Sexually-transmitted diseases in animals

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The importance of sexually-transmitted diseases (STD) in human society needs no emphasis, and during the last two decades their increased prevalence has provoked much discussion. However, as Francis Bacon (1561–1626) remarked: 'Man is of kin to the beasts by his body', and the importance of coitus as a means of transmitting disease is as well known to veterinarians as to physicians.

The presentation of STD differs in man and animals. In man, it is the symptoms and signs of the initial infection (often quite minor in themselves) which bring a patient, and his sexual contacts, to medical investigation: most human cases of STD do not present because of complications. This does not usually apply to animals. Although an animal may show local evidence of infection, more often the veterinarian's advice is sought because of the appearance of complications, and of these the most important are abortion and infertility. Because of this, STD have been studied most in species such as cattle, sheep, pigs, horses, and dogs, where regular breeding is practised and such complications become of major economic importance.

Many animals lead a social life in groups, with a large number of females associating with each male. Mating is usually restricted to the period of oestrus, but in herds of domesticated animals most females come into oestrus at about the same time, so a sire may rapidly infect a large number of females; the communal use of good sires by neighbouring animal breeders may result in the introduction of STD into previously 'clean' herds. In herds with a number of males, an infection may spread from male to male via the female, a situation common enough among humans.

Although there are many opportunities for the spread of STD between animals, this spread is limited by the resistance to infection of the female, the degree of which varies between individuals and at different stages of the oestrus cycle. During oestrus resistance is high and the marked bacterial contamination of the vagina and uterus which occurs

during service is normally eliminated within hours. However, some pathogenic organisms have developed the ability to survive in the genital tract during oestrus and have become sexually transmissible. The commonest diseases caused by these agents will now be described, and contrasted with those which occur in man.

Protozoal Infections

TRICHOMONAS

Trichomoniasis is a common protozoal genital infection in both man and animals. Bovine trichomoniasis is still economically important in some parts of the world. It is caused by *T. foetus*, a flagellated protozoon which shows minor structural differences from *T. vaginalis* (Fig. 1). The disease is

FIG. 1 Drawings of *T. vaginalis* and *T. foetus*. *T. foetus* is slightly larger, and has one of the four flagella situated posteriorly. Both have an undulating membrane and an axostyle. (Courtesy of Messrs. May and Baker)

sexually transmissible (Laing, 1956). Recently infected bulls develop a mild urethritis or balanoposthitis; the infection soon becomes asymptomatic and may then persist almost indefinitely. In cows trichomoniasis is more serious. After a short incubation period a purulent vaginitis occurs first, but *T. foetus* then commonly infects the uterus, causing a trichomonal endometritis which often renders the animal infertile. If pregnancy does occur, abortion followed by pyometra often follows. As many services may be unsuccessful, several bulls may be used who in turn become infected. The incidence of bovine trichomoniasis has declined in Britain in recent years, largely because of the introduction of artificial insemination (A.I.) with trichomonad-free semen, but it is still high elsewhere.

Human trichomoniasis resembles the bovine disease in its sexual transmissibility. The initial signs of infection are similar, vulvo-vaginitis in women and urethritis or balanoposthitis in men, and asymptomatic carrier states are likewise common, particularly in women. The important difference is that *T. vaginalis* does not normally pass the cervix and infect the uterus, and abortion is not a complication of the human disease. The consequences for human society might have been serious if *T. vaginalis* had developed the invasiveness which characterizes *T. foetus*.

It is of interest that monkeys are the host species, not of *T. foetus*, which will not survive in the simian vagina, but of *T. vaginalis* (Ruch, 1959). The organism has been recovered from both wild and captive monkeys, in whom trichomoniasis is a mild disease, as in humans, not complicated by abortion or pyometra.

