Hunting hygiene

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The book is based on the Finnish textbook 'Metsästäjän terveysoppi' by the first author. However, the book presents the tools to detect and assess diseases in game animals and the universally applicable principles of hygiene during hunting and handling meat from wild game, illustrated by numerous examples from North Europe. We thank Jonna Lohi for primary translation from Finnish to English and Ines Wolfram for proofreading the text.

The source material used for this book is so extensive that there was no room for a bibliography within its covers. We take full responsibility for the factual accuracy of the text.

Let the adventure begin!

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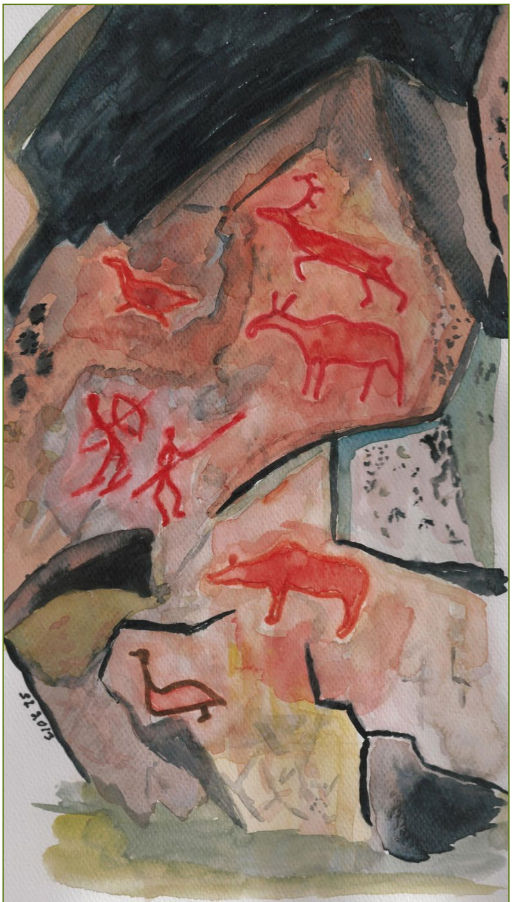
Introduction. From the woods to the table

In the history of mankind, hunting has always been of great importance. Fishing and hunting are the oldest means of livelihood. For a long time, they were almost the only ways of exploiting our vast wilderness areas. The appeal of new regions, rich with fish and game, led man to travel still further north and inhabit new lands. In addition to nourishment, game animals provided clothing and utensils. The wilderness was an abundant source of livelihood to stone-age communities. Hunters were few and far between, and their hunting methods were primitive – there was plenty of quarry to go round. Before and after the hunt, the game animal was honoured with pictures and objects, poems and chants, and celebrations.

The situation changed gradually over the centuries. Farming took over more and more land, and, simultaneously, the importance of hunting as means of finding nourishment diminished. The attitude of people changed, game became a commodity, and predators became man's rivals. Stones, clubs, slings, spears, bows and traps had to make room for gunpowder weapons.



Dozens of still visible rock paintings show the respect and value ancient people felt towards game animals.

From the medieval age to the 19th century, the right to hunt wild animals was reserved to noblemen, and became a sport or societal event. In parallel, informal hunting served to supply the rural population with animal protein. Beside food production, bagging trophies has been a motivation for hunters ever since. This, together with increasing number of hunters and shrinking areas of wilderness, drove many species of game animals to the verge of extinction.

In the 20th century, the status of hunting changed along with the development occurring in the society and the structures of livelihood. The living conditions of wild game changed, and not all game species could adapt to these changes. The living areas of wild animals became smaller and fragmented due to the effects of agriculture, industry, traffic and mining, among others. However, the situation was beneficial to some species, such as the moose, which has benefited from timber harvesting and sprouting forests. The number of hunters grew, and even the most remote old-growth forests could be reached more easily. Hunting was no longer a lifeline to anyone. Preying changed into management of game populations. Game management was perceived as part of nature conservation and the preservation of biodiversity. The

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ground was laid for modern hunting, which incorporates the principles of sustainable use, transparency and ethicality.

The call of the wilderness attracts the modern man, and for most, the hunt and its rituals is more important than the actual hunting bag. Consequently, the greatest value of hunting in most parts of the world is to give meaning to leisure.

There are many side activities involved in hunting, such as shooting sport and dog breeding, which for many are more important parts of this hobby than the actual hunting for food. Hunting trips that often take hunters abroad, quality hunting clothes and gear, latest technological devices and hunting dogs are an integral part of modern hunting.

In the remote areas of Europe, the hunting club is an important, and often virtually the only platform for social life and collaboration. In such places the end of the hunting season is marked with a traditional celebration that unifies the whole village. There are still communities where the number of fox or moose tracks calculated in the morning is considered far more interesting than the news on the radio or TV.

For man, hunting was the first means for obtaining meat for nourishment. Even today, a meal prepared from good-quality game is the highlight of modern hunting. Game is especially highly valued on the tables of gourmets. Game meat differs, to its advantage, from the meat of several production animals. Its fatty acid composition is favourable, and its micronutrient and protein content is high.

However, meat from wild game contributes a minor part to the total meat production and the average consumption is a few per cent of the total meat consumption. In individual hunting households the quantity of game can be considerably higher, but there seem to be pronounced differences between regions and countries in Europe (Table 1).

As a rule of thumb, the demand for meat from wild game is higher than the amount being placed on the market. Often, carcasses of best quality are used for domestic private use rather than being placed on the market. For some game species, seasonality in hunting and meat supply may conflict with the consumers' wish to obtain fresh game meat over the whole year. In addition, difficulties in

Table 1. Estimates on average game meat consumption in various European countries. Assumed portion sizes range from 50-200 g, consumption around two times/week can occur in hunters' households. Such data are useful when the exposure of certain consumers groups towards hazards originating from game meat has to be assessed.

Country	**Game meat (kg per person and year)**	**Consumer group**	**Reference**
Austria	4.8 (2.4-10.4)	Hunters (trained persons)	Paulsen *et al.*, 2014
Germany	13[a] (10-31)	Hunters' families	Hoffmann, 2013
Germany	0.2-0.4	Average consumer	BfR, 2010
Italy (North Italy)	4	Hunters	Ramazin *et al.*, 2010
Sweden	5-30	Hunters' families	Wiklund and Malmfors, 2014
Sweden	3-5	Interested consumers	Wiklund and Malmfors, 2014
Sweden	0.4	Average consumers	Wiklund and Malmfors, 2014
Switzerland	18.2	Hunters' families	Haldimann *et al.*, 2002

[a] Only large game considered.

providing the required amounts in adequate quality may be due to a lack of infrastructure, or training and motivation of hunters. The supply chain for some European countries is described in the figure.

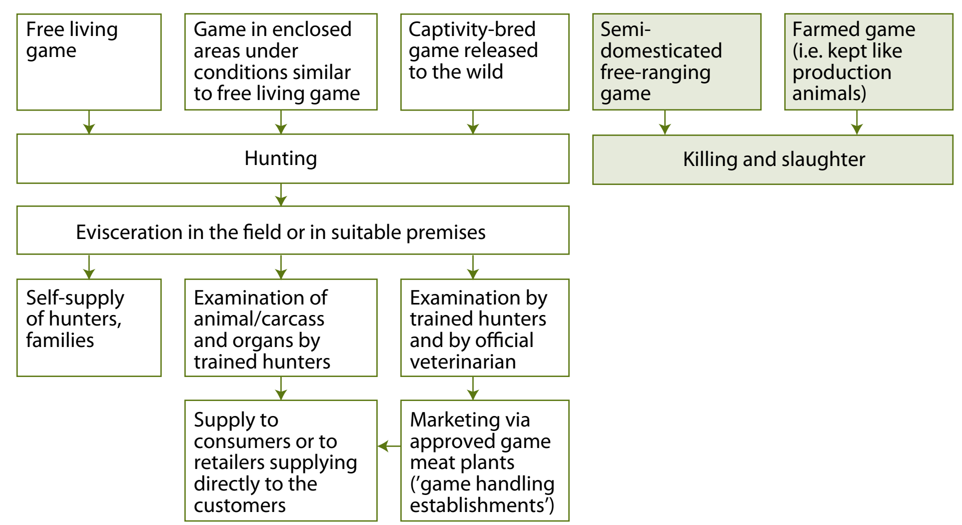
Game animals are perceived as healthy, and the food they provide is considered clean and healthy. Game that comes from clean environment, and is killed with a successful shot and handled in a hygienic manner, offers valuable and natural meat to a gourmet's table.

However, this is not always the situation. Hunting differs from controlled butchering of production animals and meat production in many ways. Hunting is done in the wild. Animals roam free in the wilderness, and their diet is uncontrolled. The condition of the environment and changes in it are quickly reflected in the game meat.

There is considerable variation in situations, circumstances and the physiological state of the animal. The game animal is killed with either a rifle or a shotgun, the placement of the shot varies, and there may be several points of shot. The bullet can carry various bacteria to the animal's bloodstream. The removal of animals' internal organs is often done at the kill site, where it is difficult to follow hygienic procedure. Transport to a slaughter establishment and chilling of the carcasses can be deficient or slow.

