


Recommendations for the use of antimicrobials in the treatment of the most significant infectious and contagious diseases in animals



Recommendations for the use of antimicrobials in the treatment of the most significant infectious and contagious diseases in animals



UNIVERSITY OF HELSINKI
FACULTY OF VETERINARY MEDICINE



Authors: The Finnish Food Safety Authority, Evira, and
the Faculty of Veterinary Medicine at the University of Helsinki

Cover picture Pixabay

Layout: Finnish Food Safety Authority Evira, In-house Services Unit

Helsinki 2018

Contents

Preface	4
Principles of antimicrobial treatment.....	6
Veterinarian’s checklist on legislation regarding antimicrobials	8
Ruminants.....	10
Pigs.....	19
Horses	26
Fish	32
Poultry	35
Bees.....	39
Cats and dogs	40
Fur animals	48



Preface

Antimicrobial medicines are of great importance in the treatment of infectious diseases in both humans and animals. Their prudent use is the key to the health of both the human and animal population. This is the only way to slow down resistance development, which is a global threat, equal to climate change. In treating infectious diseases in animals, it should be borne in mind that the effects of the use of antimicrobials are not solely limited to an individual animal or group of animals for which the antimicrobials are used. It may also affect other animals, food safety and people working and living with animals.

The routine use of antimicrobials without attempting to resolve the underlying causes will lead to ineffective use of antimicrobials. These updated recommendations further highlight the fact that antimicrobials should not always be the first option. Practitioners are obligated to identify predisposing factors, management and treatment of animals, as well as clarify measures in order to get the situation permanently under control. Finland is at the forefront of the prudent use of antimicrobials on animals. In order not to jeopardize this situation, the contribution of every veterinarian is required.

Recommendations for the use of antimicrobials in Finland date back more than 20 years. The first examples of the application of antimicrobials in the treatment of the most significant infectious and contagious diseases in animals were issued by the Ministry of Agriculture and Forestry in 1996. These were updated to become recommendations in 2003, with a new update being issued in 2009. The target is to update the recommendations at five-year intervals. Due to disruption in the availability of benzylpenicillin procaine, which started in spring 2015, the updating process was postponed.

You are in possession of a latest update of the recommendations. This update takes account of the changes to animal morbidity, new developments regarding treatment, new medicinal products that have entered the market and the changed resistance of bacteria causing diseases in animals, all of which have occurred since 2009. In particular, change in the resistance situation concerns bacteria causing skin and urinary tract infections in dogs and cats. Consequently, the recommendations on antimicrobial medication for dogs and cats have been subject to the most change in this update. However, the major change is that a whole new generation of veterinarians have entered working life.

The recommendations also draw the reader's attention to key aspects other than the selection of antimicrobials. This is particularly the case if other treatments have proved

successful or significant changes have taken place in clinical practices in recent years. However, these are principally being included to remind that the proper medication alone will not suffice.

Similarly, notifications on animal diseases which require control by law or monthly reporting have been added. If veterinarians suspect that an animal has a disease that requires control, they must immediately report the case to the municipal or provincial veterinary officer.

Recommendations for the use of antimicrobials have been updated in collaboration with experts at the Faculty of Veterinary Medicine at the University of Helsinki and Evira, the Finnish Food Safety Authority. The recommendations were initially submitted for commentary to every veterinarian, all of whom had the opportunity to comment. The fine tuning was completed in collaboration with veterinary experts. The updating of these recommendations has only been possible through broad-based expert collaboration.

Thank you to all those veterinary experts who participated in the updating process.

Sanna Elfving

Katja Hakkarainen

Mari Heinonen

Katriina Hietanen

Kirsi Juuti

Ninja Karikoski

Lassi Kauko

Susanne Kilpinen

Heini Koskinen

Helena Kuntsi-Vaattovaara

Inka Laaksonen

Riikka Lasonen

Henna Laurila

Anna-Maria Moisander-Jylhä

Eeva Mustonen

Anna Mykkänen

Sari Mölsä

Kati Niinistö

Heli Nordgren

Claudio Oliviero

Olli Peltoniemi

Maija Penttilä

Johanna Penttinen

Elina Pietilä

Leena Pohjola

Satu Pyörälä

Merja Rantala

Virpi Rantanen

Helena Rautala

Maija Räihä

Leena Saijonmaa-Koulumies

Kirsti Schildt

Riitta Seppänen

Hanna Sillanpää

Heli Simojoki

Thomas Spillmann

Katariina Thomson

Outi Vapaavuori

Minna Viitanen

Sanna Viitanen

Elias Westermarck

Animal health ETT

Suomen Kunnalliseläinlääkäriliitto r.y. (Finnish Association of Municipality Veterinarians)

Finnish Association of Veterinary Practitioners

Finnish Association for Food Animal Practitioners

The Finnish Medicines Agency Fimea

Principles of antimicrobial treatment

These recommendations seek to promote prudent use of antimicrobials in the treatment of animals, thereby mitigating antimicrobial resistance. Contagious and infectious diseases in animals must be prevented, above all, by ensuring good production conditions. However, on occasion, the use of antimicrobials is necessary. On such occasions, antimicrobial treatment must be based on legislation and the following principles:

- ▶ The use of antimicrobials must be well justified.
- ▶ Whenever antimicrobials are used in animals, they also affect human health. This applies to both production and companion animals.
- ▶ Methaphylactic antimicrobial medication must only be used when a veterinarian deems such treatment necessary on account of the severity of the case or the disease situation at the animal unit. The use of methaphylactic antimicrobial medication must always be based on veterinary grounds.
- ▶ If other treatments found to be equally effective as antimicrobial treatment are available, they must be given precedence over all other treatments.
- ▶ The course of antimicrobial treatment must not be longer than is required to cure the disease.
- ▶ Before commencing antimicrobial treatment, the veterinarian must establish, on the basis of either a clinical or a microbiological investigation that the signs of the disease indicate a bacterial infection.
- ▶ If necessary, the veterinarian shall take representative samples in order to define the causative microbe and its susceptibility to antimicrobials.
- ▶ In selecting antimicrobial, information on the patient, the cause of the infection and disease and any available medication must be taken into account. The selected antimicrobial and dosage are chosen so that the microbes are either killed or their growth rate is decreased, in order to enable the body to destroy the microbe and recover from the disease.
- ▶ Primarily, a narrow spectrum antimicrobial medicine must be used. The use of broad-spectrum antimicrobials and antimicrobial combinations should be avoided. If the pathogen is susceptible to penicillin, the illness must not be treated with other beta-lactams or broad-spectrum antimicrobials unless the patient is allergic to penicillin.

- ▶ Regarding salmonella infections, antimicrobials are only used if the case involves a systemic infection which threatens the animal's life. Antimicrobials must not be used in the prevention, eradication or treatment of salmonella infections in poultry, cattle or pigs.
- ▶ In the case of viral diseases, antimicrobials should not be used to prevent secondary bacterial infections.

While the use and prescription of antimicrobials may appear easy, their justified and proper use poses challenges.

Veterinarian's checklist on legislation regarding antimicrobials

Use of antimicrobials

Decree of the Ministry of Agriculture and Forestry on the use and distribution of medicines in veterinary practice (17/14), Appendix 2, Chapter 5

- ▶ Ensure that there is a clinical or microbiological diagnosis when using antimicrobials on animals.
- ▶ In the case of repeated courses of antimicrobials and the administration of medication to groups, ensure the microbiological diagnosis and the susceptibility of the causative microbe. If this is not possible, select a medication by other reliable means. Samples must be taken at least once a year.
- ▶ Fluoroquinolones, third and fourth generation cephalosporins, and broad-spectrum or long-acting macrolides may only be used on animals if no other effective treatment is available. The basis must be a reliable microbiological analysis, drug susceptibility testing, epidemiological knowledge, or other reasons based on veterinary grounds.
- ▶ Multiple orally-administered antimicrobials must not be administered simultaneously to animals without veterinary grounds.
- ▶ Antimicrobials must not be administered to prevent infections or diseases without veterinary grounds.
- ▶ Doses and the duration of courses must be based on veterinary grounds.

Handing over antimicrobials to farms under the herd health management scheme

Decree of the Ministry of Agriculture and Forestry on the administration and transfer of medicines in veterinary practice (17/14), Appendix 4, Chapter 2

- ▶ Antimicrobials may only be handed over to farms to treat common diseases described in the herd health management plan.
- ▶ When handing over antimicrobials, the prerequisites listed in Appendix 2, Chapter 5, must be complied with.

- ▶ If antimicrobials are used to treat recurrent diseases in animals, necessary samples must be regularly taken for microbiological diagnostics and testing drug susceptibility.
- ▶ For a single indication, only one antimicrobial option can be handed over unless laboratory tests indicate that there are veterinary grounds for treating various animals or various groups of animals with different antimicrobials.
- ▶ The choice of medication must be based on knowledge of the causative microbe and its susceptibility to antimicrobials.
- ▶ Fluoroquinolones or third and fourth generation cephalosporins must not be handed over.

Prohibited antimicrobials

Government decree on the prohibition of the use certain medicinal substances on animals or on their limited use (1054/2014, others. 22/15) Section 11

- ▶ The use of antimicrobials reserved for treating serious infections in humans is forbidden on animals. Such drugs include third and fourth generation cephalosporins, rifampicins, new fluoroquinolones and carbapenems.
- ▶ However, these may be used on animals if for the medical product in question, a valid marketing authorisation or another licence allowing it to be released for consumption has been granted in Finland. Furthermore, rifampicin may be used in conjunction with erythromycin, azithromycin or clarithromycin to treat *Rhodococcus equi* infections in foals.
- ▶ The cascade principle is not applied to these medicines. The medicine may only be used on the target animal species and the indication detailed in the marketing authorisation or in the special permit.

Ruminants

Compared with other domestic animals, the antimicrobial treatment of ruminants poses problems. The kinetics of many medicinal substances, such as volume distribution, differ significantly between ruminants and non-ruminants. In ruminants, the xenobiotic metabolism of the liver is well developed; consequently, ruminants are able to quickly eliminate medicinal substances metabolizing in their liver. The rumen of the cow is large, and when its pH value is compared with blood, it is found to be acidic. Like alkalis, ionizing medicinal substances tend to concentrate in the rumen.

Administering antimicrobials orally to ruminants poses significant problems. The medicines will be diluted in the large fluid volume. Furthermore, microbes in the rumen exhibit an active xenobiotic metabolism, enabling them to inactivate many medicinal substances. For example, trimethoprim breaks down completely in the rumen. The anaerobic nature of the rumen considerably decreases the activity of certain antimicrobials, such as aminoglycosides. A ruminant is also dependant on the well-being of the microbial fauna in its rumen; antimicrobials may damage the microbes in the rumen or select the fauna so that it develops in a disadvantageous direction. As the urine of ruminants is alkaline, medicinal substances with an acidic character will be emitted in urine more easily than alkalis.

