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Chlamydia and Chlamydophilia in bovine reproduction
Johannes Kauffold, a Axel Wehrend, b Haukur Sigmarsson a

a Large Animal Clinic for Theriogenology and Ambulatory Services, Faculty of Veterinary Medicine, University of Leipzig, b Clinic for Obstetrics, Gynaecology and Andrology of Large and Small Animals with Veterinary Ambulance, Justus-Liebig-University, Giessen, Germany

Abstract
Infection with chlamydial bacteria, specifically *Chlamydophila pecorum*, *C. abortus*, and *C. psittaci*, is common in cattle. Infection can cause different diseases of which sub- and infertility are the most often observed clinical manifestations. While bulls are usually carriers of chlamydia bearing the risk of being vectors for an infection of females, either through natural mating or artificial insemination, heifers and cows can suffer a multitude of genital disorders. However, chlamydiosis in cattle is generally considered a (multi)factorial disease with factors being related to the environment, confinement or climate. This contribution will briefly describe chlamydial infection in cattle with specific focus on reproduction.

Keywords: Chlamydia, Chlamydophilia, bovine, reproduction

Introduction
Chlamydiae are obligate intra-cellular gram-negative bacteria that cause different diseases in animals and humans. In cattle, chlamydial infections can cause abortion, polyarthritis, encephalomyelitis, keratoconjunctivitis, pneumonia, enteritis, hepatitis, vaginitis and endometritis, infertility, and chronic mastitis. Besides clinical disease, Chlamydiae may be the cause of sub-clinical manifestation. This is supported by observations in dairy herds with endemic infection and sub-optimal production records where other relevant pathogens were absent. Moreover, these observations have suggested a role for chlamydial infection as a multi-factorial disease complex. This contribution will briefly review the current knowledge on chlamydial infection in cattle with emphasis on clinical reproduction.

Taxonomy
The order “Chlamydiales” has been re-classified regularly leading to the current taxonomy of the family Chlamydiaceae separated into the genera Chlamydophila and Chlamydia, with a total of nine species, namely, *Chlamydophila abortus*, *C. pecorum*, *C. psittaci*, *C. pneumoniae*, *C. felis*, *C. caviae*, *Chlamydia trachomatis*, *Chlamydia suis* and *Chlamydia muridarum*. Three new families were added, i.e. Parachlamydiaceae, Waddliaceae, and Simkaniaceae.

There are a number of chlamydial species that can be observed in cattle including *C. pecorum*, *C. abortus*, *C. psittaci*, and *Chlamydia suis*, with the first three being clearly the most prevalent species.

Prevalence
Chlamydial infection is highly prevalent in the dairy cattle population worldwide, with seropositivity at herd level ranging from 45% to 100%. This suggests that chlamydial infections are ubiquitous in cattle. Generally, serological data are difficult to interpret, as chlamydial antibodies can be the humoral response from an infection in any part of the body, and a bacteriologically positive result not necessarily means that the individual has developed antibodies. For instance, in a recent survey conducted in six bull studs it was demonstrated that, while seropositivity was 51% the rate of PCR positivity in semen, preputial washes and feces was between 9% and 18%. Furthermore, serology failed to identify bulls shedding chlamydiae in their semen. Similarly, in a study aimed to monitor the course of a “natural chlamydial infection” in calves it was found that 60% of the animals seroconverted after inoculation, whereas all were shedding the bacteria.

As aforementioned, *C. pecorum*, *C. abortus* and *C. psittaci* are the most prevalent species in cattle. However, there seem to be specimen, gender and topographical effects. For instance, the study of
Kemmerling et al investigated vaginal swabs and revealed 56% positive for *C. psittaci*, 37% positive for *C. abortus* and 8% positive for *C. pecorum*. In contrast, stud bulls were mostly *C. psittaci* positive in semen and preputial washings, while *C. pecorum* prevailed in fecal samples. In Asia, specifically Taiwan, it seems that *C. abortus* is the most prevalent genital chlamydial species. In the United States, previous studies have mostly demonstrated *C. pecorum* and *C. abortus*, while *C. psittaci* was not found. But even within Europe, i.e. Austria and Switzerland, the most prevalent chlamydial species, respectively, were also found to be different. Generally, the different chlamydial species found in cattle can infect different organs not uncommonly at the same time. On the other hand there seems to be a genital tropism, with *C. abortus* and *C. psittaci* being the ones that are mostly infecting the genital tract. Mixed infections with two or more chlamydial species at the same time are always possible.