Hunting hygiene and the procedures included in maintaining it are the most significant factors, as far as food safety is concerned, in the production of game meat. Many deep-seated, traditional ways of handling game are still used, and they are not always the best for the hygienic quality of the end product.

Diseases, parasites and chemicals in environment can pose a threat to the health of game animals, and they can affect entire populations. They can also diminish the value of the end products obtained from game. Some game animal diseases can be transmitted to people or production animals, either directly or indirectly. Foreign substances and chemicals can pass on to people from game meat. Hunters have a greater than average risk of encountering various pathogens communicable from animals to people. The ways of handling the carcass, meat, offal and hides have an effect on this risk. Working in the area where the animals live increases the number of possible contacts with animal faeces or excretion via dust or dirt, for instance.



Variants of the game meat chain from forest to fork. Shaded fields indicate variants that are not covered in this book.

For a million years, the use of fire in cooking has been significant for the development of the human species. Cooking made food easier to digest and, more importantly, cooking also prevented many parasitic and bacterial infections. People gathered around fire, fraternized and bonded with each other. Man grew accustomed to fire biologically, anatomically and socially.

The purpose of this handbook is to help hunters:

- to identify healthy and sick game animals;
- to observe and recognise the state of the environment where game animals live;
- to identify the changes caused by diseases or parasites in the game animal;
- to know the harmful effects these changes in game animals and the state of their environment may have on the health of people and animals via game meat;
- to know how to protect themselves from these harmful effects;
- to know the hygienic procedure of handling, evisceration and further processing of wild game;
- to help in gathering information for hunting organizations and authorities, in order to assist them in making decisions concerning game animals and their environment, and to promote game animal and human health research.

The authors are aware that the book puts a focus on the conditions in Northern Europe. However, the principles of good hygiene practice of handling wild game and identification and assessment of abnormities of the live animal and the alterations of the body and inner organs are generally applicable. Human, wildlife and farm animals largely share the same environment and the awareness on hygiene and safety of meat from wild game is one cornerstone in assuring 'One Health'.

The call of the wilderness is still more important to many hunters than the actual hunting bag.

One Health – common health.

- The well-being of people, animals and environment form a single unity where everything has an effect on everything, all components are strongly tied to each other.
- Hunters have a perfect opportunity to monitor the changes in the health and condition of nature and wild animals.
- The goal of this book is to help the reader to understand this interdependency and its significance in our environment.

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1. The anatomy and physiology of game animals

The assessment of diseases and their symptoms in game animals requires a basic knowledge of the structure and functions of normal organs and tissues. In this book, the main focus is on cervids, as they are abundant in most regions of Europe and they present the most complex digestive tract. Characteristics of other game species are presented, when appropriate.

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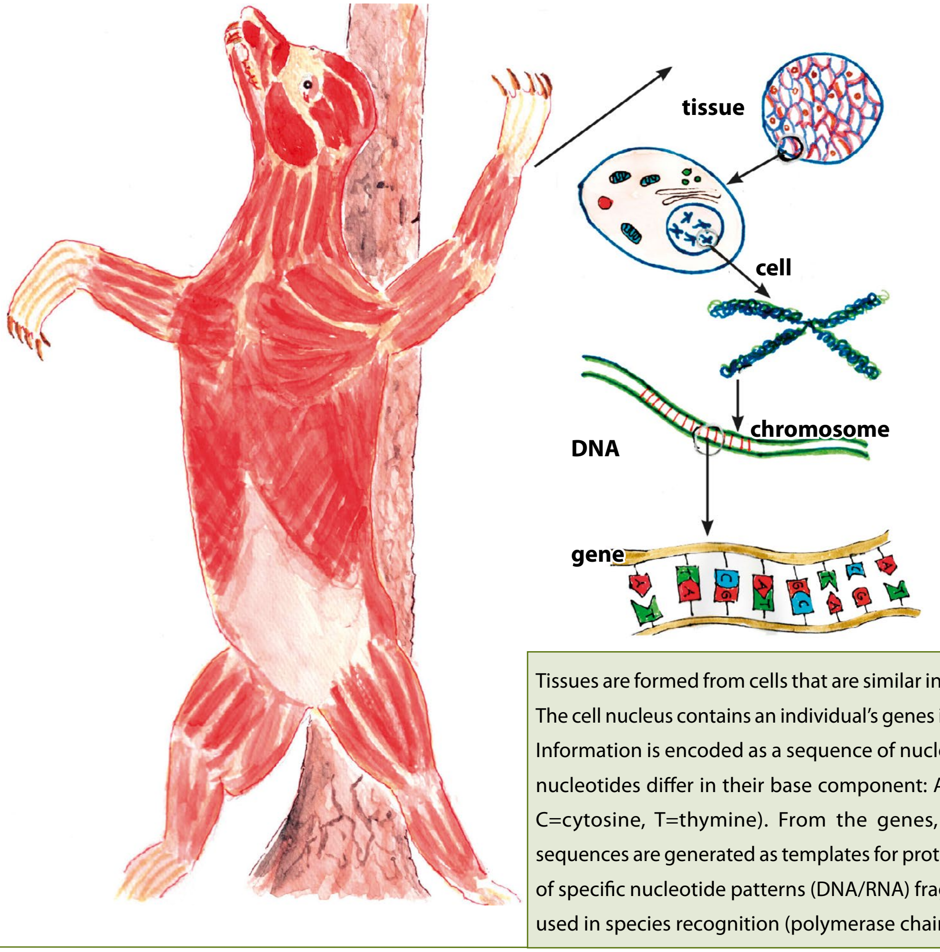
1.1 The cell

Animals are composed of functional units termed 'organs' (e.g. a muscle, the lung, the liver). Organs are, in turn, composed of functional units termed 'tissues', e.g. connective tissue, nervous tissue, etc. The basic structural unit of animal tissue is the cell. The size of cells varies between 0.1 and 0.0006 mm. Cervids are made up of approximately 100 trillion (= 100×10^{12}) cells. The main volume of a cell is filled with cytoplasm, which is surrounded by cell membrane. Cytoplasm is the place where the proteins of the organism are produced. It also contains the mitochondria that produce energy for the cell. The nucleus of the cell houses the cell's chromosomes. The chromosome is a structure of deoxyribonucleic acid (DNA) and protein which contains most of the individual's genes. Chromosomes are organised in pairs, i.e. each chromosome has a homologous chromosome

The cell is the basic structural unit of an individual.



Tissues are formed from cells that are similar in function and structure. The cell nucleus contains an individual's genes in paired chromosomes. Information is encoded as a sequence of nucleotides in a gene (DNA, nucleotides differ in their base component: A=adenine, G=guanine, C=cytosine, T=thymine). From the genes, complementary RNA sequences are generated as templates for protein synthesis. Detection of specific nucleotide patterns (DNA/RNA) fragments – for example – used in species recognition (polymerase chain reaction; PCR).

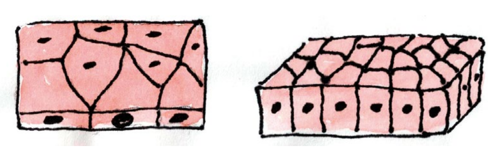
(diploid chromosomes). One chromosome in the pair comes from the father and the other comes from the mother. The elk has 27 pairs of chromosomes, the human has 23 and the dog has 39.

The gene is a molecular stretch of DNA that controls a characteristic or trait of a living organism. A cell can divide through a process called mitosis, which produces two genetically identical cells (containing two identical sets of chromosomes). This is how multicellular organisms grow and their tissues are regenerated. Gametes (i.e. sperm or egg cells) are produced by meiotic division. They contain only one (haploid) set of chromosomes. When sperm and egg cells fuse during fertilization, the embryo gets one set of chromosomes from its mother and another from its father. In meiotic division, all homologous chromosomes pair up and exchange genetic material with each other (crossing over). As a result, they produce offspring that are genetically distinct from either parent or any siblings.

1.2 Tissues

The body of animals is mainly comprised of four basic tissues: epithelial, connective, muscle and nervous tissue. Tissues are formed from cells that are similar in function and structure.

1.2.1 Epithelial tissue



Epithelial cells constitute surfaces; they are squamous or cuboid-columnar, such cells can have special functions.

Epithelial tissues cover and protect various surfaces such as the skin, the inner lining of the digestive tract, and the air passages. Epithelial cells are often sheet-like and they may have special functions, e.g. in the digestive tract or airways, where they secrete mucus. In the airways, the epithelial cells are ciliated. The function of the cilia is to remove impurities. Sensory epithelia is tissue that is specialized in receiving various signals.

1.2.2 Connective tissue

The function of connective tissue is structural, and supportive of other organs. Connective tissue is subdivided into connective tissue proper and adipose tissue. Cartilage, bone, blood and lymph are examples of specialized connective tissue. A large part of connective tissue is made up of extracellular matrix. The main protein of connective tissue is collagen, and it is the most abundant protein in mammals.