The pharmacokinetics of medicinal substances in newborn and adult ruminants differs; before the rumen starts functioning, a young ruminant resembles a non-ruminant. At this stage, many medicinal substances are absorbed well via the gastrointestinal tract. On the other hand, many young animals are sensitive to the harmful effects of antimicrobials, and the oral administration of many antimicrobials may cause diarrhoea and malabsorption. In newborns, the ability of the liver to metabolize substances is often insufficient. The half-life of medicinal substances in young calves is normally longer than in adult animals. For example, the half-life of trimethoprim is 8 hours in a calf that is 24 hours old, and one hour in an adult animal. Many antimicrobial preparations irritate tissues; consequently, intravenous administration is always to be recommended, as long as it is allowed for a preparation and possible in practice. In particular, this concerns calves.

With regard to sheep, goats and reindeer, the principals of the use of antimicrobials are similar to those applied to cattle. As sheep and goats are sensitive to tissue irritation, injecting irritating medicines into muscles must be avoided. There are pharmacokinetic differences between species; thus, dose recommendations should be based on studies conducted specifically on the target species. Unfortunately, only a few studies have been

published on the pharmacokinetics of sheep, goats and reindeer, and few medicinal preparations have been approved for them. Therefore, medicines approved for other species must be used in sheep, goats and reindeer quite extensively.

The choice of antimicrobials in ruminants is often based on empirical evidence rather than well-planned clinical trials. With regard to most antimicrobials, the optimal dose and frequency of administration in the various indications has not been clarified. In the case of certain diseases, such as pneumonia and mastitis, clinical trials have been carried out, and treatment recommendations can be based on them. Legislation on the administration of medication requires active sampling in order to enable the follow up of pathogens and their resistance, if an animal or group of animals are repeatedly treated for the same signs or if antimicrobials classified as critical are being used.

The following table summarises recommendations for the choice of medicine for microbial diseases in ruminants under current Finnish conditions. The table includes only medicinal substances for which the preparations have been granted a marketing authorisation or a special permit for food producing animals in Finland. Treatment is based on the assumption that targeted treatment is primarily used – in other words, a medicinal substance with a spectrum that is as narrow as possible. However, this is not always possible, particularly if the case involves a mixed infection caused by multiple bacteria. Recommending antimicrobials for infections for which the cause has been found to exhibit increased resistance to the substance in question has been avoided.

Dose recommendations for antimicrobials in cattle for common purposes

Check whether the dose is in accordance with the summary of product characteristics. If the dose is higher or more frequent than that indicated in the summary of product characteristics, the veterinarian must set a longer withdrawal period.

Medicinal substance	Dose mg/kg	Dose interval
Aminopenicillins	15 mg/kg	BID
Benzylpenicillin	20 mg/kg	SID
Enrofloxacin	5 mg/kg	SID
Benzylpenicillin-Natrium	9 mg/kg	BID
Penethamate penicillin	10-15 mg/kg	SID
Trimethoprim + sulfonamides	30 mg/kg	SID
Oxytetracycline	10 mg/kg	SID

Sources: Antimicrobial Therapy, edited Giguere, S. et al; Blackwell Publishing Ltd, 2013
 Guide to Antimicrobial Use in Animals, edited Guardbassi L. et al, Blackwell Publishing Ltd, 2008
 Pharmaca Fennica Veterinariae 2015

Ruminants

Recommendations for the selection of antimicrobials for ruminants in cases where the use of antimicrobials is necessary regarding the diagnosis in question. Unless specifically stated otherwise, the medicine must be administered in the form of injections.

Medicinal substances or groups of medicinal substances which, for the pathogen, the disease, the resistance situation and the characteristics of the medicinal substance, are most appropriate for treatment of the disease are specified as first-line treatment. There is also scientific evidence for the clinical efficacy of some recommended treatments, but for others no such evidence is available, and it has been necessary to accept theoretical grounds. Whenever possible, the first-line treatment aims at targeted treatment. For example, regarding diseases from which several different bacterial species can be isolated, treatment is often targeted at the most common pathogens.

Skin, ears and eyes

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Interdigital phlegmon	<i>Fusobacterium necrophorum</i> , <i>Dichelobacter</i> (former <i>Bacteroides</i>) <i>nodosus</i>	Benzylpenicillin	Oxytetracycline	Disinfecting hoof baths for healthy animals.
Digital dermatitis	<i>Treponema</i> spp.	Oxytetracycline Local treatment.		Salicylic acid as a local treatment.
Foot rot in sheep	<i>Dichelobacter nodosus</i> , <i>Fusobacterium necrophorum</i>	Oxytetracycline		Verification of the diagnosis, eradication. A monthly reported animal disease.
Infectious keratoconjunctivitis Cattle, sheep, reindeer, goats	<i>Listeria monocytogenes</i> <i>Moraxella</i> spp mycoplasma	Benzylpenicillin applied locally	Polymyxin B + oxytetracycline locally	A bacteriological sample is recommended; a diagnostic package for the eye inflammation from Evira <i>Mycoplasma bovis</i> may also give rise to eye infection.
Uveitis Cattle, sheep, reindeer, goats	<i>Listeria monocytogenes</i>	Polymyxin B + oxytetracycline	Benzylpenicillin applied systematically	<i>Listeria</i> is a monthly reported animal disease.
Ear infection	<i>Mycoplasma bovis</i> <i>Pasteurella multocida</i> <i>Histophilus somni</i> <i>Mannheimia</i> sp.	See section on respiratory tract		Is often related to respiratory infection.
Abscesses caused by <i>T. pyogenes</i>	<i>T. pyogenes</i>	Surgical opening of the abscess and the systemic administration of benzylpenicillin when necessary		

Skin, ears and eyes

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Problems with abscesses, actinobacillosis, actinomycosis, botryomycosis	<i>Actinobacillus lignieresii</i> , <i>Actinomyces bovis</i> <i>Pseudomonas</i>	No antimicrobials.		Culling of the animal, if the disease causes discomfort to the animal and is a risk of spreading the infection. Management factors.
Abscesses in sheep (Caseous lymphadenitis, CLA)	<i>Corynebacterium pseudotuberculosis</i>	No antimicrobials.		Diagnostic sampling is recommended. A contagious disease. Culling of the animal.

Respiratory tract

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Bovine respiratory disease (BRD)	<i>Pasteurella multocida</i> , <i>Mannheimia haemolytica</i> , <i>Histophilus somni</i> , <i>Mycoplasma</i> sp <i>Ureaplasma</i> sp	Oxytetracycline	Benzympenicillin Macrolides	Diagnostic sampling is recommended. Also viral agents. Deep nasopharyngeal swabs or bronchoalveolar lavage. Recurrent medication or poor efficacy of medicines: Sampling every time or at least once a year. Management factors. Group size.
	<i>Mycoplasma bovis</i> Dairy cows	Oxytetracycline		Duration of the course: one to two weeks. Lung lesions caused by <i>M. bovis</i> are often severe and irreversible; consequently, culling the animal may be a reasonable option.
	<i>Mycoplasma bovis</i> Youngstock and bulls	Oxytetracycline	Macrolides	The alternative treatment is to be selected if the signs have not eased in two days or they worsen or the disease recurs within a week. The duration of an oxytetracycline course is a minimum of 7 or 2 days after the signs have disappeared. <i>M. bovis</i> is a monthly reported animal disease
Ovine respiratory disease (pneumonia)	<i>Mannheimia haemolytica</i> , <i>Pasteurella multocida</i> mycoplasma	Benzympenicillin Oxytetracycline		Pathological examination for diagnostics. Also viral pathogens.

Gastrointestinal tract

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Diarrhoea in a newborn (neonatal diarrhoea)	<i>Escherichia coli</i> , enterotoxigenic	Trimethoprim-sulfonamides		Extremely rare in Finland. Bacteriological diagnosis. Fluid therapy is important. Colostrum, management factors. No oral administration of antimicrobials.
Diarrhoea in pre-weaning calves	several viruses, bacteria	Trimethoprim-sulfonamides, if systemic signs are present		Diagnostic sampling. Fluid therapy is important.
Coccidiosis	Eimerias	No antimicrobials.	Trimethoprim-sulfonamides for systemic signs.	Fluid therapy. Toltrazuril for prevention; not for calves used in meat production. Verification of the diagnosis through faecal samples. Improvement to hygiene.
Cryptosporidiosis	<i>Cryptosporidium parvum</i>	Improvement to hygiene.		The laboratory test is required for diagnosis. <i>C. parvum</i> is a zoonosis. No effective medication available.
Salmonellosis in cattle	<i>Salmonella</i> , <i>S. Typhimurium</i> , etc.	Antimicrobials must not be used in the prevention, eradication or treatment of salmonella infections in cattle (Decree of the Ministry of Agriculture and Forestry 1030/2013).		An animal disease that must be controlled by law. Verification of the diagnosis. If cattle has haemorrhagic diarrhoea, take a salmonella sample.
Salmonellosis in sheep	<i>S. diarizonae</i> , other serotypes are also possible	No antimicrobials.		An animal disease that must be controlled by law.
Pulpy kidney disease in sheep and goats	<i>Clostridium perfringens</i> type D	No antimicrobials.	Benzympenicillin	Fluid therapy. Restrictions on feeding. Vaccination of the flock is recommended for the future. Pathological examination for diagnostics. A monthly reported animal disease.

Reproductive tract

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Acute metritis	<i>Trueperella pyogenes</i> , <i>Escherichia coli</i> , anaerobic bacteria, streptococci, staphylococci	Benzylpenicillin	Oxytetracycline	Systemic treatment.
Endometritis	Generally an aseptic inflammation.	No antimicrobials.	Benzylpenicillin	Induction of oestrus. Local treatment if antimicrobials are administered. Uterine flushing only in exceptional cases.

Urinary tract

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Cystitis	<i>Corynebacterium renale</i> , <i>Escherichia coli</i>	Benzylpenicillin	Based on the results of susceptibility testing.	
Nephritis (pyelonephritis)	<i>Corynebacterium renale</i>	No antimicrobials.	Based on the results of susceptibility testing.	Prognosis is poor. Long duration of course.

Udder

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Streptococcus mastitis	<i>Str. dysgalactiae</i> , <i>Str. uberis</i>	Benzylpenicillin		Primarily intramammary treatment. Prevention is the key; this applies to all mastitides.
	<i>Streptococcus agalactiae</i>	Benzylpenicillin		Primarily intramammary treatment. Eradication program.
	Enterococci	No antimicrobials.	Based on the results of susceptibility testing.	Often resistant; the prognosis of bacteriological cure is uncertain.
Staphylococcus mastitis	β -lactamase negative: <i>Staphylococcus aureus</i>	Benzylpenicillin		Combination of treatments; systemic and intramammary. The prognosis of the chronic <i>S. aureus</i> mastitis is poor.
	β -lactamase positive: <i>Staphylococcus aureus</i>	No antimicrobials.	Cloxacillin First generation cephalosporins	Intramammary treatment. The prognosis is poor. Cloxacillin and first generation cephalosporins may promote the selection of meticillin-resistant strains.