TRYPANOSOMA

Dourine is an important STD of animals which has no human equivalent. It occurs chiefly in horses and asses, and is endemic in the Balkans, Africa, Asia, and South America. The causative organism, *T. equiperdum*, is spread almost exclusively by coitus (Jubb and Kennedy, 1970). Stallions initially develop balanoposthitis with preputial oedema, and mares purulent vaginitis. In both sexes the organisms proliferate in the submucosal lymphatics, whence the infection often disseminates, and after some weeks plaque-like skin lesions containing trypanosomes appear. In severe infections there is fever, emaciation, and involvement of the central nervous system, and death may follow.

Most trypanosomal diseases of both man and animals are insect-borne, but dourine is an exception. However, it is of interest that in man the occasional sexual transmission of *T. gambiense*, the causative

agent of African sleeping sickness, has been recorded (Lewert, 1968).

Bacterial infections

There are many important bacterial STD in animals. Some of these infections may be introduced through the gastrointestinal tract as well as by coitus, but it will be seen that their human counterparts are usually not STD, the infecting organisms being introduced via the gastro-intestinal tract or by some other route.

VIBRIO

Some vibriotic diseases in animals are sexually transmissible. Infection of cattle with *V. foetus venerealis* occurs only through coitus, and the disease is an important cause of foetal death (Laing, 1970). Bulls have no apparent clinical disease but carry the organisms in epithelial crypts within the preputial sac. Infected cows likewise show no overt disease, but failure of conception is common and if pregnancy does occur the placenta is invaded by the organisms with consequent early foetal death and abortion. After a time infection in cows dies out, but bulls remain infected indefinitely. As with many other STD in cattle, the incidence of bovine vibriosis has declined with the introduction of A.I., especially when antibiotics are added to the semen.

In contrast, infection of sheep by *V. foetus intestinalis* usually occurs orally. However, some rams excrete the organisms in the semen, so occasional coital transmission is a possibility. The disease is still an important cause of abortion in some areas (Fig. 2).

There is no sexually-transmitted vibriosis in man. Infection by *V. cholerae* occurs exclusively via the mouth, and abortion is not a feature of human cholera.

SALMONELLA

Some *Salmonella* infections in animals resemble vibriosis in that they may be introduced both orally and through coitus. In horses, *Sal. abortus equi* is normally spread orally (Roberts, 1971). However, orchitis has been recorded in infected stallions, and sexual transmission of the disease may occur rarely. Whatever the route of infection, abortion is a common complication. *Salmonella* infecting other species appear to have become better adapted to sexual transmission. There is good evidence that infection of sheep by *Sal. abortus ovis* takes place in this way; the organisms are excreted in the semen from testicular infections (Mura and Contini, 1954), and infection of the ewe may lead to abortion. Human *Salmonella*

FIG. 2 *Vibrio foetus* infection: opened foetal carcass of a lamb. Notice septicaemic lesions. (Crown copyright; reproduced by permission of the Controller of Her Majesty's Stationery Office)

infections are always acquired orally, and sexual transmission is not known to occur.

LEPTOSPIRA

Some leptospiral infections of animals are sexually transmitted. It has been shown that bulls infected with *Lept. pomona* may shed the organisms in the semen and can infect susceptible cows either at natural service or by A.I. (Sleight and Williams, 1961). Again, abortion may follow. In pigs, *Lept. pomona* infects the kidney and is excreted in the urine, and contamination of the semen by infected urine may lead to the transmission of the disease to females (Roberts, 1971).

Leptospiral infection of man is usually due to accidental contact with infected material from animals, the organisms being introduced *via* the

mouth or skin. However, human leptospirosis may occasionally be sexually transmitted (Turner, 1973).

BRUCELLA

Brucellosis is a disease of domestic animals of major importance. Host specialization of the parasites has given rise to five species of *Brucella*: *Br. melitensis* of goats, *Br. abortus* of cattle, *Br. ovis* of sheep, *Br. suis* of pigs, and *Br. canis* of dogs. Under natural conditions brucellosis is disseminated by both oral and coital routes and the epidemiology varies between the different species.