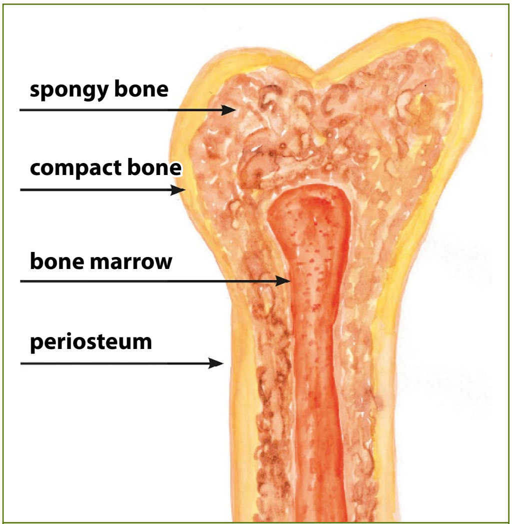
Connective tissue consists of two tissue types: loose and dense connective tissue.

Loose connective tissue surrounds other organs, muscles, nerves and blood vessels. Extracellular matrix is fluid and contains a moderate amount of elastic and collagen fibres. One of the most important functions of loose connective tissue is to provide a passage for diffusion, i.e., a route for substances to move in and out of tissues. Loose connective tissue has the best regenerative quality of all tissues, as it is still close to its embryonic state and contains a great deal of blood vessels. This quality is what the healing of wounds is based on. Dense connective tissue is fibrous and contains plenty of collagen fibres. It forms ligaments and strong fasciae or septa around the organs.

Bone tissue is highly specialized, live connective tissue. It forms the main constituent of bones, e.g. a solid or trabecular mineralised structure. The bone as an organ contains, in addition, blood vessels and nerves.

Bones are both hard and elastic and many bones are hollow. These characteristics make bones strong and resilient. Bones comprise collagen proteins and mineral substance (calcium carbonate and calcium phosphate). These make bone hard.

The outside of bones is dense compact bone, in the inside trabecular structures prevail (spongy bone). Bone marrow is located within the medullary cavity.

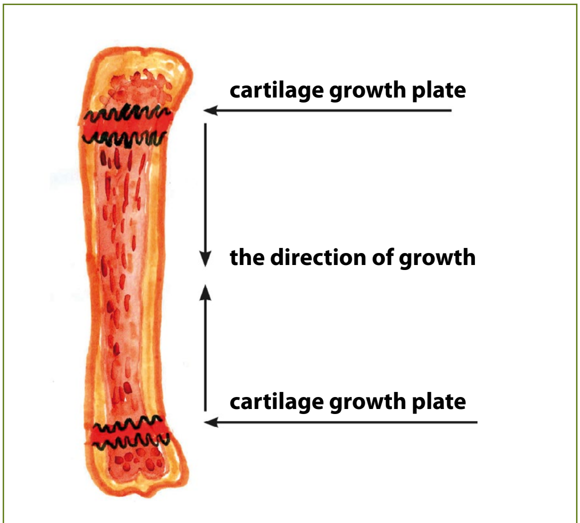


The structure of bone (spongy bone, compact bone, marrow, periosteum).

Ossification starts already in the foetal stage. Bone tissue is formed by ossification from cartilage or connective tissue. The last parts to ossify are the so called growing zones at the ends of long bones. These zones are where the bone grows in length. New bone is produced by the periosteum. The processes of bone growing thicker and the healing of fractures are based on the function of the periosteum.

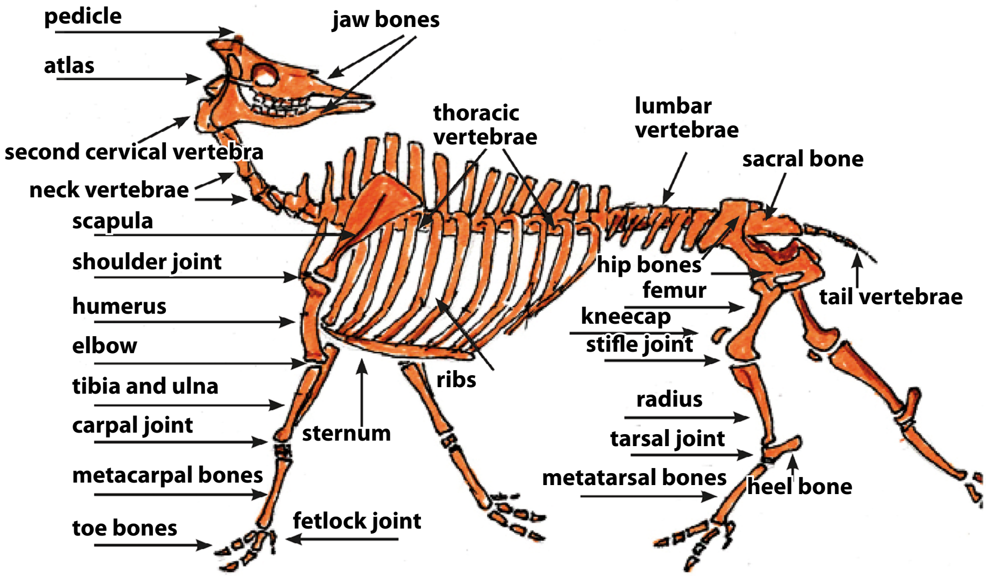
Bone tissue is under constant alteration, old tissue is destroyed and new tissue is formed. Ossification can be disturbed, for instance, due to deficiency of vitamin D or minerals. This may lead to a disease called rickets.

Bones protect vital, soft organs such as the brain, the spinal cord and the bone marrow. Bones take part in the regulation of the mineral metabolism. They function as



The bone growth in length occurs at the cartilaginous growing zones, growth in width at the peritoneum.


The healing of fractures is based on the function of the periosteum. In this picture, the thighbones of a 60 kg wild boar are shown (Photo: Peter Paulsen). The animal showed normal behaviour and had no difficulties in moving.



Cervid skeleton comprises approximately 200 different bones. They include the flat skull bones, nose bones, bones of upper and lower jaw, and bones of the body and extremities.

an important reserve of calcium, phosphate and magnesium. The shape and size of bones vary: they can be long as limb bones or short as vertebrae. Bones of the shoulder and skull are flat, and pelvis bones are so called irregular bones.

Bones form the skeleton of the body. They give the body its species-specific shape and form a skeleton together with cartilage tissue.

Bird skeleton is adapted for flight. The bones are light, thin and hollow, and they have a honeycomb structure. In addition, their strong keeled sternum, or breastbone, serves as an attachment site for the muscles used for flight.

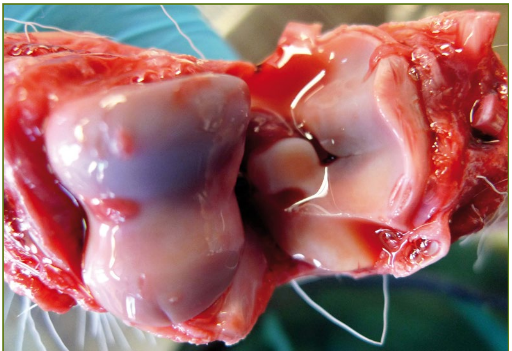
Bird bones are light and pneumatised, and the sternum is well developed, to allow insertion of the pectoral muscles (breast muscles) which operate the wings.

Bone marrow is tissue located in the medullary cavity of long bones. Red marrow consists of a great deal of blood vessels and cells. Red blood cells, platelets and most white blood cells arise in red marrow.

Yellow marrow is mainly made up of connective tissue and fat. As the animal ages, red marrow is replaced by yellow marrow. An adult animal has red marrow only in the ribs, the pelvis and the sternum.

Cartilage is semi-rigid tissue that does not contain blood vessels or nerves. This tissue is found in joints, ear lobes, the nose, the larynx and costal cartilages, and between the vertebrae of the spine. Cartilage is more flexible than bone, but once broken, it has more limited repair capabilities. In mature cartilage, the division of cartilage cells occurs very slowly, and if the tissue is damaged, its ability of regeneration is very limited.

Yellow bone marrow is mainly made up of connective tissue and fat. It is one of the fat reserves of the body.



Joint cartilage is found in the joints at the bone ends.

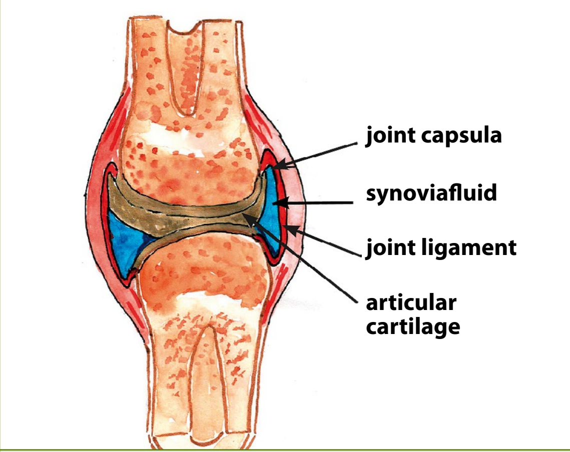
1.2.2.1 Synostoses

Bones can fuse together by immovable joints, e.g. in the flat bones of the skull, which fuse together by forming sutures. Cartilaginous joints between the ribs and the sternum are flexible.

A joint is the location at which two bones connect. They are constructed to allow movement. The ends of articulating bones are covered with flexible articular cartilage. A joint is surrounded by articular capsule made up of connective tissue. Inside the capsule, synovial fluid supplies lubrication and nutrients to the articular cartilage. The joint is supported by ligaments.

A simple hinge movement of the joint is the most common. The hip and shoulder joints have three axes (flexion, extension and abduction).


The flat skull bones ossify into tight sutures. Note the pedicles.