Udder

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
	β -lactamase negative: coagulase-negative staphylococci (KNS)	Benzylpenicillin		Intramammary treatment.
	β -lactamase positive: coagulase-negative staphylococci (KNS)	No antimicrobials.	Cloxacillin First generation cephalosporins	Intramammary treatment. Cloxacillin and first generation cephalosporins may promote the selection of meticillin-resistant strains.
<i>E. coli</i> mastitis	<i>Escherichia coli</i>	No antimicrobials.	Enrofloxacin Marbofloxacin	Supportive therapy. Antimicrobials necessary only for newly-calved cows and in severe cases.
Klebsiella mastitis	Klebsiellas	Enrofloxacin.		The prognosis of bacteriological cure is poor.
<i>Mycoplasma bovis</i> mastitis		No antimicrobials.		Diagnosis using PCR. No treatment. The animal should be culled, even if the infection is latent and the milk normal in appearance. A monthly reported animal disease.
Summer mastitis	<i>Trueperella pyogenes</i> , <i>Streptococcus dysgalactiae</i> , anaerobic bacteria	Benzylpenicillin	Aminopenicillins	Systemic treatment. The prognosis is poor for the affected quarter; supportive therapy.
Other infectious causes of mastitis	<i>Mycoplasma</i> spp.	No antimicrobials.		Supportive therapy. Prognosis uncertain.
	Coryneforms (the most common being <i>Corynebacterium bovis</i>)	No antimicrobials.	Intramammary benzylpenicillin	Hygienic measures are important.
	Bacillus species	No antimicrobials.		
	Yeasts	No antimicrobials.		The laboratory test is required for diagnosis. Supportive therapy. Prognosis uncertain.
Mastitis in sheep	<i>S.aureus</i> <i>Mannheimia</i> sp	Benzylpenicillin	Aminopenicillins (a high dose)	Special attention should be paid to the susceptibility of <i>S. aureus</i> . Intramammary treatment is not suitable for sheep.
Mastitis in goats		Treatment on the basis of a bacteriological diagnosis, when necessary		Special attention should be paid to the susceptibility of <i>S. aureus</i> . Intramammary treatment may also be applied.

Musculoskeletal system

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Cellulitis, bursitis	<i>Trueperella pyogenes</i> , anaerobic bacteria, streptococci, staphylococci	No antimicrobials	Benzyloxyethyl penicillin	Normally chronic.
Arthritis	<i>Trueperella pyogenes</i> , <i>Escherichia coli</i> , other bacteria	Benzyloxyethyl penicillin	Oxytetracycline	The prognosis of polyarthritis is poor. If several animals are affected, diagnostic sampling should be conducted.
	<i>Mycoplasma bovis</i>	Oxytetracycline		The prognosis of <i>M.bovis</i> arthritis is poor. Culling of the animal is recommended. Treatment may be attempted in mild cases or in a single joint infection . Duration of the course: one to two weeks. A monthly reported animal disease.

Other infections

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Systemic infections of newborn ruminants (omphalitis, polyarthritis, meningitis, sepsis)	Several bacterial species (<i>E. coli</i> , <i>Trueperella pyogenes</i> , streptococci, staphylococci)	Trimethoprim-sulfonamides	Oxytetracycline Benzyloxyethyl penicillin + enrofloxacin	Prevention is important. Colostrum. Management factors. If multiple deceased animals are involved, diagnostic sampling should be conducted.
Umbilical infections	<i>T.pyogenes</i> , streptococci, staphylococci	Benzyloxyethyl penicillin		Management factors, colostrum. Surgical treatment if no response to medication.
Tetanus	<i>Clostridium tetani</i>	Not to be treated in the field.	Benzyloxyethyl penicillin	Prognosis is poor.
Listeriosis	<i>Listeria monocytogenes</i>	Benzyloxyethyl penicillin	Oxytetracycline	A large dose of benzyloxyethyl penicillin is used (note the withdrawal period). If possible, samples should be taken in order to verify the diagnosis. Pathological examination. A monthly reported animal disease.
Malignant oedema	<i>Clostridium septicum</i>	Benzyloxyethyl penicillin	Oxytetracycline	Prognosis is poor. Verification of diagnosis, pathological examination.
Tick-borne fever	<i>Anaplasma phagocytophilum</i>	Oxytetracycline		A short course. An animal disease that must be controlled by law.

Other infections

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Bovine babesiosis (piroplasmosis)	Babesia	Imidocarb (a preparation subject to a special permit)		A monthly reported animal disease.
Necrobacillosis in reindeer, calf diphtheria/ necrotic laryngitis in calves	<i>Fusobacterium necrophorum</i>	Benzylpenicillin	Oxytetracycline	

Prevention of infections in connection with surgical procedures

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Gastrointestinal tract (torsion of abomasum or traumatic reticulo-peritonitis)		Benzylpenicillin	Benzylpenicillin + fluoroquinolones Oxytetracycline	Longer treatment and a broader spectrum if the abdominal cavity is contaminated during the operation. If complications are detected during an operation of traumatic reticuloperitonitis, the prognosis is poor.
Caesarean section		Benzylpenicillin	Benzylpenicillin + fluoroquinolones Oxytetracycline	Longer treatment and a broader spectrum if the abdominal cavity is contaminated during the operation.
Treatment of a teat injury		No antimicrobials unless mastitis is present	Benzylpenicillin First generation cephalosporins	Intramammary treatment, in addition to milking at short intervals.

Pigs

Most of the diseases treated in pigs are caused by microbes; consequently, antimicrobials are the most widely used medicines in pigs. Therefore, pig farms should pay attention to the use of antimicrobials, withdrawal periods, the emergence of resistant bacterial strains and alternatives to antimicrobials. Veterinarians are tasked with planning farm-specific measures, which maintain health and prevent diseases, enabling a reduction in the use of antimicrobials. Factors related to environmental conditions and hygiene, the quality of feed, sufficient supply of colostrum and the minimisation of factors which expose pigs to diseases are important aspects in the prevention of many disease outbreaks. With regard to swine diseases, the division into compartments in accordance with the production phase and animal groups and an all-in/all-out system are the key operational models in preventing disease outbreaks. All administration of medication must also be financially justified. The terms of the stakeholders' health classification register for pig farms take into account infections that are significant in Finland, such as porcine enzootic pneumonia, swine dysentery and progressive atrophic rhinitis. The primary aim is to maintain pig farms free from such infections and if necessary, to eradicate significant pathogens from production units.

Medication is administered to individual pigs through injections or to groups of pigs via feed or water. The veterinarian responsible for the farm decides on a case-by-case basis when it is better to shift from treatment of individual pigs to group medication. Regarding groups, the 20% rule can be used as a guideline. When morbidity exceeds 20% or mortality 2%, medication is shifted from individuals to groups. In large units, it is often necessary to switch to group medication at an earlier stage, as the administration of medication to a large number of individual pigs becomes too laborious. The advantage of group medication is considered to be its ease and, on occasion, its affordability: less work is required, as an injection does not need to be administered to each pig individually and the animals will not become stressed on account of the treatment. However, sick animals do not eat or drink normally, so the amount of medicine that they receive may be too low. At the same time, medication is administered to perfectly healthy animals. If antimicrobials are administered in feed or water, at least initially animals that do not eat must be individually treated through injections.

Some infectious diseases in pigs concern individual animals only; in such cases it is expedient to treat only sick animals individually. Administering medication individually in groups of animals is laborious, and the use of separate pens for sick animals facilitates the targeting of sick pigs in administering medication. A good pen for sick animals helps them to recover, and its use is an integral part of the treatment of sick pigs.

Only a few studies exist on the pharmacokinetics of medicines in pigs. In pigs, the absorption of medicines from the gastrointestinal tract is, in principle, similar to that of humans. In parenteral administration of medicines, it must be borne in mind that adult pigs have a thick layer of subcutaneous fat, which makes the technique of intramuscular injections difficult to master. The absorption of medicine from fat tissue is unpredictable; some medicinal substances may remain in the fat, and sufficient concentrations do not reach the site of the infection. Due attention must be paid to the correct dosage of medicines in newborn piglets: overdoses and concentrated preparations must be avoided. Procaine penicillin is not recommended for pregnant sows because the risk of abortion.

The choice of antimicrobials must be based on a diagnosis that is as accurate as possible. This also includes the identification of the causative microbe and the antimicrobial susceptibility testing. In order to reach a diagnosis, a post-mortem examination must be performed on the carcasses of a few pigs that had been sick with typical signs, or other samples must be taken for laboratory examination, particularly if a large number of pigs exhibit such signs or they exhibit signs repeatedly. If antimicrobials are administered as group treatments or repeatedly to individual animals due to similar signs, legislation also requires that veterinarians must ensure the microbiological diagnosis and the antimicrobial susceptibility of the causative microbe.

A medication plan should be drawn up for each pig farm to ensure that the range of different antimicrobials remains as small as possible. Response to treatment is followed up and, if necessary, samples are sent to a laboratory for antimicrobial susceptibility testing.

With regard to group medication, the number of animals to be treated and the duration of the treatment are carefully assessed on a case-by-case basis. If eradication of the pathogen is impossible, and if recurrent cases of disease are detected in a certain age group, herd health measures should be taken to prevent the animals from falling ill. The planning and implementation of preventive measures requires an accurate diagnosis.

Special attention must be paid to the prevention of post-weaning diarrhoea caused by enterotoxigenic *Escherichia coli* bacteria. Recurrent use of antimicrobials increases the risk of resistance to antimicrobials. The *E. coli* bacteria which cause diarrhoea may exhibit resistance to several antimicrobials simultaneously (multiresistance). Also the use of zinc oxide (ZnO) is associated with resistance problems. MRSA strains isolated from pigs very often have a zinc-resistance gene, and the use of zinc oxide may increase the occurrence of MRSA bacteria in pigs.

Dosage of antimicrobials in pigs

In the summary of product characteristics, some doses of antimicrobials are too low. Research on effective doses is only accumulated slowly, and knowledge transfer to the field is challenging. Marketing authorisations for medicines have been granted based on research conducted using specific doses, and this also determines the withdrawal period. Veterinarians may advise that a medicine should be used in doses higher than those indicated in the summary of product characteristics, or more frequently but, in that case, they must then

set a longer withdrawal period. In Sweden, in 2012, the Medical Products Agency gathered information on the use of antimicrobials, including instructions of doses¹. The publication includes most recent research on the dosage levels to be used in pigs.

Pigs

Recommendations for the selection of antimicrobials for pigs in cases where the use of antimicrobials is necessary regarding the diagnosis in question. Unless otherwise stated, recommendations are for systemic treatment. Medicinal substances or groups of medicinal substances which are most appropriate for treatment of a disease in terms of pathogen, disease, resistance situation and characteristics of the medicinal substance are specified as first-line treatment. Thus, medicinal substances which are effective for the most common pathogens of a disease have been selected as the first-line treatment. Whenever possible, the primary option must be targeted treatment. For example, regarding diseases from which several different bacterial species can be isolated, treatment is often targeted at the most common pathogens.