In goats, infection with *Br. melitensis* occurs through the oral ingestion of organisms shed after abortion (Burrows, 1968). In cattle as well, infection with *Br. abortus* usually takes place orally, although direct inoculation through the skin can occur. However, the development of septicaemia often leads to genital infection (Laing, 1970); bulls may thus develop orchitis and in cows the uterus is invaded (Smith, Keppie, Pearce, Fuller, and Williams, 1961). Sexual transmission of the disease then becomes possible, either at natural service or by A.I. (Jubb and Kennedy, 1970).

Infection with *Br. ovis* in sheep is unknown in Western Europe but is common elsewhere. In this disease, although infection *via* the gastrointestinal tract does occur, as in bovine brucellosis, the coital route is more important, and infection often passes from ram to ram *via* the ewe (Laing, 1970). Infected rams show lowered fertility, excrete large numbers of organisms in the semen, and may develop epididymo-orchitis. Fertility in the ewe is generally not affected, but animals infected early in pregnancy may abort.

In porcine brucellosis, an infection further adapted towards sexual transmission is seen. Infection of swine by *Br. suis* is common in the USA although not in Western Europe. Although it can be spread orally, the main cause is mating with an infected boar (Roberts, 1971), and a boar shared between breeders may at times become a major source of infection. Such boars develop epididymo-orchitis and produce an infected semen of normal appearance. Granulomatous lesions and mucosal cysts of the endometrium, in which *Br. suis* is found, occur in sows and may persist for years. The disease, like *Br. abortus* infections, causes infertility and early foetal death.

Finally, *Br. canis*, a newly identified member of the genus, has caused important losses in breeding kennels of beagles in the USA (Carmichael and Bruner, 1968). In these outbreaks, the infection was entirely sexually transmitted.

Thus brucellosis in animals exhibits an epidemiological spectrum. In goats infection is oral,

usually from a genital source. In cattle infection is usually oral but occasionally coital. In sheep either route is possible. In pigs the coital route predominates. In some dogs the coital route is invariable. In all these animals abortion is a common complication.

There is no naturally occurring brucellosis in man. However, he may acquire *Br. abortus*, *Br. melitensis*, and *Br. suis* from infected domestic animals. Man to man infection is extremely rare (WHO, 1953); brucellosis in humans is not known to be sexually transmissible, nor do infected women show any tendency to abort.

MYCOPLASMA

The pathogenicity of *Mycoplasma* in the genital tract is uncertain in both animals and man. *M. bovi-genitalium* in cows is associated, not necessarily causally, with vaginitis, cervicitis, salpingitis, infertility, and sometimes abortion. In infected bulls no clinical disease is present, but the organisms can be recovered from the semen. *M. bovi-genitalium* is believed to be sexually transmissible, but it has been isolated from virgin heifers so other routes of infection may be possible. The pathogenicity of *M. bovi-genitalium* is at present undecided (Afshar, Stuart, and Huck, 1966).

A similar rather equivocal situation exists in cases of human *Mycoplasma* infection. In both men and women the prevalence of *M. hominis* and T-strain mycoplasma in the genital tract increases with sexual activity, but their pathogenicity is undecided. It is not now believed that *Mycoplasma* causes a significant amount of non-specific urethritis (NSU) (see McCormack, Braun, Lee, Klein, and Kass, 1973). In women there is evidence that *M. hominis* may sometimes cause pelvic inflammatory disease (Mårdh and Weström, 1970) and fever after abortion (Tully, Brown, Sheagren, Young, and Wolff, 1965), and T-strain mycoplasma has been implicated in some puerperal infections (Russell and Fallon, 1970; Sompolinsky, Solomon, Leiba, Caspi, Lewinsohn, and Almog, 1971). Finally, it has recently been suggested that *Mycoplasma* may be responsible for some cases of infertility (Gnarpe and Friberg, 1972) and abortion (Kundsinn and Driscoll, 1970). Human strains of *Mycoplasma* are undoubtedly sexually transmissible, but despite a great deal of research the resulting disease states, if any, have yet to be defined.