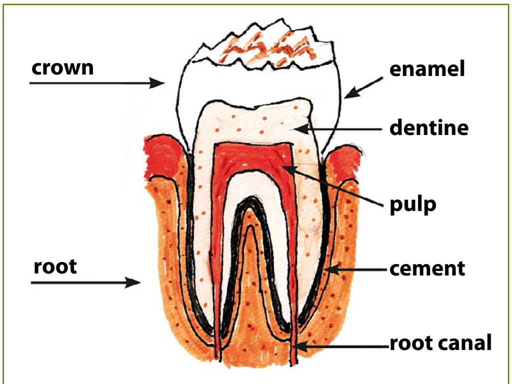


The structure of joint. Joint capsule, synovial fluid, ligament, joint cartilage.

Teeth are attached to the bones of upper and lower jaw (maxilla and mandible). They are used for cutting and grinding food. Dentine and cementum are equivalent of regular bone. Enamel is the hardest tissue of the organism.

Cervids have baby incisors and first premolars before their permanent teeth erupt. In their lower jaw, new-born calves have incisors and canines, and the first premolars and molars. The calf is able to eat plant material immediately after birth. The lower jaw incisors of ruminants are loosely attached and move while the animal is chewing. Their incisors are single-rooted and shaped like a chisel. They are used to collect food.

Diastema is a gap between the canines and premolars. Like other ruminants, cervids lack upper incisors which are replaced by a hard, cartilaginous plate.



The structure of tooth.


New-born calves have incisors and canines, and the first premolars and molars.


The incisors of cervids are chisel-like, single-rooted and loosely attached.

Premolars and molars are wide-tipped and double-rooted (the third molar has three roots). In the masticating surface there are enamel cusps that aid in the grinding of plant material.

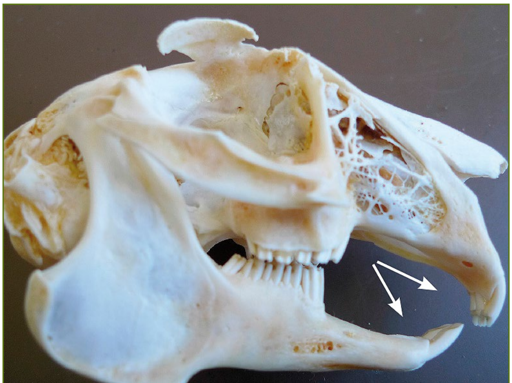
Birds do not have teeth, but instead they possess a ventriculus, or gizzard, that contains stones swallowed by the bird to aid in the grinding process of digestion.

Cervids lack incisors in their upper jaw. They are replaced by a hard cartilage plate (1). Behind the plate is an olfactory sense organ called Jacobson's organ. (2).

The molars of cervids are wide-tipped and double-rooted. Their masticating surface is formed from sharp enamel cusps.

Predator teeth are well suited for a diet of animal flesh. Also their molars have cutting edges. The teeth of the wild boar and the bear (in the picture) are of an intermediate type and represent hypocarnivorous teeth.

The canines of the wild boar are tusks that grow continuously. They are an adaptation to soil rummaging, but also an efficient defensive weapon, especially for males whose tusks can protrude from the mouth as long as 12 centimetres.



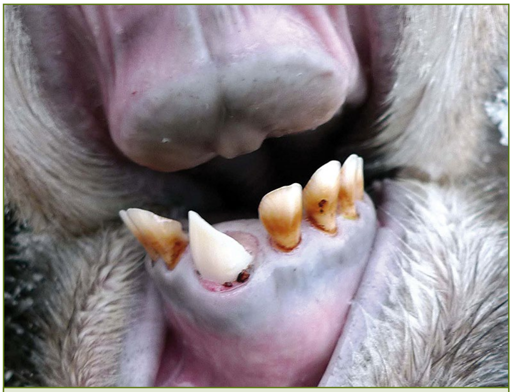
The incisors of hares are paired, and they grow continuously.

The beaver has only four incisors, two in the upper and two in the lower jaw. They grow continuously and stay sharp, because only the front of the tooth has a hard enamel cover.

1.2.2.2 Age estimation

The age estimation of cervids is often based on inspection of teeth. The most reliable method of estimation is the changing of teeth. The baby teeth of the moose calf change into permanent teeth during the first year of its life. However, there are exceptions, a late calf may still have milk teeth in the following autumn, but the other features of its body, such as the relative length of its head, reveal the truth.

The teeth of cervids do not grow in length, but wear causes changes. With age, the sharp, chisel-like shape of the incisors turns blunt and the root canal is exposed. As the premolars and molars wear, the cusps of their masticating surfaces become lower and fuse together. Food quality and regional differences have an effect on the wear changes. The range of error in age estimation



A moose calf's baby teeth change into permanent teeth during the first year of its life.

A late-born moose calf can still have milk teeth in the following autumn.

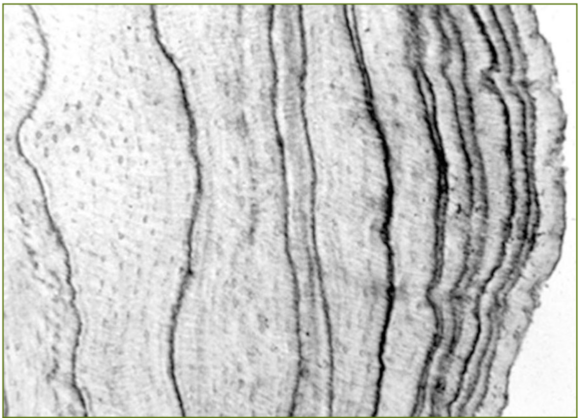
In the first autumn of their life, the premolars of cervids give way to permanent teeth and the first molar erupts. In autumn, the moose calf has four molars.

The sharp enamel cusps of a young adult. Adult cervids have six molars.

With age, the sharp, chisel-like shape of the incisors turns blunt and the root canal is exposed. Pictured here are the incisors of a young moose, a middle-aged moose, and a moose older than ten years.

The teeth of a 7-year-old (above) and the worn teeth of a 14-year-old moose. The older moose had starved to death, as he was unable to masticate his food.

can be two to three years. In accordance with the seasons, there is a build-up of cement and bone in the roots of the teeth. This build-up is more solid in winter and less solid in summer. When examined with a microscope, the zones are shown as dark and light areas in the cross-section. With this method, the first incisor root cross-section is examined. This method may also produce errors of one to two years in age estimation.



In accordance with the seasons, there is a build-up of cement and bone in teeth roots. This build-up is more solid in winter and less solid in summer. Pictured here the transverse section through a tooth root of a 10-year-old moose.

The baby teeth of the bear change into permanent teeth during the first year of its life. If you shoot an individual who has milk teeth, it is a cub born in the same year (above). Below a 1.5-year-old yearling (Photos: Olavi Ehrukainen).

Other signs to aid elk age estimation are, among others, the depth of the frontal groove, the thickness of the pedicle, the shape of the beard and changes in the colour of the fur. For wild game species in general, examination of external animal characteristics, including change and wear of teeth, provide only estimates of the animal's age and accuracy decreases with increasing age. Microscopic examination of sections of teeth – if applicable – gives more accurate results.

Calf's frontal groove (left) is almost straight. It deepens with age (right).

Moose pedicle grows thicker with age. The antlers of a 2-year-old (right) and a 7-year-old moose (left).

In the prime of his life, the pointed beard of a young bull (left) has developed into an impressive, widely attached bell (right).

If the width of a brown bear's front paw is over 13 cm, it is a male (Photo: Olavi Ehrukainen).

Reindeer (genus *Rangifer*) is the only cervid with antlers also on females.

1.2.2.3 Antlers

Only male cervids have antlers. The only exception to this is the reindeer (genus *Rangifer*). Both male and female reindeer have antlers.

Cervid antlers are true bone and they grow from the tip, unlike bovines, whose horns grow from the base.

Growing antlers are covered with skin called velvet, which is rich in blood vessels and nerves. Therefore it is sensitive to pain and accidents. Velvet antlers are the fastest growing mammal tissues. The growth can be two centimetres or 100 grams per day. The velvet period lasts three to five months.

Antler growth is regulated by several hormones such as testosterone (in female reindeer also oestrogen, progesterone and placental hormones), corticoids and the growth hormone.

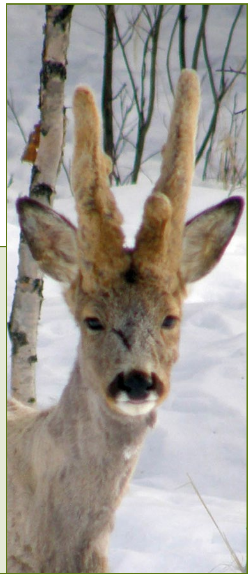
Right and left antlers are often mirror images of each other.

The bloodstream of antlers is gradually diminished by calcification and the antlers ossify. The antler surface is compact bone, the interior is dense spongy bone. The velvet on the surface of the antler dies and starts to come loose.

On the verge of mating season, animals thrash their antlers against trees and bushes and the velvet is lost. The handsome colour of the antlers comes from the tannic acids in the trees.

After the male mating period, the antler bone becomes brittle at the base, the antler falls off and the area heals, until new growth begins in spring. The function of the antlers is to improve chances in the

The pedicles of a new-born are protuberations of unspecialized epithelial tissue, blood vessels and nerves located in the forehead.