Respiratory tract

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Pleuropneumonia	<i>Actinobacillus pleuropneumoniae</i>	Benzylpenicillin	Tiamulin Tetracyclines	Vaccination is possible. <u>Resistance:</u> <i>A. pleuropneumoniae</i> strains may exhibit reduced susceptibility to penicillin. Some <i>A. pleuropneumoniae</i> strains exhibit resistance to tetracycline. A monthly reported animal disease.
Progressive atrophic rhinitis (PAR) Rare; the diagnosis must be ensured through laboratory examinations. Condition of being free from the disease is included in the Sikava health classification register	<i>Toxigenic Pasteurella multocida</i>	Tetracyclines	Trimethoprim-sulfonamides	Primarily eradication. A monthly reported animal disease.
Porcine enzootic pneumonia Rare; the diagnosis must be ensured through laboratory tests. Condition of being free from the disease is included in the Sikava health classification register	<i>Mycoplasma hyopneumoniae</i>	Tiamulin Lincomycin	Tetracyclines	Primarily eradication. Benzylpenicillin for secondary infections in fattening pigs A monthly reported animal disease.

¹Dosering av antibiotika till gris – ny rekommendation (lakemedelsverket.se)

Respiratory tract

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Pneumonia and bronchitis (bronchopneumonia) in piglets and as a secondary infection in pigs of all ages	Streptococci	Benzylpenicillin	Trimethoprim-sulfonamides	
	<i>Pasteurella multocida</i>	Benzylpenicillin	Trimethoprim-sulfonamides	
Rhinitis and pneumonia, particularly in suckling and weaned piglets	<i>Bordetella bronchiseptica</i>	Trimethoprim-sulfonamides	Tetracyclines or based on the results of susceptibility testing.	<u>Resistance:</u> Some Finnish <i>B. bronchiseptica</i> strains exhibit reduced susceptibility to trimethoprim-sulfonamides.

Gastrointestinal tract

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Gastroenteritis, diarrhoea in piglets	Toxigenic <i>Escherichia coli</i>	Trimethoprim-sulfonamides Aminopenicillins	Based on the results of susceptibility testing.	Vaccinating sows is recommended for the prevention of diarrhoea in suckling piglets. <u>Resistance:</u> Some <i>E. coli</i> strains may be multiresistant.
Post-weaning diarrhoea 1–14 days after weaning	Toxigenic <i>Escherichia coli</i>	Trimethoprim-sulfonamides Aminopenicillins	Based on the results of susceptibility testing.	<u>Resistance:</u> Following up the response to treatment is important; some toxigenic <i>E. coli</i> strains may be multiresistant.
Haemorrhagic diarrhoea in piglets 1–7 days old	<i>Clostridium perfringens</i> , Type C	Phenoxymethylpenicillin Aminopenicillins		Vaccination of sows must start immediately. Oral administration of medication to piglets is preferable. Administration of medication should be continued only as long as the vaccination programme begins to provide protection. A monthly reported animal disease.
Diarrhoea in piglets 1–7 days old	<i>Clostridium perfringens</i> , Type A	Benzylpenicillin	Aminopenicillins	Vaccination of sows
Swine dysentery Rare; the diagnosis must be ensured through laboratory tests. Condition of being free from the disease is included in the Sikava health classification register	<i>Brachyspira hyodysenteriae</i>	Tiamulin	Based on the results of susceptibility testing: Lincomycin Tylosin or another macrolide	Primarily eradication. A monthly reported animal disease.

Gastrointestinal tract

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Diarrhoea caused by other brachyspira species	<i>Brachyspira pilosicoli</i> (<i>Brachyspira intermedia</i>)	Tiamulin	Based on the results of susceptibility testing: Lincomycin Tylosin or another macrolide	
Proliferative enteropathies	<i>Lawsonia intracellularis</i>	Tylosin or another macrolide	Tiamulin Tetracyclines	Other possible concurrent intestinal infections will affect the choice of medication. Vaccination is possible.
Salmonellosis	Various types of salmonella	Antimicrobials must not be used in the prevention, eradication or treatment of salmonella infections in pigs (Decree of the Ministry of Agriculture and Forestry 1030/2013).		An animal disease that must be controlled by law. Verification of the diagnosis.
Oedema disease	<i>Escherichia coli</i> producing oedema disease toxin	Trimethoprim-sulfonamides Aminopenicillins	Based on the results of susceptibility testing.	

Kidneys and urinary tract

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Inflammation of the bladder (cystitis), urinary tract infection	<i>Escherichia coli</i>	Trimethoprim-sulfonamides	Amino-penicillins	Resistance: The antimicrobial susceptibility of <i>E. coli</i> bacteria in normal flora may vary considerably.
Urinary tract infection (cysto-pyelonephritis)	<i>Actinobaculum suis</i>	Benzylpenicillin	Amino-penicillins	

Reproductive tract

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Metritis (endometritis)	Coliforms	Trimethoprim-sulfonamides	Based on the results of susceptibility testing.	Resistance: The antimicrobial susceptibility of <i>E. coli</i> bacteria in normal flora may vary considerably.
	Gram-positive bacteria	Benzylpenicillin		
Balanoposthitis	<i>Actinobaculum suis</i>	Benzylpenicillin	Amino-penicillins	

Mammary gland

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Postpartum dysgalactia syndrome (PDS), acute mastitis	Gram-negative bacteria (normally <i>Escherichia coli</i>)	Trimethoprim-sulfonamides	Amino-penicillins	If there are recurrent cases in the herd, issues related to prevention must be reviewed <u>Resistance</u> : The antimicrobial susceptibility of <i>E. coli</i> bacteria in normal flora may vary considerably.
Chronic mastitis	Gram-positive bacteria	Benzylpenicillin	Amino-penicillins	

Central nervous system

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Meningitis-encephalitis (Meningo-encephalitis)	Streptococci, in particular <i>Streptococcus suis</i> typically in weaners (Less common: <i>Haemophilus</i> sp., <i>Listeria monocytogenes</i> , <i>Escherichia coli</i>)	Benzylpenicillin	Amino-penicillins <i>S.suis</i> if necessary, based on the results of susceptibility testing.	The emergence of <i>S. suis</i> disease outbreaks are generally associated with predisposing factors (for example stress, high animal density, changes in the environmental temperature). If necessary, a more detailed examination of the primary cause of central nervous system signs must be performed; viral infections may also give rise to signs in the central nervous system. <u>Resistance</u> : <i>S. suis</i> strains can exhibit resistance to tetracycline and lincomycin and reduced susceptibility to penicillin.

Musculoskeletal system

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Arthritis	Streptococci, <i>Haemophilus parasuis</i> , <i>Erysipelothrix rhusiopathiae</i>	Benzylpenicillin	Aminopenicillins Tetracyclines	
	<i>Mycoplasma hyosynoviae</i>	Tylosin Lincomycin Tiamulin		
Foot infections	<i>Fusobacterium necrophorum</i> , <i>Trueperella pyogenes</i> + other	Benzylpenicillin	Tetracyclines	

Systemic infection

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Swine erysipelas	<i>Erysipelothrix rhusiopathiae</i>	Benzylpenicillin	Tetracyclines Aminopenicillins	Vaccination is possible. A monthly reported animal disease.
Glässer's disease	<i>Haemophilus parasuis</i>	Benzylpenicillin	Trimethoprim-sulfonamides Aminopenicillins Tetracyclines	Vaccination is possible; a preparation subject to a special permit.

Skin

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Greasy pig disease (exudative epidermitis)	<i>Staphylococcus hyicus</i>	Benzylpenicillin	Based on the results of susceptibility testing.	<u>Resistance:</u> Some <i>S. hyicus</i> strains exhibit resistance to penicillin. Individual strains exhibit resistance to trimethoprim-sulfonamides, tetracycline or enrofloxacin.
Dermatitis	<i>Staphylococcus aureus</i>	Based on the results of susceptibility testing.		Also MRSA may cause dermatitis. <u>Resistance:</u> <i>S. aureus</i> strains commonly exhibit resistance to penicillin. Resistance to tetracycline, lincomycin, macrolides, trimethoprim-sulfonamides or enrofloxacin also occurs.

Ears

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Otitis media	Streptococci	Benzylpenicillin	Trimethoprim-sulfonamides	

Other

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Tail biting	Several (of oral microflora)	Benzylpenicillin		
Necrobacillosis in piglets	<i>Fusobacterium necrophorum</i>	Benzylpenicillin	Trimethoprim-sulfonamides	

Horses

While horses are valuable domestic animals, some horses are also food-producing animals. Legislation provides exceptions regarding medication to be administered to horses. These exceptions are based on the fact that horses are identified and that they have identification documents.

Horses are food-producing animals and medicines approved for food-producing animals may be used on them. In exceptional circumstances, medicinal substances detailed in the list of equine veterinary medicines (Commission Regulation (EU) N: o 122/2013) may also be used on horses. These medicines have a six-month withdrawal period, and information on their administration must always be entered in the identification document, unless the equine animal is not intended for slaughter for human consumption. If the equine animal is not intended for slaughter for human consumption, medicines whose usage is prohibited in food-producing animals may also be used on the horse in question. Equestrian organisations have also issued doping-related withdrawal periods for medicines. These concern riding and trotting horses engaged in competitions.

Many factors restrict the use of antimicrobials in horses. An adult horse is entirely dependent on the microbes in its intestines. Some antimicrobials affect the microbes in the colon by disrupting its balance and may in this way, for example, cause fatal diarrhoea in a horse. On account of their undeveloped intestinal microbes, foals are less sensitive to the negative effects of antimicrobials; consequently, a wider range of antimicrobials can be administered to them. Horses are also sensitive to tissue irritation caused by medicines.

Whenever sampling is possible, the treatment of an infection should be based on the identification of the pathogen and on the examination of its susceptibility to antimicrobials. Samples should be taken and handled in an appropriate manner. Legislation on medication also requires sampling if an animal is repeatedly treated for the same signs or if antimicrobials classified as critically important are used.

Information on the role that various pathogens play in the diseases of different organ groups are indicative only, as the geographical area and the use of medicinal substances select microbes that cause a disease. If the response to treatment when using the selected antimicrobial is poor, it is of vital importance to verify the diagnosis and to attempt to find out the pathogen and its susceptibility to antimicrobials.

The following table summarises treatment options, based on the literature and on empirical evidence, for infections in horses caused by different microbes. Some medicines are subject to a special permit.

Horses

Recommendations as alternatives to selection of antimicrobials for horses in cases where the use of antimicrobials is necessary regarding the diagnosis in question. Unless otherwise stated, recommendations are for systemic treatment.

Medicinal substances or groups of medicinal substances which are most appropriate for treatment of a disease in terms of pathogen, disease, resistance situation and characteristics of the medicinal substance are specified as first-line treatment. Thus, medicinal substances which are effective for the most common pathogens of a disease have been selected as first-line treatment. Whenever possible, the primary option must be targeted treatment. For example, regarding diseases from which several different bacterial species can be isolated, treatment is often targeted at the most common pathogens.