It may be asked whether there are any animal diseases which resemble the two most serious human bacterial STD, gonorrhoea and syphilis. The question is easily answered in the case of gonorrhoea, as there is no animal infection in any way like it. Indeed, in the natural state, *Neisseria* are virtually

non-pathogenic to animals, although some primates have with difficulty been inoculated experimentally with *N. gonorrhoeae*. Man is thus the only member of the animal kingdom with a sexually-transmissible neisserial infection.

Treponemal disease is uncommon in animals, but rabbit syphilis is a well-known clinical entity. The causative organism, *T. cuniculi*, is morphologically identical to *T. pallidum*, although there are antigenic differences (Smith and Pesetsky, 1967). Rabbit syphilis is a low-grade treponematoses which is spread by direct contact, including coitus. The disease is predominantly mucocutaneous and drags on for months, but the late complications of human acquired syphilis are never seen. Even in pre-myxomatosis days, rabbit syphilis showed a peculiarly local distribution (Middleton, 1935); the disease is now uncommon, although it persists in some wild rabbit colonies.

A naturally occurring treponematoses of cynocephalus monkeys was described by Fribourg-Blanc, Neil, and Mollaret (1966). There was no clinical disease, but FTA and TPI tests were positive, and treponemes morphologically identical to *T. pallidum* were demonstrated by indirect immunofluorescence in lymph node material from some of the animals. This infection appears to be geographically localized, since it was found in cynocephalus monkeys from Guinea, but not from Kenya or Cambodia. Nothing is known of its natural history or means of spread.

Rabbit syphilis has resemblances to human herd-type treponematoses, particularly pinta. However, no disease resembling human acquired syphilis exists in animals, and again man is unique in this respect.

Chlamydial infection

Chlamydial genital infection exists in both animals and man. Isolates from animals belong to Group B, forming intracellular inclusions which do not stain with iodine. *Chlamydia* in the genital tract in animals is regarded as definitely pathogenic (Storz, Carroll, Ball, and Faulkner, 1968; McKercher, 1969), and it is one of the causes of epizootic bovine abortion, particularly in Central and Southern Europe and in California. Coital transmission has not been established with certainty, although the organisms have been recovered from the semen of bulls with seminal vesiculitis. In epizootic abortion of sheep, which is likewise due to *Chlamydia*, infection usually occurs by the oral route; however, the isolation of *Chlamydia* from the semen of rams and serological studies indicate that sexual transmission is also a possibility (Tamarin and Landau, 1963).

Strains of *Chlamydia* from human sources belong to Group A, forming inclusions which stain with

iodine. These organisms are sexually transmissible and have been recovered from upwards of 40 per cent. of men with NSU and from their sexual contacts (Dunlop, Vaughan-Jackson, Darougar, and Jones, 1972; Oriel, Reeve, Powis, Miller, and Nicol, 1972). Many workers believe that *Chlamydia* is a major cause of NSU, although this is disputed by others (Richmond, Hilton, and Clarke, 1972). One of the best known chlamydial STD in man, lymphogranuloma venereum, has no animal equivalent. There is no evidence that *Chlamydia* is associated in any way with human abortion.

Viral infections

In man, only three authenticated viral STD are known, genital warts, genital herpes, and molluscum contagiosum, and there are counterparts to all of these infections in animals.

PAPILLOMAVIRUSES

Genital warts are quite common in man and in several animal species. Human genital warts are sexually transmissible; rarely, they may develop after the transfer of wart virus from a skin wart to the genitals (Oriel, 1971a). A similar natural history has been observed in the genital warts of cattle. Lesions on the penis and vulva usually develop through coitus with an infected animal but, as in man, they may occasionally spread from warts on the skin. Bovine warts have more fibrous tissue than the human variety (Formston, 1953); they contain a papillomavirus morphologically similar to other wart viruses (Crawford and Crawford, 1963), but this virus is unlike human wart viruses in not being strictly species-specific (Segre, Olson, and Hoerlein, 1955).

Anal warts are often seen in humans, particularly in those who practise anal coitus (Oriel, 1971b). Warts at this site seem to be very unusual in animals; although genito-anal contact is, of course, common among animals, actual anal coitus does not occur.