Antlers grow from the tips by cartilage ossification. At that time they are covered with dermis called velvet. The velvet period lasts three to five months. The antlers of the western roe deer develop in late winter (Photo: Lea Silén).

At the start of the rut, the velvet is removed by rubbing the antlers against vegetation. The handsome colour of the antlers comes from the tannic acids in the trees (Photo: Lars Björk).

inter-species competition for food. Antlers are also used in determining rank within the herd, and in male-male competition for mates during breeding season. Antlers are not much used as defence against predators, as hooves are more efficient for that purpose. During the growth period in summer, velvet antlers are efficient thermo regulators due to their active blood circulation. When competing for food, antlers on females ensure nourishment for the developing foetus. Therefore, they are not shed until after calving in spring.

Deformed antlers occur when antlers grow uncontrollably and they do not fall off. The reason for this can be disturbances in testosterone production, testicular damage or infection, or environmental toxins or chemicals.

After the male rut, the antler bone at the base becomes brittle, the antler falls off and the area is covered with epithelium.

Velvet antlers are efficient thermo regulators due to their active blood circulation.

The cause for deformed antlers can be, e.g. environmental toxins.

1.2.3 Muscle tissue

The basic function of muscles is to produce motion. This is based on the muscle cells' ability of contraction.

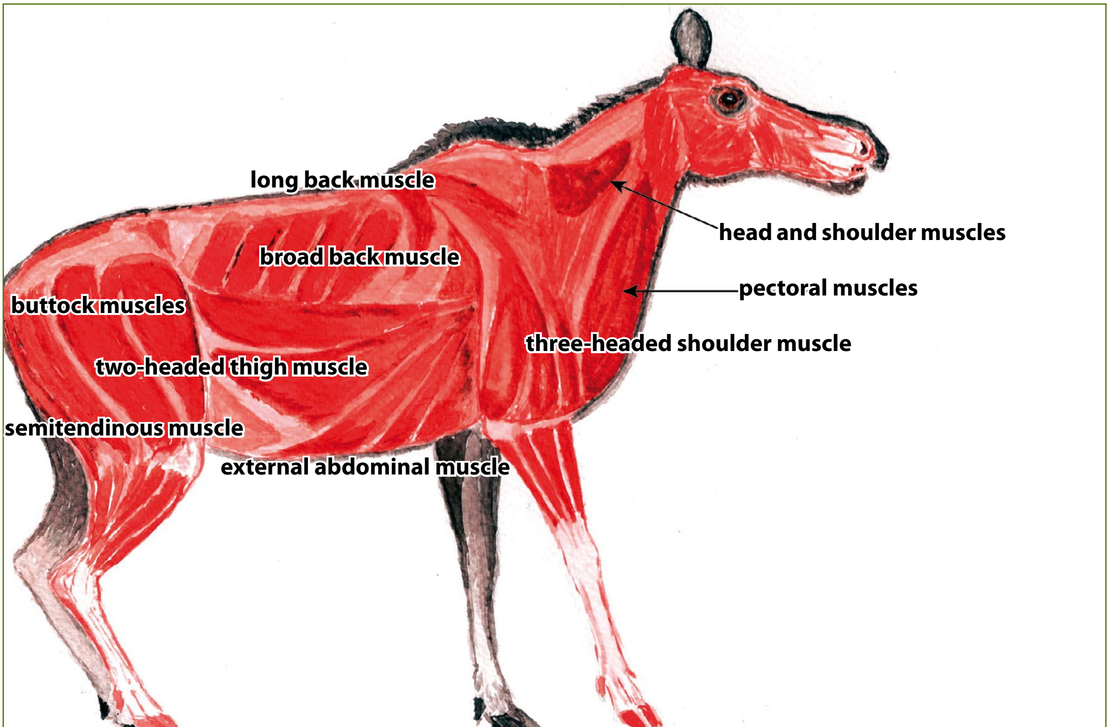
There are three types of muscle tissue: skeletal muscles (striated), the cardiac muscle, and the muscles of internal organs (smooth). Skeletal muscle cells are multinucleated, and the regular sequence of so called contractile elements produces a dark-light-dark-etc. pattern when examined under the microscope, thus the term 'striated muscle'.

Skeletal muscle cells are multinucleate. The regular order of so called contractile elements makes them appear striated under the microscope.

Smooth muscle cells contain one nucleus. By function they are slow.

Voluntary, or somatic, nervous system is responsible for stimulating muscle cell contraction. The function of muscle cell contraction is to produce the movements of the body. Tendons and membranes connect skeletal muscles to the bones.

Fascicles or bundles of skeletal muscle fibres are comprised of muscle tissue, connective tissue, nerves and blood vessels. Skeletal muscle system is composed of different size fascicles and their combinations. The necessary energy for the contraction of skeletal muscles can be produced anaerobically without oxygen, using carbohydrates as energy. This activity produces lactic acid. This method of energy production is used in short-time actions.



Skeletal muscle system is composed of different size fascicles and their combinations. They are attached to bones by tendons and membranes.

Aerobic energy production with oxygen is best suited for long-lasting activity. Then the sources of energy are primarily fats and also carbohydrates, and in extreme circumstances, proteins. Then lactic acid is not produced.

Cardiac muscle cells are shorter and form a network-like structure. They are involuntary and their function is synchronized. The stimulation for contraction originates in the cardiac muscle, but the involuntary (autonomous) nervous system can affect the rhythm, e.g. due to stress.

The cells of the smooth muscular system are spindle-shaped and contain one nucleus. The cells surround various internal organs such as the intestines and blood vessels, the uterus, and the muscles that cause hairs to stand on end. Smooth muscles are slow and not under conscious control. The contractions of the smooth muscle system cause the movement of food through the digestive tract, and the contractions of the uterus during birth.

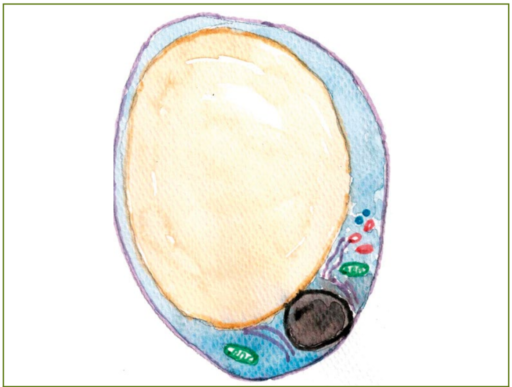
1.2.4 Adipose tissue

Adipose or fat tissue is loose connective tissue. It contains large cells filled with lipid droplets, adipocytes, that are supported by filaments. As the lipid droplet fills up the adipocyte, the nucleus and cytoplasm are located on the periphery of the cell.

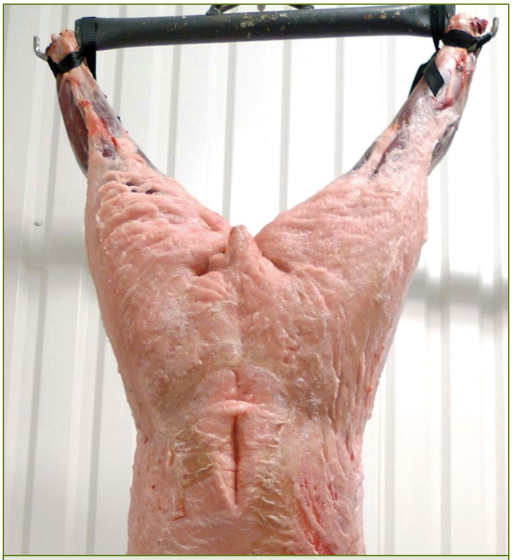
Adipose tissue functions as the largest energy reserve of the body. It also functions as heat insulation and cushions the organism against external impacts. Adipose tissue is mainly found in subcutaneous tissue and around some internal organs such as kidneys.

Brown adipose tissue is found in new-borns. The colour of the tissue is caused by the great number of iron-containing mitochondria it contains.

The function of brown fat is to generate body heat in new born animals even in cold circumstances, as the new-born are unable to generate heat by shivering.



Adipose cell filled with a large lipid droplet.



Adipose tissue is the largest energy reserve of the body. Pictured here a subcutaneous fat layer of a bear ready for hibernation.

Adipose tissue comprises adipose cells supported by strands of connective tissue.

1.2.5 Blood and the circulatory system

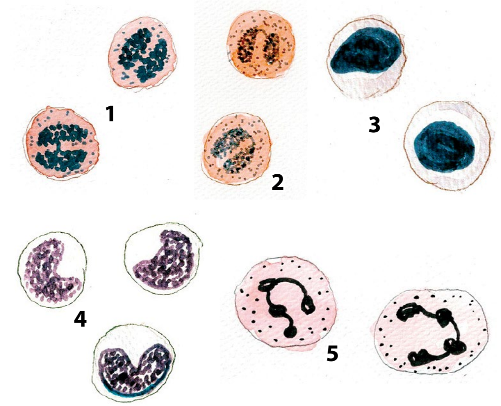
Blood is a fluid, specialized form of connective tissue. By the pumping action of the heart, blood is circulated around the body through blood vessels via the lungs and, again, the heart. Through the lungs, blood delivers oxygen in red blood cells to the tissues of the body, and transports metabolic carbon dioxide away from the same cells. It delivers nutrients such as vitamins, micronutrients and proteins to the tissues and takes metabolic waste away through kidneys. The hormones that regulate the functions of the organism are delivered to their target tissues by blood. It also transports white blood cells that control the resistance of the body, and antibodies produced by the organism. One of the functions of blood is to regulate the core temperature of the body. In cervids, along with other mammals, blood accounts for approximately 7% of body weight.