Skin, subcutaneous tissue

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Superficial and deep skin infection	Staphylococci streptococci corynebacteria	Disinfecting washes, for example, chlorhexidine or iodine	Benzylpenicillin Trimethoprim-sulfonamides	The key to treatment is to ascertain and remove the factors that expose the horse to pathogens. Remember <i>Dermatophilus congolensis</i> .
Cellulitis, lymphangitis	Staphylococci, streptococci	In distal parts, iodine or equivalent poultices and supportive treatment	Benzylpenicillin Trimethoprim-sulfonamides	In severe cases, a bacteriological sample, supportive treatment and systemic antimicrobial treatment (Benzylpenicillin+gentamicin*)/ treatment at a veterinary hospital Remember cellulitis that responds to cortisone.
Wounds and abscesses	Mixed infection	Local treatment of the wound. Draining the abscess.	Benzylpenicillin Trimethoprim-sulfonamide Benzylpenicillin + gentamicin* (only if the wound extends to a joint, tendon sheath or body cavity)	Tetanus prophylaxis. Secretion from an abscess inactivates trimethoprim-sulfonamide. Bacteriological sample, if necessary.

Eyes

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Ulcer cornea, bacterial keratitis	Staphylococci Streptococci, pseudomonas	Local treatment: Chlortetracycline* oxytetracycline (ointment) Chloramphenicol only for the equine animal not intended for slaughter for human consumption Fusidic acid	Ofloxacin Tobramycin	Culture is recommended, particularly in prolonged cases. If the cornea has an ulcer, no corticosteroids should be used. Prolonged or complicated cases must be assessed as early as possible by a veterinarian having expertise in ophthalmology
	Fungi	Administration of medicine in accordance with instructions issued by a veterinarian having expertise in ophthalmology.		If necessary, treatment at a veterinary hospital

Respiratory tract

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Sinusitis	Mixed infection	Draining and lavage of the sinus	Benzylpenicillin	In many cases, the problem is caused by a tooth; thus, recovery requires removal of the tooth or treatment of the root canal.
Infections in the upper respiratory tract	Normally viruses	Rest and supportive treatment No antimicrobials.		In chronic cases: Transtracheal sample for the identification of the causative microbe.
Infections in the lower respiratory tract, pneumonia and pleuropneumonia (shipping fever)	<i>Streptococcus equi</i> subsp. <i>zooepidemicus</i> , other streptococci, <i>Actinobacillus</i> sp. <i>pasteurellas</i> . Mixed infection in the case of pleuropneumonia and aspiration pneumonia; in this case, the above-mentioned bacteria and the following, among others <i>Escherichia coli</i> , bacteroides, <i>prevotella</i> and <i>porphyromonas</i> bacteria.	Benzylpenicillin In severe cases, benzylpenicillin + gentamicin * (+ metronidazole) or Trimethoprim +sulfa (+metronidazole). Administration of metronidazole only for the equine animal not intended for slaughter for human consumption. Metronidazole may only be used for serious mixed infections.	Benzylpenicillin + enrofloxacin	Transtracheal sample or culture of pleural fluid. Treatment must start quickly and efficiently. Often requires treatment at a veterinary hospital.

Respiratory tract

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Rhodococcus infections in fowls	<i>Rhodococcus equi</i>	Clarithromycin + rifampicin or Erythromycin + rifampicin. Rifampicin may only be used in combination with macrolides. (Tends to develop resistance if used alone)		Lung lesions must be verified through X-ray or ultrasound examination. If necessary, a bacteriological sample from the trachea or from focus of infection is taken. Response to treatment and lung lesions must be followed up during treatment. Duration of treatment is 3 to 5 weeks. Extreme care must be taken when administering medication; in an adult horse (mare) macrolides may cause fatal diarrhoea.
Strangles	<i>Streptococcus equi</i> subsp. <i>equi</i>	Poultice on abscesses and drainage.	Benzylpenicillin if severe systemic signs.	Primarily no antimicrobials. The horse may become a carrier. Atypical forms of the disease also occur. A contagious disease. A monthly reported animal disease.

Gastrointestinal tract

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Inflammatory intestinal diseases post-antibiotic diarrhoea	Clostridium bacteria, salmonella infections, a mixed infection	Supportive treatment. Assessment of the need for antimicrobial medication.	Metronidazole (not for salmonella) Note! For the equine animal not intended for slaughter for human consumption	Isolation of the patient. Intensive care, when necessary. Administration of antimicrobials to patients with salmonella only in life-threatening situations. Drug susceptibility must be determined. Salmonella in horses is an animal disease that must be reported.

Reproductive tract

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Retained fetal membranes (more than 6 hours) and puerperal metritis	Mixed infection	Supportive treatment. Trimethoprim-sulfonamide	Benzylpenicillin + gentamicin *	Uterine flushing is an essential part of the treatment.

Reproductive tract

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Endometritis	Streptococci	Uterine flushing and benzylpenicillin applied locally.		Culture of a sample from the uterus. If a fungal infection is suspected, culture must always be performed.
	Coliforms	Uterine flushing and gentamicin * applied locally.	Based on the results of susceptibility testing.	

Other

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Peritonitis	Mixed infection; also anaerobic	Benzylpenicillin + gentamicin * (+ metronidazole) Timethoprim+ sulfonamide (+ metronidazole) Administration of metronidazole only for the equine animal not intended for slaughter for human consumption	Benzylpenicillin + enrofloxacin	Guarded prognosis. Often requires treatment at the veterinary hospital.
Neonatal diseases: Umbilical and joint infections, osteomyelitis, infectious osteitis, respiratory tract infections, sepsis.	<i>Streptococcus equi</i> subsp. <i>zooepidemicus</i> , <i>Actinobacillus</i> sp. <i>Escherichia coli</i> , other Enterobacteriaceae <i>Staphylococcus aureus</i>	Benzylpenicillin Ampicillin + gentamicin * Trimethoprim-sulfonamides	Celtiofur * Doxycycline	The need for the foal's treatment at the veterinary hospital must be assessed, and treatment must start quickly. Bacteriological culture before treatment (blood, synovial fluid, etc.). Celtiofur is recommended only based on the results of susceptibility testing. Third-generation cephalosporin preparations intended for other animals are not allowed to be used on horses. Only preparations containing cephalosporin and subject to a special permit may be used on horses.
Joint infections in adult horses (trauma-induced)	Staphylococci, actinobacillus bacteria, streptococci, enterobacteria	Flushing the joint and intra-articular antimicrobials (gentamicin *, amikacine).	Benzylpenicillin + gentamicin *	Cytology and culture of synovial fluid.
Hoof abscess		Opening of the abscess, iodine poultice.		Tetanus prophylaxis.

Other

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Mastitis	<i>Streptococcus equi</i> subsp. <i>zooepidemicus</i> is the most common cause; other causes include staphylococci, actinobacillus bacteria, enterobacteria	Milking at short intervals, supportive treatment. Assessment of the need for antimicrobials.	Benzylpenicillin or based on the results of susceptibility testing.	A milk sample must be examined before treatment begins.
Infected surgery wound		Local treatment	Based on the results of susceptibility testing.	A bacteriological sample is important in the case of an Infected surgery wound.

Surgical prophylaxis

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Surgical procedures in the gastrointestinal tract area		Benzylpenicillin + gentamicin *		To be administered intravenously 15–30 minutes before incision. The cleaner the operation, the shorter the duration of the post-operative antimicrobial medication.
Bone operations, arthroscopy.	Bone operations, arthroscopy.	Not required in operations involving Cleanliness Class 1		The need for antimicrobial prophylaxis must be assessed on a case-by-case basis. In clean operations, administration of antimicrobials is not to be continued post-operatively. Tetanus prophylaxis.
Castration	Castration	Not required in a veterinary hospital. Benzylpenicillin in field conditions		

* Preparations subject to a special permit

Fish

The medicine is administered to fish almost always as group medication. With regard to the administration of medicines, fish deviate from warm-blooded animals as water temperatures determine their metabolic activity. A rule of thumb is that the metabolic rate doubles for each 10 °C rise in temperature. The metabolism of fish even at its most intense does not reach the basic metabolic level of mammals and birds.

The water in which fish live always contains a large number of bacteria, some of which may be opportunistic pathogens. Environmental factors play a significant role in fish falling ill. Optimal conditions such as sufficiently low fish density, water temperature, oxygen content and quality are important factors in the prevention of diseases. For some bacterial infections that occur in Finland – furunculosis (*Aeromonas salmonicida* subsp. *salmonicida*), vibriosis (*Vibrio anguillarum*) and the *Yersinia ruckeri* infection – a vaccination is available. Under a special permit, it is also possible to obtain a vaccine against the *Flavobacterium psychrophilum* infection.

Antimicrobials are normally administered in feed. Feed manufacturing plants mix medicine with feed mass and manufactured medicated feed should be primarily used. If the required medicated feed is not available, the medicine may be coated on ready-made feed with fish or rapeseed oil at the fish farm. The medicine and oil will form a film on the surface of feed pellets, which may become detached and remain floating in water, instead of the medicine finding its way to the fish via feed. This can be prevented by preparing the medicinal feed one day before administering it to the fish. This will ensure that the oil and the medicine are properly adhered to the feed. A supply lasting several days should not be mixed at the same time because the oil will become rancid.

The majority of antimicrobials are used on juvenile fish, which means that residues play no role. Administering medicine to adult fish that are close to their slaughtering date may affect food safety. The withdrawal period is calculated in degree days, which is the sum of average daily temperatures. For example, if the temperatures during three days are 10 °C, 12 °C and 14 °C, 36 degree days will have accumulated. The most commonly used withdrawal period is 500 degree days; for example, if the water temperature is approximately 10 °C, 50 days are required before the withdrawal period is over. By bringing forward slaughtering instead of administering medicine, medicinal costs and long withdrawal periods can sometimes be avoided. If medicine is used at a recirculating aquaculture plant, the withdrawal period should generally be set for each circulation separately, i.e. in the same water recirculation system, the withdrawal period also applies to basins to which no medication has been applied.

The first signs of a bacterial disease include a reduction in appetite. This affects the amount of antimicrobials that fish receive from their feed and, via this, the antimicrobial content in their tissues. When considering the dose, account must be taken of the reduced metabolic rate of fish in cold water. In cold water, the appetite of fish is markedly reduced, or they do not eat feed at all. Poor appetite may lead to the underdosing of antimicrobials, which increases the risk of resistance development. The situation can be mitigated by using medicinal products that are more concentrated than ordinary ones, whereby the amount of medicinal product given in a kilo of feed is larger and fish are more likely to consume the necessary amount of medicine.