HERPESVIRUSES

Infectious pustular vulvovaginitis and balanoposthitis (bovine coital exanthema) is a common disease of cattle. It is caused by a herpesvirus which is apparently identical to the virus which causes infectious rhinotracheitis (Brown and Bjornson, 1959). Only cattle are naturally susceptible and the onset is sudden. Multiple papules form on the penis, vulva, or vagina which soon become vesicular and later ulcerate. The lesions heal in a few weeks, but relapses are common. The disease is highly contagious and is often transmitted by coitus, although infection by other routes, including A.I., is possible. There is some evidence that the infection may cause abortion in cows

(McKercher and Wade, 1964; Afshar, 1965). In bulls, degenerative changes in the seminiferous tubules may occur, with a period of infertility lasting for several months (Studdart, Barker, and Savan, 1964).

The relationship between pustular vulvovaginitis and infectious rhinotracheitis has been much discussed. It has been suggested (McKercher and Theilen, 1963) that the bovine virus, known mainly as a genital pathogen in Europe, was introduced into North America in about 1930 and became exalted in virulence, acquiring the power to spread by the respiratory route. This is the only infective agent yet recorded which can spread by both the genital and respiratory pathways.

In horses, a herpesvirus infection is responsible for coital vesicular exanthema, a sexually-transmissible disease similar to bovine coital exanthema (Pascoe, Spradbrow, and Bagust, 1968). It is not clear whether this agent is similar to the equine herpesvirus which causes rhinopneumonitis, but it is antigenically distinct from the bovine virus.

In dogs, a herpesvirus has been isolated from the canine genital tract (Poste and King, 1971), where it was associated with infertility, abortions, and stillbirths in a small pack of breeding Alsations. It was shown to reproduce the clinical features of vesicular lesions in the vaginal and preputial mucosa in experimental animals. The transmissible cytopathic agent isolated is a typical member of the herpesvirus group, but cross-neutralization tests failed to reveal a serological relationship between this agent and virus from human sources or bovine or equine rhinotracheitis virus.

In its clinical manifestations, infectivity, and tendency to relapse, human genital herpes is similar to bovine coital exanthema and equine vesicular exanthema. Although *Herpesvirus hominis* has recently been recovered from prostatic and testicular biopsies (Centifanto, Drylie, Deardourff, and Kaufman, 1972), there is at present no evidence that human herpetic infections are associated with infertility or abortion.

POXVIRUSES

Contagious pustular dermatitis (orf) is a mucocutaneous disease caused by a poxvirus. It is confined in the natural state to sheep and goats, although man may be infected accidentally. In sheep the disease commonly occurs on the lips and mouth. Vesicles are followed by pustules or proliferative wart-like lesions and spread is usually by direct contact between animals. Orf also occurs on the genitals (Fig. 3) and may be spread at service. Balanoposthitis and vulvitis of sheep ("pizzle rot") is a related or perhaps identical disease. Trueblood, Chow, and Griner

FIG. 3 *Contagious pustular dermatitis (orf) of sheep. Vulval lesions.* (Crown copyright; reproduced by permission of the Controller of Her Majesty's Stationery Office)

FIG. 4 *Molluscum contagiosum of penis. The lesions resemble those of genital orf, but are smaller*

(1963) grew a poxvirus from infected sheep in cell monolayers and found only minor differences from the orf virus. They thought that the two diseases might be caused by different strains of the same organism. The lesions which form on the penis or vulva resemble those of orf, and the disease is sexually transmissible (Tunncliffe, 1949).

Human molluscum contagiosum is also caused by a poxvirus; the lesions resemble small individual lesions of orf (Fig. 4). Like orf, molluscum contagiosum is sexually transmissible (Cobbold and MacDonald, 1970).

Parish (1961) described a genital papilloma in pigs, in which proliferative lesions occur on the penis and around the vulva. The disease may be sexually transmissible in the natural state, and has been transmitted experimentally. It is caused by a poxvirus (Allison, 1965). No human counterpart is known.