The straw-yellow plasma constitutes most (55%) of blood fluid. The rest of the blood is constituted from blood cells: red blood cells (erythocytes), white blood cells (leucocytes) and platelets (thrombocytes).

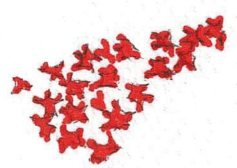
Blood cells are made in the bone marrow of flat bones. Some white blood cells are also made in lymph glands. The function of red blood cells is oxygen transport. They contain haemoglobin (Hb) which is an iron-rich oxygen binding protein. White blood cells take part in the defence of the body either by 'eating' infectious agents (pathogens) or producing antibodies into the blood.

Platelets take part in the process of blood clotting by adhering to each other in points of bleeding.

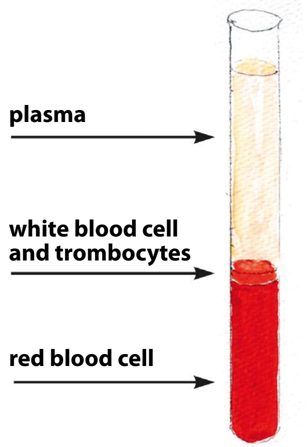
Red blood cells transport oxygen to cells.



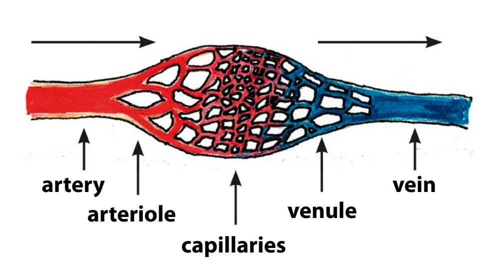
Basophils (1), eosinophils (2), lymphocytes (3), monocytes (4) and neutrophils (5) are the white blood cells of blood. They are involved in the function of the immune system.



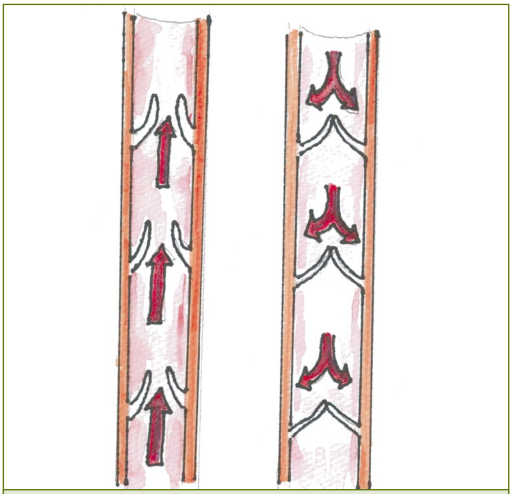
Platelets adhere to each other and form a blood clot to the point of bleeding.



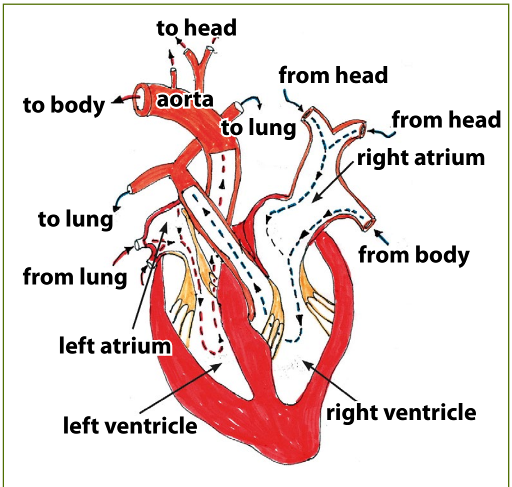
Composition of blood.



The exchange of oxygen, carbon dioxide and metabolic waste between blood and tissues takes place in the capillaries.



Veins contain valves that prevent the backflow of blood.



The heart is a muscular pump that gets a stimulus to contract from the cardiac muscle itself. Heart valves prevent blood from flowing in the wrong direction.

The circulatory system comprises the heart and blood vessels. The vascular system is a network of piping inside which blood flows. Blood is carried from the heart through the arteries and returned back through the veins. Inside the blood vessels there is pressure that is created when the heart contracts and pumps blood to the arteries. Blood pressure is the pressure inside the arteries carrying blood away from the heart.

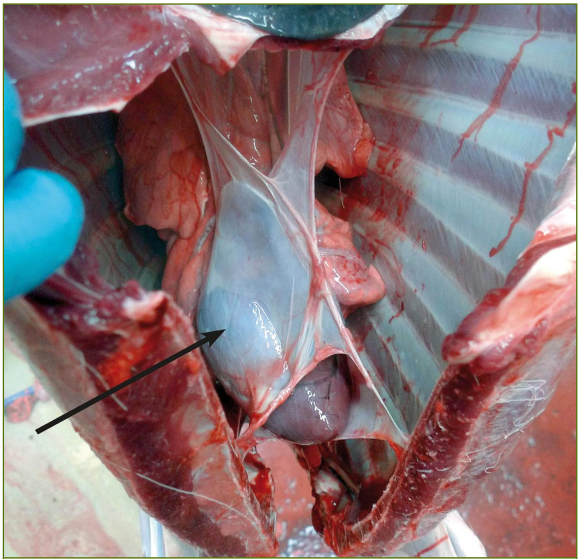
Large arteries branch into arterioles and further into capillaries in the tissues, thus forming a capillary network. The exchange of oxygen, carbon dioxide and metabolic waste between blood and tissues takes place in the capillaries. From the capillaries, blood is transported to venules which eventually converge to become veins, which then return blood back to the heart through the great veins. In the veins, the flow of the blood is assisted by the small pressure caused by muscles and motion as well as the pulsating of the arteries next to the veins. Veins contain valves that prevent backflow of the blood.

In pulmonary circulation, the right ventricle of the heart pumps deoxygenated blood to the lungs, where the blood cells exchange carbon dioxide into oxygen. Oxygenated blood re-enters the left atrium through the left pulmonary vein.

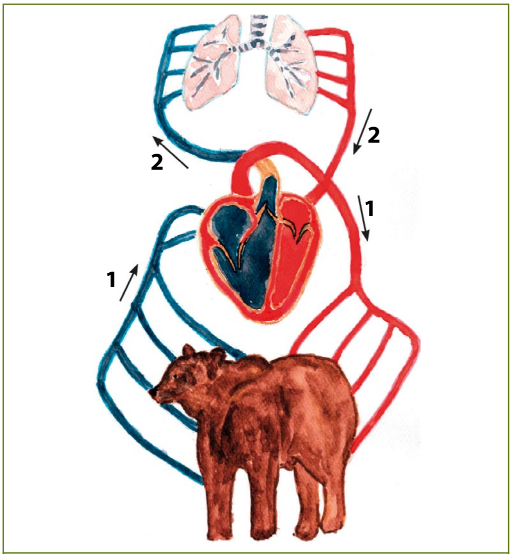
In systemic circulation, the left ventricle of the heart pumps oxygenated blood through the aorta to the body.

After servicing the cells, blood returns to the right atrium of the heart through large veins called the inferior and superior vena cava.

The heart is a muscular pump which gets a stimulus to contract from the cardiac muscle itself, and which is regulated by the autonomous nervous system. Four cardiac valves manage that blood only flows to one direction. The cardiac muscle is surrounded by pericardium.



Pericardium reduces friction caused by heart contractions.

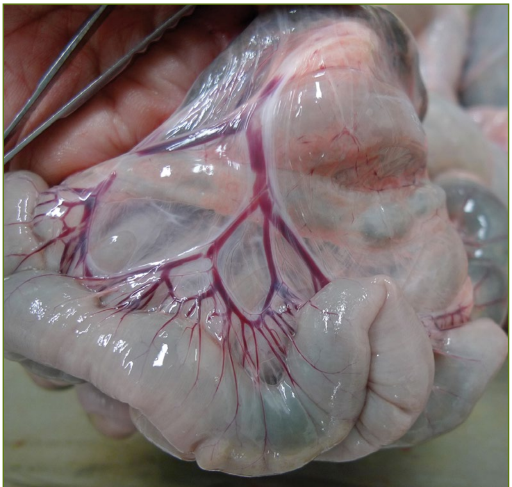


Systemic circulation transports oxygenated blood to tissues (1) and deoxygenated blood to heart. Pulmonary circulation transports deoxygenated blood to the lungs, from where oxygenated blood returns to the heart (2).

1.2.6 Lymphoid tissues and the lymph

Lymphoid tissues located around the organism form a system of organs whose function is to protect the body from pathogens and foreign substances. The lymphatic system comprises lymph, free white blood cells or lymphocytes, and the actual lymphoid tissues. These are the thymus, spleen, lymph nodes and lymphatic vessels.