When calculating the antimicrobial concentrations in feed, it is necessary to know the amount of feed consumed by fish over 24 hours, calculated as a percentage of their body weight. During the cold water season, the amount of feed that fish consume is often clearly less than 1 % of their body weight, while juvenile rainbow trout may consume as much as a maximum of approx. 5%. It is often practicable to mix medicine with a smaller volume of feed than that consumed by the fish in one day. Normal pellets should initially be given to fish that are the most intense consumers of feed, after which medicated feed can be administered while ensuring that the daily amount of medicine is completely consumed. No time should be wasted in starting the treatment of bacterial infections in fish; rather, action should be taken as quickly as possible when medical treatment is needed. In most cases, fish farmers will seek help for an acute problem concerning disease when the daily mortality rate of a fish group that has fallen ill reaches the magnitude of a few tenths of a percent.

In addition to the oral administration of medicine, it is possible to administer antimicrobial medicine to valuable brood fish via injections. While injections in the abdominal cavity are the most common method, intramuscular administration is also used. Absorption from white muscle tissue – which the muscles of fish are mostly composed of – is slow. Administration of antimicrobials through bathing should be avoided, unless the problem involves newly hatched fry which have not yet eaten anything.

Before antimicrobial medication is initiated, samples must be taken. Legislation requires veterinarians to verify the microbiological diagnosis and the susceptibility of the causative microbe if medication involves the administration of medicine to groups. Fish farmers may send fish with typical signs to Evira for testing if the veterinarian is unable to visit the farm at short notice before medication is started. Testing of samples is important in order to determine resistance, regarding both further treatment and the follow-up of resistance. Increased resistance gives rise to concern because the number of medications available on the market and that are intended for fish is limited.

Some fish diseases for which antimicrobials are typically prescribed fall – on the basis of the Animal Diseases Act – under a category of animal diseases that must be controlled by law or reported monthly, and the occurrence of which in Finland must be monitored. Submitting samples is also essential because it enables a diagnosis to be made for the notification procedure. It is virtually impossible to diagnose fish diseases in the field. Furthermore, the signs of some bacterial and viral diseases resemble each other. The testing of samples ensures that the problem does not involve a disease that must be controlled by law or another viral disease. By contacting Evira's fish disease veterinarians in advance, fish farmers will receive instructions for submitting samples. Small fish should be submitted preferably alive in an oxygen bag, and larger fish should be packed in ice in a styrofoam box. Fish selected as samples should primarily consist of individuals that are still alive but exhibit

clear signs. If feed is used to attract fish in order to collect the sample, only healthy ones are usually obtained.

Fish

Recommendations to select antimicrobial for fish in cases where the use of antimicrobials is necessary regarding the diagnosis in question.

Medicinal substances or groups of medicinal substances which are most appropriate for treatment of a disease in terms of pathogen, disease, resistance situation and characteristics of the medicinal substance are specified as first-line treatment. Thus, medicinal substances which are effective for the most common pathogens of a disease have been selected as the first-line treatment. Whenever possible, the primary option must be targeted treatment. For example, regarding diseases from which several different bacterial species can be isolated, treatment is often directed at the most common pathogens.

A septicemic infection

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Vibriosis	<i>Vibrio anguillarum</i>	Oxytetracycline	Trimethoprim-sulfonamides	During warm water period. Vaccination is possible.
Furunculosis. (ASS)	<i>Aeromonas salmonicida</i> subsp. <i>salmonicida</i>	Oxytetracycline	Trimethoprim-sulfonamides Based on the results of susceptibility testing.	During warm water period. Vaccination is possible. A monthly reported animal disease.
ASA, the contagious skin infection	<i>Aeromonas salmonicida</i> subsp. <i>achromogenes</i>	Oxytetracycline	Trimethoprim-sulfonamides	During warm water period. A monthly reported animal disease.
<i>Yersiniosis</i>	<i>Yersinia ruckeri</i>	Trimethoprim-sulfonamides	Based on the results of susceptibility testing.	During cold and warm water period A monthly reported animal disease.
Columnaris disease, gill rot and/or a septicemic disease (formerly flexibacteriosis)	<i>Flavobacterium columnare</i> (formerly <i>Flexibacter columnaris</i>)	Oxytetracycline	Florfenicol for farms in which a poor response to an oxytetracycline treatment is detected.	During warm water period.
Rainbow trout fry syndrome and the cold water disease	<i>Flavobacterium psychrophilum</i> (formerly <i>Flexibacter psychrophilus</i>)	Oxytetracycline	Florfenicol for farms in which a poor response to an oxytetracycline treatment is detected.	During cold water period.

Chronic nephritis, septicemic disease

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
BKD, bacterial kidney disease	<i>Renibacterium salmoninarum</i>	No antimicrobials.		During cold water period. No efficient treatment available. A health classification category granted by Regional State Administrative Agencies to farms subject to voluntary health monitoring for the BKD disease.

Poultry

Poultry refers here to the breeders and production animals of broilers, chickens and turkeys. Poultry diseases always involve an entire flock falling ill, in which case a prompt decision on the administration of medicine must be taken. Several factors affect the decision. The most important of them is the cause behind the disease – in other words, is the case such that medication is actually effective. The age of birds, losses caused by the disease and cost of treatment always play a role in the decision-making.

Legislation requires that veterinarians verify the microbiological diagnosis and the antimicrobial susceptibility of the causative microbe if the medication is administered to groups. **Before initiating the treatment, dead or euthanized birds, samples of their organs or blood or bacterial samples must be sent for testing to obtain diagnosis. Antimicrobial treatment in poultry is based on susceptibility testing.** Based on a veterinarian's assessment and if the situation so requires, medication can be initiated before the results of susceptibility testing are available. In the case of necrotic enteritis, a diagnosis based on the clinical signs is also possible, and determination of antimicrobial susceptibility is not a prerequisite for starting medication.

The health care of poultry is primarily based on disease prevention. Often, the cause of poultry falling ill is insufficient hygiene, inadequate animal material, or poor conditions, poor care and poor water or feed quality. In poultry, bacterial diseases are mostly secondary, and secondary infections are not normally treated with antimicrobials.

The administration of medication to poultry is problematic due to the fact that only a few medicinal products have been approved for use in poultry in Finland. Medicinal products, which are approved for use on layers producing eggs for human consumption, are even fewer. Therefore, some alternatives in these recommendations cannot be used.

In most cases, medicine is administered in drinking water. Some medicines can also be administered in feed, and valuable chickens can be treated individually by injections. If it is planned to administer medicine in drinking water, the water must be checked to ensure that it contains no substances that could impair the effects of the medicine. High concentrations of iron, calcium and magnesium, as well as metal containers and piping, may render tetracyclines inactive. Measuring water usage in order to mix the correct medicinal concentration is very important, as water consumption may deviate significantly from the

average values. Leaking water systems may lead to an overestimation of water consumption, resulting in a medicinal concentration in water that is too low. Therefore, the condition of the water system must be checked before medication is initiated.

Broiler breeders suffer to some extent from arthritis and tenosynovitis during the rearing period (at the age of 10–14 weeks), normally caused by *Staphylococcus aureus*. In addition, they may exhibit occasional infections caused by *Escherichia coli*.

The need for antimicrobials in the broilers is very low. Necrotic enteritis may give rise to medication needs in them. On rare occasions, broilers may exhibit arthritis and tenosynovitis, which normally are not treated; instead, sick individuals are culled. The long withdrawal periods of medication hamper the administration of medicine to broilers.

Turkeys and chickens may contract erysipelas (*Erysipelothrix rhusiopathie*) or fowl cholera (*Pasteurella multocida*). Both diseases are triggered by stress and insufficient hygiene. Both swine erysipelas and fowl cholera can be treated with antimicrobials. However, these diseases recur after medication is discontinued. Turkeys and chickens may be vaccinated against erysipelas if the incidence of this disease is high and cannot be stopped through a change in conditions. On occasion, turkeys and chickens exhibit infections caused by *E. coli*.

Coccidiosis is an intestinal disease caused by a unicellular parasite known as *Eimeria*. In practice, coccidiosis is not treated; instead, the treatment is based on prevention. Ionophoric coccidiostats mixed in feed are administered to broilers and turkeys. All broiler breeders, organic broilers and many egg-producing hens kept on floors are vaccinated against coccidiosis when they are around one week of age. However, some vaccinated birds have shown signs of coccidiosis. Toltrazuril can be used to treat coccidiosis.

Medicines effective in the treatment and prevention of the blackhead disease – histomoniasis (*Histomonas meleagridis*) – in turkeys are not available in Finland; thus, the control of this disease is based on good hygiene and on the “all-in-all-out principle”.

Poultry in backyard farms

For the administration of antimicrobial medication to backyard poultry, the same principles are applied as for production poultry. The decision on the administration of medicine and the choice of medicine should always be based on isolating the bacterium and determining its antimicrobial susceptibility. The most commonly observed signs in backyard poultry (for example, respiratory tract signs or diarrhoea) may be caused by a number of pathogens (virus, bacterium or fungus), and a field diagnosis cannot be made without taking a sample. Therefore, as a matter of prudence, antimicrobials should not be used to treat unspecified disease signs. Often, by the time the owner detects signs of a disease in a chicken, the disease is too progressed that the benefits of medication are limited. Furthermore, in backyard poultry, problems with environmental conditions are the most common reason for chickens falling ill; thus, before antimicrobial medication is started, or at least simultaneously with it, attention must be paid to environmental conditions. In addition, when a sick chicken is treated, veterinarians should always bear in mind the possibility of the occurrence of contagious diseases that must be controlled by law (avian influenza and Newcastle disease).

Antimicrobial treatments are rarely indicated for backyard poultry. Based on Evira's necropsy material, diseases in many cases are not caused by bacterial infections but, rather, by poor conditions and care. Conducting a field diagnosis is difficult, and antimicrobials are all too often prescribed for precautionary reasons.

Poultry

Recommendations to selection of antimicrobial for poultry in cases where the use of antimicrobials is necessary regarding the diagnosis in question.

Medicinal substances or groups of medicinal substances which are most appropriate for treatment of a disease in terms of pathogen, disease, resistance situation and characteristics of the medicinal substance are specified as first-line treatment. Thus, medicinal substances which are effective for the most common pathogens of a disease have been selected as the first-line treatment. The objective is to select a preparation with a spectrum that is as narrow as possible, in accordance with the pathogen.

Gastrointestinal tract

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Necrotic enteritis	<i>Clostridium perfringens</i>	Phenoxymethylpenicillin*	Amoxicillin* Tylosin Trimethoprim-sulfonamides Tetracycline	

Musculoskeletal system

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Arthritis and tenosynovitis in broiler breeders	<i>Staphylococcus aureus</i>	Phenoxymethylpenicillin*	Amoxicillin* Trimethoprim-sulfonamides Tetracycline	Based on the results of susceptibility testing.
Arthritis and a systemic infection in turkeys	<i>Staphylococcus aureus</i> is the most common	Phenoxymethylpenicillin*	Amoxicillin* Trimethoprim-sulfonamides Tetracycline	Based on the results of susceptibility testing.

Other

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Erysipelas	<i>Erysipelothrix rhusiopathiae</i>	Phenoxymethylpenicillin*	Amoxicillin* Trimethoprim-sulfonamides Tetracycline	Vaccination is possible. A monthly reported animal disease.