Transmissible venereal tumour of dogs

This disease is characterized by the appearance of indolent nodular lesions on the penis and vagina (Fig. 5). There is no definite evidence of a viral cause, and it is thought that the tumour cells themselves are sexually transmitted. When dogs are kept under control the incidence is low, and for this reason it is now extremely rare in Britain where it is practically confined to dogs imported from abroad (Howell, Ishmael, and Joshua, 1969), but it is common in the south of France, Puerto Rico, Asia, and elsewhere.

Histologically, the tumour cells resemble lymphosarcoma cells, but their nature and origin are not known. The number of chromosomes in the cells is constantly reduced from the normal 78 to 59; this seems to hold good regardless of the part of the world from which specimens are obtained (Murray, James, and Martin, 1969). It is therefore thought that the tumour is sexually transmitted as a clone of cells. These may lead to the formation of antibodies, and

FIG. 5 Transmissible venereal tumour of the penis in a 4-year-old spaniel (Courtesy of Prof. E. Cotchin)

about 16 per cent. of tumours regress spontaneously with the development of immunity. It is not normally malignant, but occasionally metastases may appear.

Being spread by the transfer of cells from donor to recipient, the transmissible venereal tumour is unique in animals, and no human equivalent is known. The possibility that human genital warts may occasionally be sexually transmitted as a clone could be entertained; there is nothing about the natural history of human genital warts which would make this idea inconceivable.

Discussion

Sexually-transmitted diseases are common in animals and it is interesting to compare them with human infections. In some there is a close resemblance. The natural history of human and bovine trichomoniasis, for example, is very similar, although *T. foetus* is more severely pathogenic than *T. vaginalis*. Bacterial STD, on the other hand, show considerable differences between man and animals. Infections by *Vibrio*,

Salmonella, *Leptospira*, and *Brucella* are almost never sexually-transmitted between humans, where the route of infection is predominantly oral. Among animals, however, infection is often transmitted by coitus as well as *via* the gastrointestinal tract, and some species of these micro-organisms have become adapted to exclusive sexual transmission.

Some well-known human STD such as gonorrhoea, chancroid, and lymphogranuloma venereum do not exist in animals, yet viral STD, particularly genital warts and genital herpes, are very similar in man and animals. All these similarities and differences cannot be fully explained, but we have considered them in connection with what is known about the evolution of infectious diseases in general.

Cockburn (1963) regarded it as axiomatic that all parasites were ultimately descended from free-living forms. Symbiosis between these forms and the larger animals took place millions of years ago, and the body orifices were among the first sites to be occupied. Parasitic mutants of these primitive organisms developed through natural selection, and from this point onwards symbiotic evolution of both host and parasite has taken place so that today both are peculiarly adapted to one another and to the prevailing ecological conditions.

This theory can be applied to trichomoniasis. The flagellated protozoa of the gastrointestinal and genital tracts are lumen-colonizing organisms. Many saprophytic forms exist, such as *T. tenax* and *T. hominis* of the human gastrointestinal tract. *T. gallinae* in chickens and *Giardia lamblia* in man are gastrointestinal pathogens, while *T. vaginalis* is pathogenic in the genital tracts of man and monkeys and *T. foetus* in cattle. Whether *T. vaginalis* evolved from *T. foetus*, or both from an ancestral form, cannot now be decided. However, both are perfectly adapted to sexual transmission and this may well confer considerable biological advantages on the organisms.

In many bacterial infections of animals an interplay between the gastrointestinal and coital routes of infection is seen. This is well shown in brucellosis; in this disease, as in vibriotic, salmonellar, and leptospiral infections, a bacteraemia develops, with genital involvement which may lead to sexual transmission of the infection to other animals. However, vibriosis in cattle and brucellosis in dogs are transmitted only through coitus.