It is part of the circulatory system. It begins as lymphatic capillaries near the blood capillaries. Lymph system has thin walls that allow permeation of proteins and even cells. Lymph capillaries converge into larger lymph vessels that gather lymph from the intestines and various parts of the body. Before the lymph enters the blood stream, it is filtered through lymph nodes. Lymph is the plasma that has filtered to the intercellular space from blood capillaries. The circulation of the lymph is maintained by the smooth muscles of the lymph vessels, the movement of skeletal muscles, and the pressure pulses of the neighbouring arteries. Movement advances the lymph flow. One of the functions of the lymph system is to transport various substances from

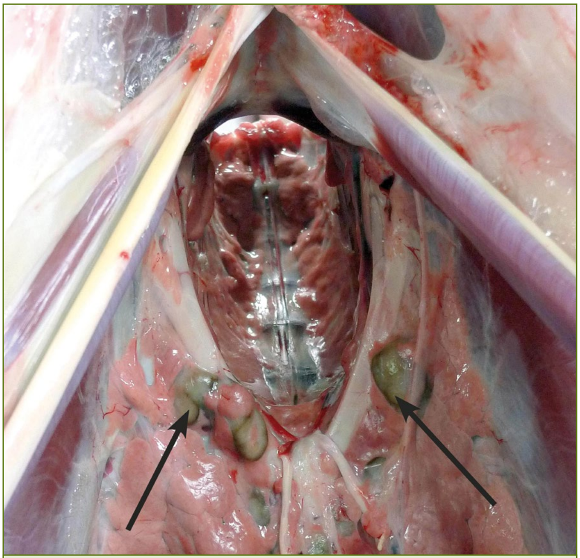


Lymphatic system is an integral part of the circulation. The lymph system transports fatty acids absorbed from the intestines to the blood stream. Lymphatic vessels are practically colourless and less prominent than red coloured blood vessels.

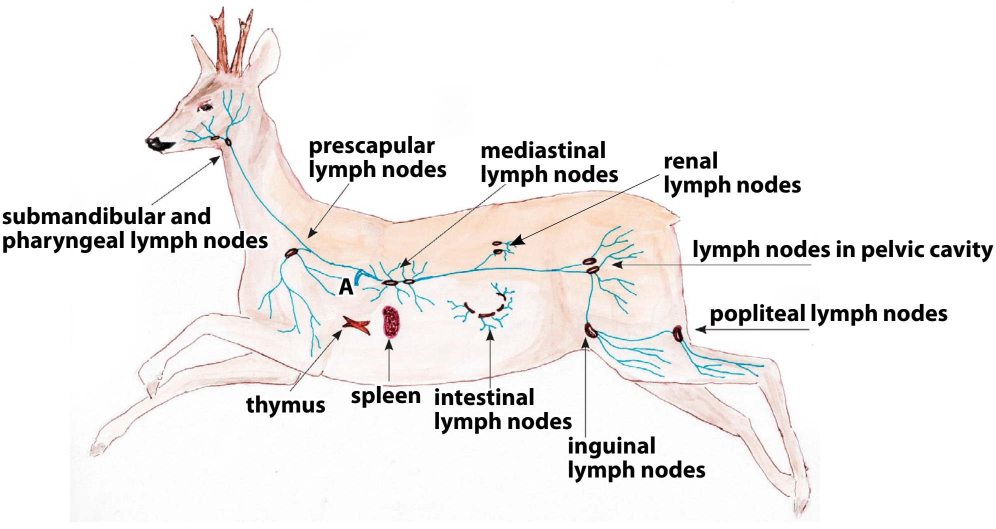
the tissues to the circulation. It also transports nutrients, especially fats, from the intestines to the blood stream.

A lymph node is a small, oval-shaped, encapsulated lymph tissue organ, through which the lymph flows. The substance of the lymph node is divided into an outer cortex and inner medulla. The lymph nodes take part in the immune system of the body; they function as filters through which the lymph fluid is strained on its way to blood. Lymph nodes also trap and destroy bacteria and viruses from blood. If there is an infection or tumour affecting the body, lymph nodes usually become enlarged.

The oval-shaped lymph node filters the lymph for pathogens trying to enter the body.



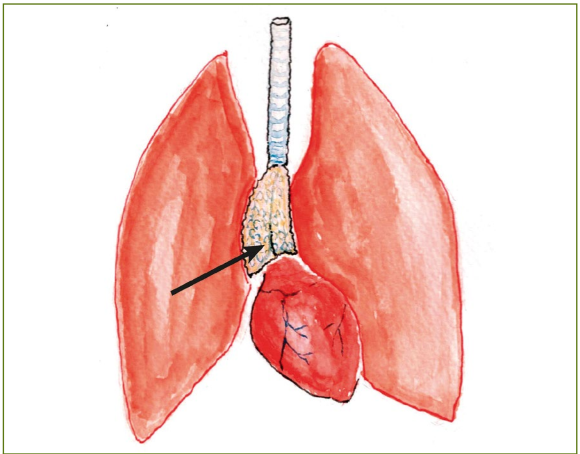
Pelvic lymph nodes.



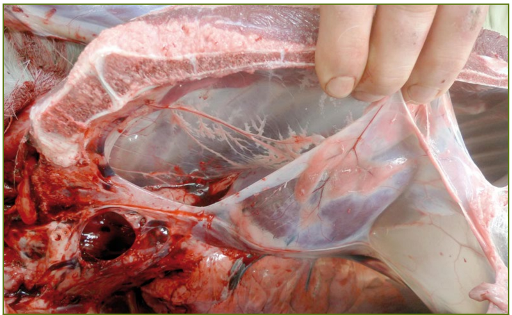
The lymphatic system and lymphoid tissues of the body. Before the lymph enters the blood stream (at A), it is filtered through lymph nodes.

The thymus is a lymphoid organ composed of two lobes. It is located in the thoracic cavity, in the mediastine. During the foetal period, lymphocytes ripen in the thymus. The thymus is relatively large in new-borns compared with their body size, and it degenerates as the animal grows up.

Thymus of a moose calf.



The thymus is located in the thoracic cavity, in front of the heart.

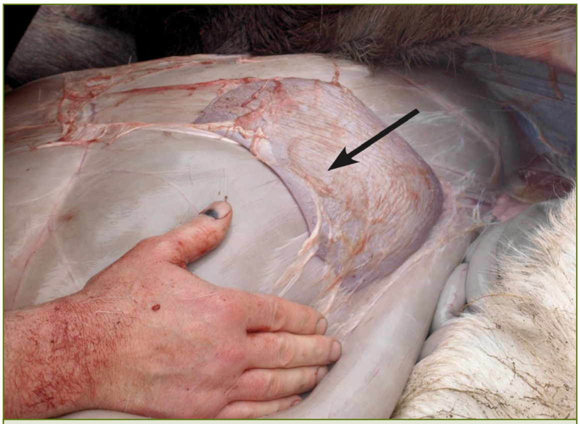


The lungs are separated by a suspensory structure, the mediastinum.

The spleen is a soft, dark red lymphoid organ that has an important function in the immune system of the body. It is located on the left side of the rumen or stomach.

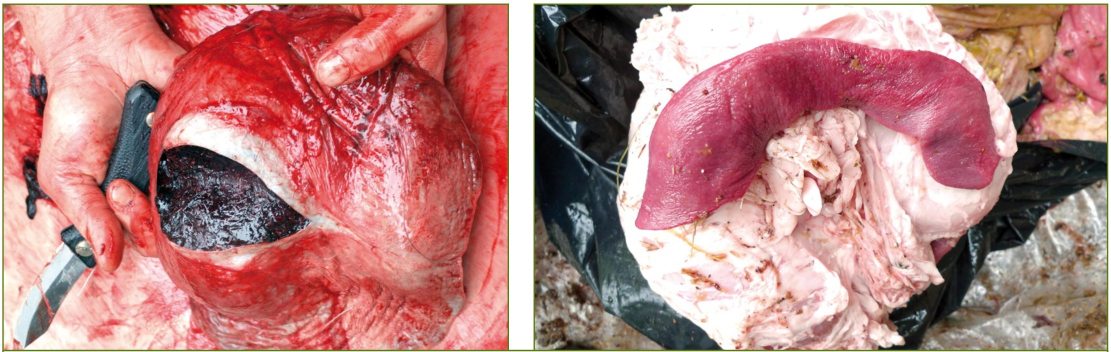
During the foetal period, the spleen and liver function as the place where blood cells are created. Later, the spleen is where white blood cells are created and blood cells are stored.

The spleen is surrounded by a connective tissue capsule. The interior comprises both white and red pulp. The white pulp is regular lymphoid tissue where lymphocytes and antibodies are created. The red pulp has all kinds of cells of the blood, but it is especially abundant with macrophages who have an important function in the defence of the body.



The spleen is located on the left side of the rumen or stomach.

The spleen of a hare.


The spleens of a moose (left) and a bear (right).