Other

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Pasteurella infection in adult chickens and turkeys	<i>Pasteurella multocida</i>	Phenoxymethylpenicillin*	Amoxicillin* Trimethoprim-sulfonamides Tetracycline	Based on the results of susceptibility testing.
Colibacillosis (a systemic infection)	<i>Escherichia coli</i>	Amoxicillin*	Tylosin Trimethoprim-sulfonamides Tetracycline	

* Product subject to a special permit

Bees

At present, no approved antimicrobial product for bees is available in Finland. However, under a decree 17/14 issued by the Ministry of Agriculture and Forestry on the use and distribution of medicines in veterinary practice, medicinal products approved for use in other production animals can be used in bees. In this context, it must be observed that medicinal products dissipate in a beehive through a process of chemical disintegration, necessitating veterinarians to prescribe a sufficiently long withdrawal period for honey. In practice, a sufficiently long withdrawal period means that honey produced during the summer in which medication was administered cannot be used as a foodstuff.

Adult bees

Bacterial diseases in adult bees are relatively unknown, difficult to diagnose and often secondary. Often, when examination results are available, the situation is already over and any treatment is useless. All in all, little studies exist on antimicrobial medication for contagious diseases in bees. With varroosis becoming more prevalent, secondary infections are also expected to increase. Varroosis is a disease that controlled by law in the Åland Islands. At present, no medication exists for treating a disease caused by the *Nosema apis* and *N. ceranae* microsporidian parasites in adult bees.

Larvae and brood

No antimicrobials are recommended for the treatment of American foulbrood and European foulbrood, two bacterial diseases in larvae. For example, in Sweden, Denmark, Germany and Britain, antimicrobials are not normally used for treating brood diseases. In the eradication of American foulbrood, the artificial swarm method has been reported to have achieved a success rate of higher than 95% without resorting to antimicrobial treatment. Practical guidance aims to ensure that no antimicrobials are administered in normal cases in the eradication of American foulbrood. Neither should antimicrobials be used for preventive purposes. American foulbrood is a disease that must be controlled by law.

If antimicrobials need to be administered, oxytetracycline is an appropriate medicine and should be used only when the beehive is being cleaned. Oxytetracycline is administered as a one-time dose in a solution within one week of cleaning after the bees have been transferred onto empty foundations. Honey produced during the summer in which medication was administered must not be used as a foodstuff due to residues. Previously, combinations of sulfonamide-trimethoprim were used in bee medication but they should not be used due to long-term residues.

Larvae also exhibit fungal diseases (chalkbrood disease and stone brood), which can be diagnosed but for which no known antimicrobial treatment exists.

Cats and dogs

Antimicrobials are the most often used drugs in cats and dogs. Recommendations for antimicrobial use have been written to help the selection of primary medication for the most common infections in dogs and, when applicable also in cats. The objective is also to standardise the treatment practices in Finland. The recommendations are based on literature, expert opinions and the antimicrobial resistance situation in Finland. A response to antimicrobial treatment can be expected in two to three days if the signs are caused by bacterial infection and the correct antimicrobial has been selected for treatment. In skin infections, a positive response is expected in a week. If signs recur, the cause must be investigated.

The occurrence of multi-resistant strains is increasing in companion animals. These include the MRSP (meticillin-resistant *Staphylococcus pseudintermedius*) and ESBL bacteria (gram-negative bacilli producing extended-spectrum beta-lactamase). Animals at risk include those that have undergone multiple antimicrobial treatments, do not respond to treatment or suffer from multiple infections. Animals at risk should always be sampled and tested for resistant bacteria, since the results may affect the treatment and the selection of the antimicrobial drug. Infections caused by multi-resistant bacteria should not be treated with antimicrobials, however, if necessary the selection should be based on drug susceptibility testing.

In many cases the cats and dogs can be treated without the use of antimicrobials. These include small wounds, minor skin damage and acute gastrointestinal diseases (i.e. diarrhoea and vomiting). Similarly bacteriuria is present rarely in cats with lower urinary tract disease, and the routine administration of antimicrobials in treating many dental illnesses (i.e. gingivitis, parodontitis and acute dental fractures) is unnecessary. In clean and clean-contaminated surgical procedures, the administration of antimicrobials is unnecessary or they should only be used peri-operationally.

According to legislation, the use of certain macrolides, fluoroquinolones and extended-spectrum cephalosporins must be well-founded, since their use is associated with a serious risk of resistance development. The resistance situation of pathogens in companion animals has rapidly deteriorated in Finland. Bacterial diagnostics are important in order to identify the cause of the infection and determine its susceptibility to antimicrobials. Tentative use of antimicrobials is acceptable in cases in which it is not possible to take samples for bacterial culture or their results are not yet available. Even in such cases, the treatment must be targeted at the presumed pathogen and the drug selected must have as narrow antibacterial spectrum as possible.

Cats and dogs

The table summarises the recommendations for the selection of antimicrobials for cats and dogs in cases in which the use of antimicrobials is necessary to treat the disease. The text focuses primarily on diseases of dogs but can also be used in selecting antimicrobials for cats when applicable. Unless otherwise stated, recommendations are for systemic treatment.

Medicinal substances or groups of medicinal substances which are most appropriate for treatment of a disease in terms of pathogen, disease, resistance situation and characteristics of the medicinal substance are specified as first-line treatment. Thus, medicinal substances which are effective for the most common pathogens have been selected as the first-line treatment. Bacteriological diagnostics and determination of drug susceptibility help in choosing the right treatment in individual cases.

Skin

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Local and superficial skin inflammation (for example, a hotspot, skin fold inflammation)	<i>S. pseudintermedius</i>	No antimicrobials. Shaving hair and applying antiseptic preparation locally.		The possibility of a <i>Malassezia</i> infection must also be taken into consideration.
Superficial skin infection (hair follicle infection, impetigo)	<i>S. pseudintermedius</i>	No antimicrobials. Shaving hair and application of antiseptic preparation locally.	Assessment of the need for systemic antimicrobial medication: Clindamycin ¹ First generation cephalosporin ¹	The primary cause and factors predisposing the animal to bacterial infections must be solved and corrected in the case of recurring skin infections. As the resistance situation is poor, systemic treatment should be based on bacterial culture and drug susceptibility testing. While results are pending, repeated washing with an antiseptic preparation is recommended. ¹ Use highest recommended dose
Deep skin infection (pyoderma)	Probably <i>S. pseudintermedius</i>	Local treatment/ washing with an antiseptic preparation. Treatment of the underlying cause	Based on the results of antimicrobial susceptibility testing. Clindamycin ¹ First generation cephalosporin ¹ The treatment of a severe infection must begin with the application of first generation cephalosporin ¹ while the results are pending.	The underlying cause and factors that expose the animal to pathogens and maintain the condition must be solved. Controlling the healing process is important. ¹ Dose is at the upper limit of recommendations.

Skin

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Bite wounds	<i>Pasteurella</i> staphylococci, streptococci, anaerobic bacteria	Amino- penicillin ± clavulanic acid ¹		Drainage, removal of necrotic tissue and local treatment of the wound are necessary. ¹ Dose is at the upper limit of recommendations.
Abscess	<i>Pasteurella</i> , staphylococci, streptococci, anaerobic bacteria	No antimicrobials. Opening, draining and local treatment.	Aminopenicillin +/- clavulanic acid ¹	¹ Dose is at the upper limit of recommendations.

Ears

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Otitis externa	<i>Malassezia pachydermatis</i> Staphylococci, streptococci corynebacteria In chronic cases, also <i>Pseudomonas</i> <i>Enterobacteriaceae</i>	No antimicrobials, if cytology exhibits a large number of microbes but no inflammatory cells. Local and/or systemic treatment of inflammation with corticosteroid Cleaning by applying antiseptics locally.	If a microbial infection, application of antimicrobials locally Fusidic acid Polymyxin B Chronic or recurring bacterial otitis externa in which antimicrobials are used locally: Fluoroquinolone Gentamicin	A cytological examination of the sample is important. The root cause, predisposing factors, and factors that maintain the condition must be solved. The healing process must be controlled. Lavage of the outer auditory canal when necessary. Chronic otitis externa is often accompanied by otitis media; it is recommended that a veterinary dermatologist is consulted.

Respiratory tract and the thoracic cavity

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Infective tracheobronchitis, Canine Infectious Respiratory Disease complex (CIRD), "kennel cough"	Viruses <i>Bordetella bronchiseptica</i> <i>Mycoplasma</i> spp	No anti-microbials.	Doxycycline Trimethoprim-sulfonamide	Primarily an acute viral infection; will heal in 7–14 days without treatment if no complications arise.

Respiratory tract and the thoracic cavity

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Pneumonia dogs	<i>Pasteurella</i> spp., <i>Escherichia coli</i> <i>Streptococcus</i> spp. <i>Bordetella bronchiseptica</i> (particularly in puppies), <i>Staphylococcus</i> spp.	Amoxicillin/ clavulanic acid ¹ Doxycycline	Fluoroquinolone + aminopenicillin	Except for bordetella, the primary medicine is amoxicillin/clavulanic acid. Severe cases require treatment at a veterinary hospital. ¹ requires a high dose at short intervals (20 mg/kg 3 times a day)
Pyothorax	<i>Pasteurella</i> spp. <i>Actinomyces</i> spp. Anaerobic If trauma-induced, also <i>Enterobacteriaceae</i> Mixed infections	Amino-penicillin Amoxicillin/ clavulanic acid	Metronidazole Fluoroquinolones Based on the results of causative microbe and antimicrobial susceptibility testing.	Bacterial culture of the pus and testing for drug susceptibility. Draining the pus and thoracic cavity lavage are essential for positive outcome. Surgery, when necessary. Often requires treatment at a veterinary hospital.
Respiratory tract infections in cats (bronchitis, pneumonia)	<i>Pasteurella</i> spp. <i>Chlamydomphila</i> spp. <i>Bordetella bronchiseptica</i> <i>Mycoplasma</i> spp. <i>Streptococcus</i> spp. <i>Escherichia coli</i>	Doxycycline Amoxicillin/ clavulanic acid	Aminopenicillin + fluoroquinolone	Respiratory tract infections in cats are often complex; the possibility of a numerous diseases including asthma, chronic bronchitis or lungworm infections must be taken into consideration.

