more than one database therefore rows and columns cannot be summated*

These can result either from random accidents, which occur rarely during meiotic fusion or the first stages of cellular division, or from mutations that tend to be transmitted by the male. When these latter abnormalities occur at a high frequency, the ram appears to be infertile or of low fertility; this is easy to detect in rearing systems where reproduction is controlled but difficult to identify in extensive rearing.

Before making a diagnosis of male genetic low fertility, the absence of a genital infection by, for example *Brucella ovis* or *Chlamydia psittaci*, should be assured. These organisms cause low fertility in males and are transmissible to the female.

### 1.4.2 Nutritional and toxic causes

The live foetus is nutritionally dependent on its mother and is subjected to her deficiencies and toxicities. If there is already a severe deficiency in the dam it will be reflected during the course of gestation. Low fertility, on the other hand, may occur as a result of numerous deficiencies including energy, protein, vitamins, minerals, but is only one of many symptoms of such deficiencies. The foetus is poorly protected against toxicities: poorly equipped for detoxification and/or excretion of dangerous products, it accumulates these substances to which the dam is subjected until, in most cases, definitive, lethal lesions and abortion occur. The placenta can, in the same way, suffer major vascular disruption from toxic, endotoxic or anaphylactic shock which can affect the dam and lead to the death of the foetus. It occurs when there is:

1. Direct intoxication, from the chemical products used in agriculture or industry, by consumption of toxic vegetation or food contaminated by mycotoxins.

2. Indirect intoxication, secondary to a general bacterial or viral infection, particularly when a strong febrile reaction occurs due to bacterial endotoxin.

### 1.4.3 Infectious causes

Infection can reach the placenta basically by two routes:

1. the ascending route via the vagina, cervix and uterus;

2. the descending blood route, by far the most important route of abortive disease.

In the ascending infection, an external contaminant crosses the antimicrobial barrier of the cervix, for example during insemination or obstetric handling, then settles in the endometrium, frequently causing infertility and/or early abortion, or it may directly invade the membranes then the placenta and the foetus.

In the descending infection, during the course of the bacteraemic or viraemic phase of a general infection, the trophoblastic cells of the placenta - certain of which are active "macrophage-like" - capture some of the circulating bacteria [2, 4]. These foetal cells without doubt have the capacity to destroy a large number of invading organisms but they are not immunologically equipped to oppose those organisms that are "facultative or obligatory intracellular parasites" [11]. On the contrary, the placenta offers, by virtue of its blood supply and numerous metabolic activities, the ideal physiological and nutritional conditions for the rapid multiplication of bacteria, allowing the breakdown of all lines of defence.

The capture of circulating bacteria, however, is not obligatory. Contrary to the accepted theory there is no particular "tropism" of bacteria towards the pla-

centa, capture tending to occur randomly, by chance and in relation to the level and duration of the bacteraemia. Placental capture occurs less frequently, under normal conditions, than phagocytosis by the purifying organs of the body, the liver and spleen. Under controlled experimental conditions it has been shown that each of the 10-12 placenta in the uterus of a mouse can act as an independent unit [3] and that, up to a point, a single captured bacteria is sufficient to infect an individual placenta [4]. These results can be transposed to ruminants where the cotyledons seem to act independently of each other. It is not exceptional to find uninfected cotyledons alongside infected ones on the same placenta or even neighbouring cotyledons infected by different organisms. This leads to the conclusion that initial colonisation in ruminants occurs in the same way as in the mouse: a very small number of accidentally captured bacteria are sufficient to "colonise" a cotyledon where, in the absence of any maternal immunity, they multiply rapidly to excessive levels - up to $10^{12}$ *B.abortus* per g of cotyledon in bovines [1] - causing serious lesions and abortion.

### 1.4.4 Immunity in abortive diseases

Maternal immunity can work at two levels, systemic and local, and can partially or totally protect the foetus. In general, from results and observations in mice, cattle and sheep infected with Brucella, one can predict that the following process occurs :

1. Initial access of bacteria to the placenta can be limited by the strong reduction in the level and duration of the bacteraemic phase, principally by the action of opsonic antibodies.

2. Immunity can then pass over the placental barrier - probably at the inflammatory centre - in the form of maternal immune antibodies and lymphocytes [5], by mechanisms that are currently poorly understood.

3. If totally protected, the foetus will be born at term from an infected dam but will not necessarily be protected from contracting infection post-partum.

4. If partially protected, the foetus can be born prematurely or at term, infected or uninfected, with many placental cotyledons infected to varying degrees. The foetus born infected can, according to the causal organism, survive and make a full recovery with or without after effects or residual congenital infection, then becoming a possible source of subsequent recontamination for the flock.

According to the organism, the level of contamination and the age and stage of gestation at the time of contamination, the primary bacterial infection can be eliminated and leave a solid and lasting natural systemic immunity or, after a possibly abortive acute phase, persist in an inapparent chronic state. Immunity in this latter case is sufficient to protect the placenta during a new cycle of infection or on recontamination. This is why, according to current theory, the ewe generally only aborts once from a given infection, usually during the first gestation.

Understanding the mechanisms of immunity has justified the long-practised natural preventive method whereby immature lambs are placed in contact with (infected) adults at the time of birth. This technique certainly reduces the frequency of abortion, but can also be responsible for the persistence of infection in a flock. The technique has been effectively replaced today by prevention using live attenuated vaccines.

### 1.4.5 Abortive infections ; epidemiology ; hygiene

Besides epidemiological traits specific to individual infectious organisms, "abortive diseases" resulting from infections have two major features in common :

1. Genital excretion, the principal, but not the only, source of contamination.

2. The ovine species whose (a) gregarious behaviour and (b) often confined cohabitation with other susceptible species of animals, contains and/or spreads the potential of infection.

These features are the basis of the epidemiological cycle of infection within and between flocks.

In a theoretical breeding situation where ewes have no contact with other vectorial species (e.g. horses, cattle, camels, dogs) and lambing takes place in accommodation with strict application of the rules of isolation and hygiene, abortive disease will not exist. In contrast, the epidemiological reality in sheep breeding is the opposite. In seasonal movement and nomadic rearing, for example, in order to exploit forage resources animals must be moved and come into contact with other flocks thereby creating suitable conditions for the maintenance and spread of abortive disease. Moreover, it is common for many types of infection to coexist in the same flock, sometimes in the same animal.

The personnel in charge of diagnosis and prevention of the diseases should be aware of the basic theories of the epidemiology of abortive disease - the role of the birth, vector species and containment, coexistence of many infections - as well as the features specific to each organism; in particular, resistance and/or multiplication in the external environment (*Brucella, Coxiella, Salmonella, Listeria*) and the role of intermediary hosts (*Toxoplasma* and cats).

Finally it must be re-emphasised that many of these infections (*Brucella, Coxiella, Listeria*) can seriously affect humans who become contaminated during contact with animals, for example, during obstetrical handling or by consumption of infected products (milk or fromage frais, raw meat or offal). The pregnant human female is particularly susceptible to several of the small ruminant diseases causing abortion and/or perinatal foetal infections (*Listeria, Toxoplasma, Brucella, Chlamydia, Coxiella*). They must avoid contact with infected animals at all costs since these organisms can cause fatal or seriously disabling human diseases. While humans commonly contract infections from animals they are epidemiological end points and rarely transmit the diseases back to animals except in the absence of basic hygiene.

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