This group of diseases may indicate one way in which the STD have evolved. However, other evolutionary pathways are possible. Most species of *Trypanosoma* are transmitted by insects, but *T. equiperdum* has spread to areas where suitable insect vectors are lacking by becoming sexually transmissible. Cockburn (1963) commented that it was

surprising that more vector-borne infections had not succeeded in doing this.

There is no sexually-transmitted infection caused by *Neisseria* in animals, and gonorrhoea is clearly a late arrival on the evolutionary scene. *Neisseria* are virtually non-pathogenic to animals, although saprophytic forms exist. *N. gonorrhoeae* may well have resulted from a mutation, or a series of mutations, of a saprophytic strain in the human mouth or genital tract; at what period in the world's history this event occurred is a matter of opinion, but the biological advantages which this mutant has obtained need hardly be emphasized.

The relationship between human and rabbit syphilis may be examined in the light of Cockburn's theories. He suggested a primaevial symbiosis between free-living treponemes and the larger animals, followed by the appearance of pathogenic strains. A symbiotic evolution of both man and parasite, conditioned by environmental factors, led to the appearance, in different racial and ethnic groups, of pinta, yaws, and endemic syphilis. A final mutant, *T. pallidum*, adapted for sexual transmission, had biological advantages over other treponemes as living conditions improved, and acquired syphilis in its modern form thus appeared. We might see the treponematoses of cynocephalus monkeys described by Fribourg-Blanc and others (1966) as a persisting example of the sort of avirulent treponematoses which may have preceded treponemal disease in man. Although rabbit syphilis, as has been seen, resembles pinta, and *T. cuniculi* resembles *T. pallidum*, the two diseases could be envisaged as having evolved independently from an unknown ancestral treponematoses; alternatively, rabbits could have been parasitized from man or *vice versa*.

The viral STD are similar in man and animals. There are only minor differences between genital warts in the two, and human genital herpes bears a close resemblance to herpetic diseases of some animals. There are also similarities between the poxvirus infections molluscum contagiosum and genital orf. The origin of viruses has been much debated, but Almeida and Waterson (1968) suggested that they arose very early in the evolutionary scale. Viruses are fairly simple organisms which may be capable of only relatively minor mutation, unlike bacteria whose complicated enzyme systems and nucleic acids are susceptible to evolutionary changes which could lead to major alterations in pathogenicity. Some viral infections may be very old. For example, Campbell (1969) described lesions resembling osteopetrosis in the long bones of dinosaurs; osteopetrosis is also seen today in a fowl disease caused by a virus of the avian leucosis group (Young,

1966). It may be that the viruses which cause STD have remained relatively unaltered since primordial times, which would make the viral STD by a long way the earliest.

The association between STD and abortion or infertility is well known in animals; indeed, it is perhaps the major reason why veterinarians study these infections. Protozoal infections such as trichomoniasis, bacterial infections such as vibriosis and brucellosis, and viral infections such as herpes are regularly associated with abortion in animals. With the exception of early syphilis, little is known about any possible association between STD and human abortion, although, as has been seen, *Mycoplasma* has an equivocal role in this connection. Of no less interest is the question of infertility in relation to STD. In this, as in other matters, physicians may have much to learn from their veterinary colleagues.

In animals, STD have become much less prevalent as a result of control measures. Of these, the simple device of A.I. with non-infected donor semen has been the most successful. Drug therapy of infected animals is too expensive to be used except in special circumstances, and the simple expedient of enforced exclusion of the animal from coitus until the infection has died out is often used. Some STD physicians may wish that a similar draconian measure was available for humans.

Summary

Sexually-transmitted diseases (STD) are common in animals. In this paper, the most important protozoal, bacterial, and viral STD of animals are described and contrasted with human STD. The evolutionary implications of the relationship are discussed.

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Maladies sexuellement transmises chez les animaux

SOMMAIRE

Les maladies sexuellement transmises (MST) sont fréquentes chez les animaux. On décrit, dans cet article, les plus importantes des MST animales dues à des protozoaires, des bactéries ou des virus, et on les oppose aux MST humaines. On discute les implications de ces études comparées quant à l'évolution.