Oral cavity and gastrointestinal tract

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Gingivitis, parodontitis	Anaerobic and facultative anaerobic bacteria, a mixed infection	No anti-microbials. See "notes."	Aminopenicillin ± clavulanic acid Clindamycin	Removal of tartar and decayed teeth. Antimicrobials should not be the only treatment. Chlorhexidine gluconate as local treatment.
Root abscess	Anaerobic and facultative anaerobic bacteria, a mixed infection	No anti-microbials.	Aminopenicillin ± clavulanic acid Clindamycin	Removal of the tooth, root canal therapy, or opening of the abscess as first-line treatment. Antimicrobials if the animal shows systemic signs
Acute gastroenteritis, no systemic signs	Only rarely caused by a bacterium	No anti-microbials. Supportive treatment		Supportive treatment is the key; the disease is self-contained

Oral cavity and gastrointestinal tract

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Acute gastroenteritis; the animal exhibits systemic signs or is immuno-suppressed	Aetiology is often unclear. Sometimes <i>Campylobacter</i> spp. <i>Salmonella</i> spp.	Based on the results of antimicrobial susceptibility testing.	Trimethoprim-sulfonamides Ampicillin ± fluoroquinolone	Systemic signs include fever, haemorrhagic diarrhoea, inflammatory or toxic leukogram and rise in CRP level. Diagnosis based on faecal culture. <i>Campylobacter</i> are also isolated from animals exhibiting no signs. Remember that salmonella is an animal disease that must be controlled by law.
Tylosin-responsive diarrhoea (chronic, recurring diarrhoea)	Aetiology remains unknown but probably involves dysbiosis of the microbe in the intestines	Tylosin		The effect of tylosin is probably based on factors other than its antimicrobial impact. Initial dose 25 mg/kg once a day for a duration of 7 days. Response to treatment has occurred and the diarrhoea recurs, the dose is 5 mg/kg once a day.
Inflammatory bowel disease (IBD)	Aetiology unclear.	Immuno-modulatory treatment	Tylosin Metronidazole	
Anal sac inflammation	<i>Escherichia coli</i> , proteus, clostridia, enterococci, anaerobic bacteria	No anti-microbials. Emptying and repeated lavage of the anal sacs.	Amoxicillin/ clavulanic acid	

Reproductive tract

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Bacterial prostatitis	<i>Escherichia coli</i> , klebsiellas	Trimethoprim-sulfonamide	Fluoro-quinolones	Bacterial culture and cytology (urine, prostate fluid, prostate puncture). A long course (4 weeks) Anti-testosterone treatment or castration should also be considered. Prostate hyperplasia without a bacterial infection is common and requires no antimicrobial treatment.

Reproductive tract

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Metritis	<i>Escherichia coli</i>	Surgical treatment and only perioperative antimicrobial for prophylaxis. Trimethoprim-sulfonamide administered orally for a period of time if an animal has systemic signs, in addition to surgical treatment.	If no surgical treatment, an antimicrobial course in addition to a medicinal evacuation of the uterus: Trimethoprim-sulfonamide Amoxicillin + clavulanic acid	Surgical treatment is most important.

Urinary tract

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Acute urinary tract infection with no complications	<i>Escherichia coli</i> , proteus, enterococci, staphylococci, streptococci	Trimethoprim-sulfonamide Amoxicillin + clavulanic acid	Fluoroquinolone based on the results of susceptibility testing.	Due to increased antimicrobial resistance, bacterial culture of a cystocentesis sample and the determination of drug susceptibility must be performed. Recommended course duration is around 7 days. In the case of recurring urinary tract infections or infections which do not respond to treatment, solving the underlying cause is essential. In complex urinary tract infections the antimicrobial treatment for 4 weeks.

Musculoskeletal system

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Arthritis (bacterial arthritis)	Young animals: Pasteurella and streptococci	Lavage of the joint Amino-penicillins Amoxicillin/ clavulanic acid		Diagnosis and antimicrobial treatment based on a synovial fluid sample: cytology, cell count and bacterial culture. In case of young animals, bacterial culture of blood is also recommended.
	Adult animals: Staphylococci	Lavage of the joint First generation cephalosporin Clindamycin		

Eyes

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Conjunctivitis	Dogs: Staphylococci, streptococci	Fusidic acid	Chloramphenicol	Sampling is recommended in order for the diagnosis to be verified.
	Cat: <i>Chlamydophila psittaci</i> , mycoplasmas	Doxycycline Tetracycline or chloramphenicol locally. In the case of very young animals (<4 months), doxycycline may be replaced by macrolides (for example, azithromycin).	Fluoroquinolones Fluoroquinolones	In cats, viruses are the most common cause; careful assessment for the need of anti-viral medication. If necessary, antimicrobials for a secondary bacterial infection.
Keratitis (ulcerative)	Staphylococci, streptococci, also pseudomonas bacteria	Chloramphenicol	Eye drops containing fluoroquinolone or tobramysine if pseudomonas are suspected	NOTE! Refer the animal for a specialist for further treatment if no clear response to treatment emerge within a few days. If the eye has an ulcer, corticosteroids should not be used. In cats, viral keratitis is common.

Other

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Peritonitis	Several, depending on the origin of the infection (for example, <i>Escherichia coli</i> , enterococci, anaerobic).	Amoxicillin/ clavulanic acid	Aminopenicillin + fluoroquinolone Aminopenicillin + gentamicin*	Bacteriological sample (from the abdominal cavity). Medication always starts parenterally. Normally requires treatment in a veterinary hospital.
Borreliosis (dogs)	<i>Borrelia burgdorferi sensu lato</i>	Doxycycline 10 mg/kg SID- BID 30 days	Amoxicillin 20 mg/kg TID 30 days	
Anaplasmosis	<i>Anaplasma phagocytophilum</i>	Doxycycline for dogs, 5 mg/kg BID or 10 mg/kg SID for the duration of 2–3 weeks		No research evidence on the effects of antimicrobial treatment on cats exists.
Ehrlichiosis	<i>Ehrlichia canis</i> (dogs)	Doxycycline for dogs, 5mg/kg BID or 10mg/kg SID for a duration of 4 weeks		Extremely rare in cats.
Leptospirosis (dogs)	<i>Leptospirosis</i>	Doxycycline 5 mg/kg BID 14 days		An animal disease that must be controlled by law.

Surgical prophylaxis

Procedure category	Probable causative microbe	Primary antimicrobial medicine	Secondary antimicrobial medicine	Notes
<u>Cleanliness category 1:</u> Procedure (for example, removal of a skin tumour, castration, clean orthopaedic operations).	Staphylococci, streptococci	Procedure lasting < 60min: No antimicrobials. procedure lasting > 60 min: Ampicillin Orthopaedic and neurological operations: First generation cephalosporin Other: Aminopenicillins		Prophylactic antibiotic is administered intravenously approximately 30 minutes before first incision. Duration of prophylaxis peri-operationally (until the incision is closed).
<u>Cleanliness category 2:</u> Procedure (for example, sterilisation, caesarean section, pyometra with no complications, removal of uroliths, operation on the gastrointestinal tract).	Depending on the surgical site, staphylococci, enterobacteria, streptococci, anaerobic bacteria	Procedure lasting < 60min: No antimicrobials. Procedure lasting > 60 min. Pyometra, surgery on the urinary tract: Trimethoprim-sulfa Surgery on the gastrointestinal tract: Aminopenicillin		Prophylactic antibiotic is administered intravenously approximately 30 minutes before incision. Prophylaxis continues for a maximum of 12–24 hours after surgery.
<u>Cleanliness category 3–4:</u>	Depends on the surgical site	Chosen on the basis of the surgical site and the most likely cause.		Prophylaxis peri-operationally, antimicrobial medication is continued if an infection is detected in the surgical area.

Fur animals

Fur animals refers to the blue fox, silver fox and their crosses, raccoon dog, mink and polecat. Research on the use of antimicrobials in the treatment of different microbial diseases in fur animals is almost non-existent, and treatment is mostly based on practical experience and the susceptibility testing in certain diseases. If antimicrobials are administered to groups of animals or repeatedly to treat the same signs, legislation requires that veterinarians must verify the microbiological diagnosis and the susceptibility of the causative microbe. Feed hygiene must be ensured, particularly in summer, in order to avoid gastrointestinal disorders.

While all the animals at the farm are often treated at the same time, some treatments may be individual. Medicines are administered either mixed with feed or injected. Sick animals have a poor appetite and they drink little; for such animals, medication through injection is the best option with regard to the outcome of treatment. The number of different antimicrobials at a farm should be kept minimum. Targeting antimicrobial treatment to the causative microbe of an outbreak, requires testing of samples.

Only a handful of preparations are available, which have a marketing authorisation for fur animals, but antimicrobials licensed for other animal species may also be used. Additionally, there is an oral phenoxymethylpenicillin available on a special permit. In foxes and raccoon dogs, the dosage is roughly equivalent to that for dogs, and in minks, that for cats.

Fur animals

Recommendations for choosing antimicrobials for fur animals in cases where the use of antimicrobials is necessary regarding the diagnosis in question.

Medicinal substances or groups of medicinal substances which are most appropriate for treatment of a disease in terms of pathogen, disease, resistance situation and characteristics of the medicinal substance are specified as first-line treatment. Thus, medicinal substances which are effective for the most common pathogens of a disease have been selected as the first-line treatment. Whenever possible, the primary option aims to the targeted treatment. For example, regarding diseases from which several different bacterial species can be isolated, treatment is often targeted at the most common pathogens.

Gastrointestinal tract

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Gingivitis, parodontitis	Streptococci	Benzylpenicillin	Lincomycin or based on the results of susceptibility testing.	Is associated with the changing of teeth May also be caused by clostridium bacteria.
Gastroenteritis, diarrhoea	<i>Lawsonia intracellularis</i>	Tylosin	Tylvalosin	May be a problem with feed hygiene. Microbiological diagnosis. Coccidiosis is also possible.
	Other bacteria	Based on the results of susceptibility testing		At present, the role of other microbes as pathogens, for example, campylobacteria and <i>E. coli</i> is unclear
Gastrointestinal infections in mink cubs	Age 0–15 days streptococci, staphylococci	Benzylpenicillin	Amoxicillin Lincomycin	Coccidiosis is also possible.
	Age 15–35 days <i>E. coli</i>	Trimethoprim-sulfonamides	Amoxicillin (+ clavulanic acid)	
	Age >35 days Varies, multiple causative bacteria	Based on the results of susceptibility testing		

Skin, subcutaneous tissue and joints

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Abscesses, phlegmons, arthritis	Streptococci, Staphylococci, <i>Arcanobacterium phocae</i>	Benzylpenicillin	Lincomycin or based on the results of susceptibility testing.	
FENP (Fur animal epidemic necrotic pyoderma)	<i>Arcanobacterium phocae</i>	Euthanasia	Benzylpenicillin	

Urinary tract

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Cystitis	Streptococci	Benzylpenicillin		
	<i>Escherichia coli</i>	Trimethoprim-sulfonamides	Based on the results of susceptibility testing	

Reproductive tract

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Metritis	Streptococci, staphylococci, <i>Clostridium</i> sp.	Benzylpenicillin or based on the results of susceptibility testing	Based on the results of susceptibility testing	
	<i>Escherichia coli</i>	Trimethoprim-sulfonamides	Based on the results of susceptibility testing	

Mammary gland

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Mastitis	Streptococci	Benzylpenicillin	Based on the results of susceptibility testing	
	<i>Escherichia coli</i>	Trimethoprim-sulfonamides		

Respiratory tract

Disease	Causative microbe	First-line treatment	Alternative treatments	Notes
Pneumonia	Multiple causes	Based on the results of susceptibility testing		Distemper is also possible.