### Routes of transmission

Chlamydiae can be shed by almost all secretions and excretions (vaginal, ocular, and nasal fluids, semen, urine etc.), with fecal shedding being the most important route. Also, the bacteria can be found in aborted material such as fetuses as well as placentae. Animals usually infect themselves via the horizontal route through ingestion or inhalation. Venereal transmission seems possible. However, available data still raise questions for example of the bacterial load in semen that is necessary for an infection, the pathogenicity of different species, and possibly also the survivability of Chlamydiae after extension of semen during semen processing. Vertical transmission has yet not been reported.

### Effects of chlamydial infection on health and fertility

Generally, infection with chlamydia is considered a multifactorial disease, with several factors related to housing, climate, hygiene etc. being contributors. Until recently, chlamydial infection was considered a sporadic event in cattle with no clinical signs or a sub-clinical course that does not have effects on the animal soundness. In a more recent study, however, where 100 randomly-selected dairy farms were investigated for the effects of chlamydial infection on production traits, a clear relationship was found to average annual milk production (8681 vs. 9197 kg in infected vs. non-infected animals), number of lactations/animal (2.4 vs. 2.9), rates of abortion, premature calving and perinatal calf deaths (P<0.001). Most importantly, the study revealed that sanitation was better on Chlamydia negative farms again supporting the fact of a multifactorial genesis of Chlamydia-associated disease and that management factors can have a positive effect on the occurrence of the disease.

Besides general health, Chlamydiae, specifically *C. abortus* and *C. pecorum* have been shown to effect milk yield, either by inflammation or subclinical disease.

An infection with chlamydia may cause sub- or infertility. Infected bulls may suffer from vesiculitis, or may not be affected at all. Interestingly, infected bulls did not show impaired semen quality as measured on the basis of standard semen parameters. As aforementioned, regardless of being diseased, bulls can shed Chlamydia via semen, and shedding can be intermitted which then puts some difficulties on diagnostics and interpretation of diagnostic results. An interesting finding by an in vitro study conducted by our group is that Chlamydia bind to specific receptors of the sperm membrane (spermadhesines) that are necessary for the sperm to be bound to oviductal cells of the sperm reservoir, i.e. the utero-tubal junction. While this may lead to a reduced capability of sperm to be attached to oviductal cells (and may thus impair the fertility and survivability of the sperm), this mechanism may also be part of an “active” transmission process of Chlamydia through semen.

Any part of the genital tract of a cow or heifer can be infected. Swabs taken from different parts of the genital tract including vagina and uterus but also the oviduct (Kauffold et al., unpublished) frequently proved positive for Chlamydia. Sporadic abortion can occur. Also, sporadic cases of endometritis and vaginitis due to chlamydial infection has been described. Interestingly, the fact that Chlamydia was found in different oviductal segments suggests that, as in humans, laboratory animals but also swine, the oviduct is a target organ for an infection. Whether or not this may have consequences for oviducital functions is yet not known. However, the fact of an “oviductal postivity” per se suggests that Chlamydia may damage or interfere with oviducital functions either structurally
and/or functionally. An oviductal infection may be the “ideal” explanation of subfertility or rebreeding of cows and heifers, that otherwise do not show any clinical disease.

Conclusions

There is clear evidence that chlamydiae are endemic in the cattle population. It is also clear that bacteria can cause clinical disease. However, subclinical cases are the predominant manifestation. Sub- and infertility are the most often seen clinical signs. Any part of the genital tract can be infected. Whether or not an infection results in structural and/or functional damage is dependent on a multitude of factors related to e.g. environment, confinement or climate. Thus, management measures that are aimed to improve these factors are beneficial toward avoiding chlamydiosis in cattle.

References