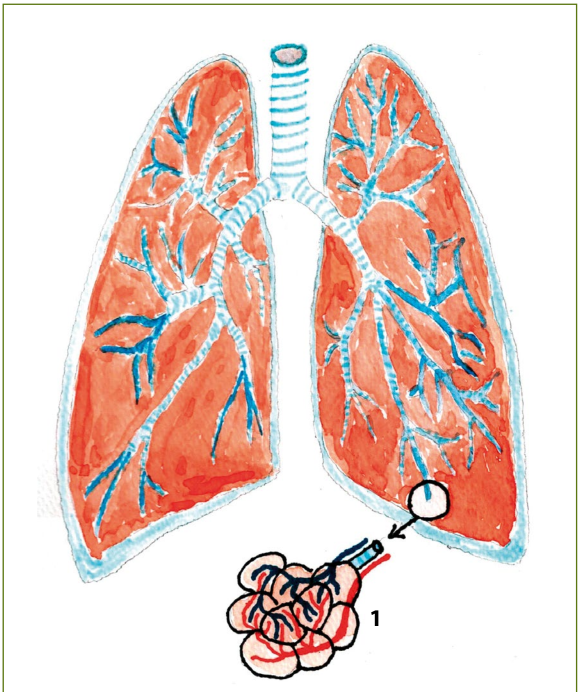
1.2.7 Respiratory system

Simply put, respiration is the transfer of oxygen from air into cells, and of carbon dioxide from cells to air.

The upper respiratory tract comprises nasal passages, the pharynx and the larynx. They take part in the warming, filtering and humidifying of inhaled air. Also vocalization and the perception of smells take place in the upper respiratory tract.

The lower respiratory tract comprises the windpipe (trachea) and the bronchial tubes. The primary bronchial tubes branch out into bronchi and further into bronchioles and alveoli, where the exchange of gases between inhaled air and blood takes place.


Cartilage nasal conchas are covered with olfactory epithelium.



The structure of lungs. The exchange of oxygen and carbon dioxide between blood and air occurs in the alveoli (1).

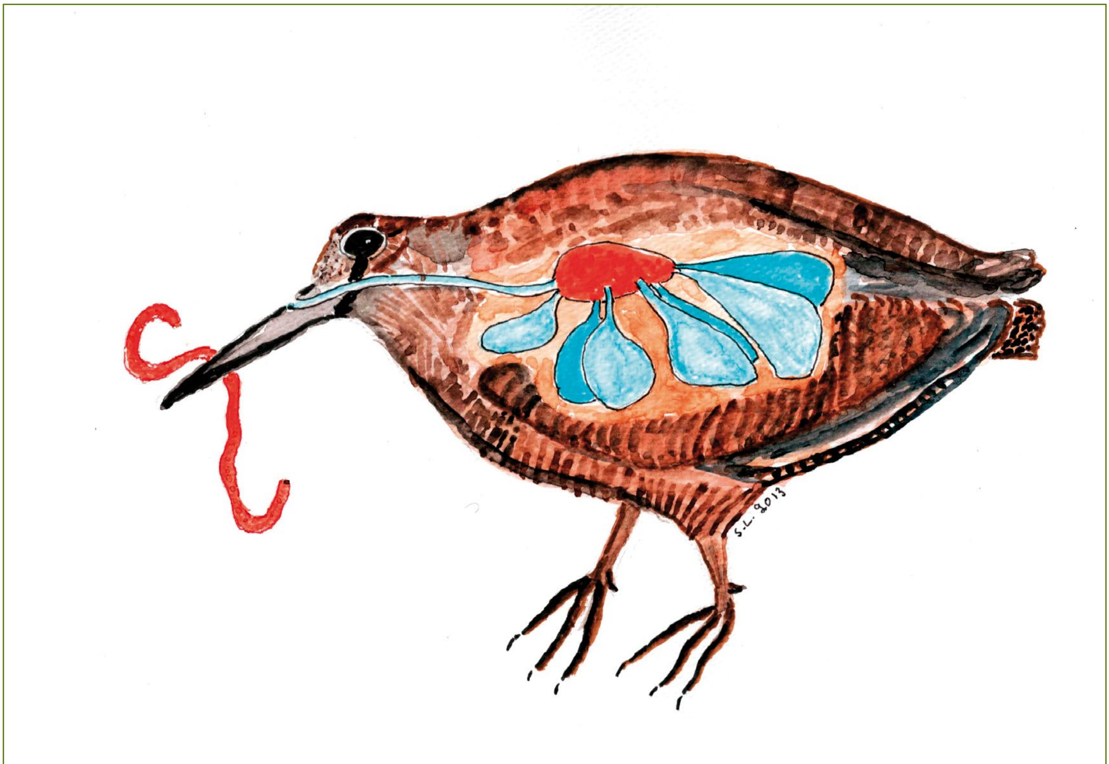
Both lungs are divided into (three to five) lobes. The lungs are surrounded by a two-layered membrane sack (pleura) that reduces friction during respiratory movements.

External intercostal muscles, the diaphragm and abdominal muscles function as muscles of respiration. The contraction of the diaphragm creates negative pressure to the lungs and this causes an airflow into them. Exhalation is a passive process, caused by the elasticity of the lungs.

Birds lack a diaphragm which is replaced by the pumping action of the sternum. The lungs of birds are small and compact. Air enters through the nares to the trachea and lungs and through them continues to the air sacs.

Thin-walled air sacs expand in the bird's body cavity and bones. Their action ensures a continuous air flow in the lungs and efficient oxygen intake during flight.

Healthy lungs of a reindeer.

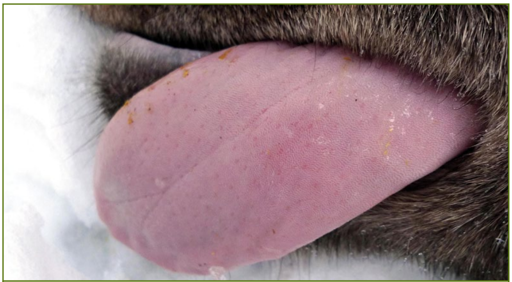


The thin-walled air sacs of birds ensure efficient air flow from the lungs, and the oxygenation of muscles during flight. They are difficult to notice and are best distinguished when infected, e.g. when suffering from fungal infection

1.2.8 Digestive system

Digestion is a process which begins in the mouth and passes through the pharynx and oesophagus to the stomach, and continues through the small and large intestines to the rectum.

In monogastrics, the digestion of food occurs mainly from the effect of digestive enzymes. Most of the nutrients are absorbed through the wall of the small intestine. Undigested matter is gathered in the colon where more nutrients and water are still absorbed. The rest leaves the body as faeces through the anus.


Moose's tongue is large and coarse.

1.2.8.1 Mouth, teeth and tongue

The tongue and front teeth are important in the collecting and chewing the food. The ruminant tongue is large and coarse. They lack upper front teeth and instead have a thick dental pad.

Ruminants do not chew while eating. The chewing of food with molars occurs while the animal ruminates.


This bear had eaten oats on the field at night, and berries during the day. Bears like oats, but for monogastrics the digestibility of raw oats is poor.

1.2.8.2 Digestive glands and digestion

Digestive glands are exocrine, autonomous glands. The enzymes they secrete perform the actual digestion in monogastrics. The enzymes break the nutrients into smaller components suitable for absorption. The cells use the absorbed nutrients as energy source and building material.

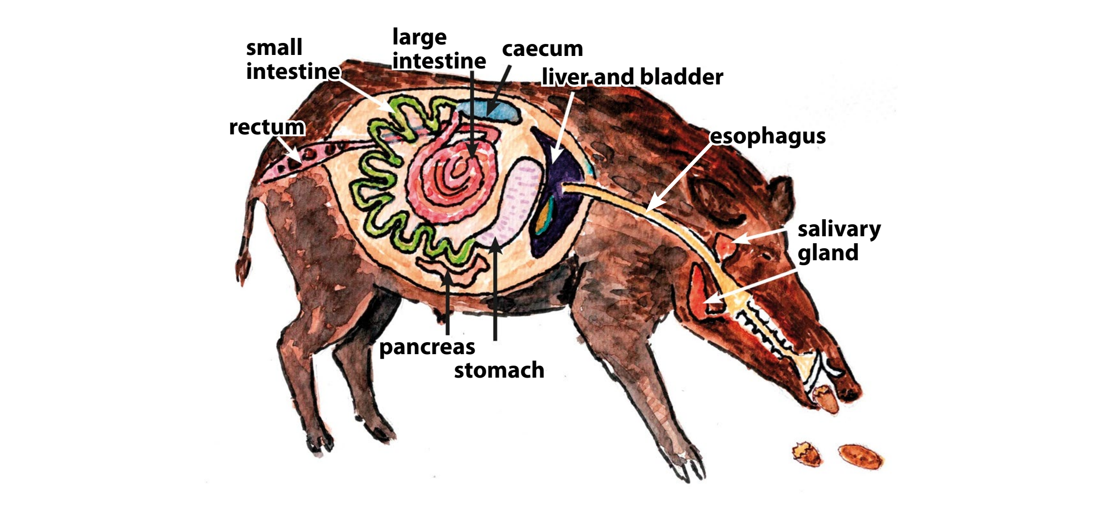
Carbohydrates are broken down into simple sugars, of which the most important is glucose. Carbohydrates are the most important source of energy for cells.

Proteins break down into amino acids. They are used as the building material of the body.

Fats enter the cells in the form of fatty acids and glycerol. They re-fuse into fats and are used either as building materials for cells or food storage for adipose cells.

Digestive glands comprise the salivary glands, gastric glands, intestinal glands, the pancreas and the liver. Saliva, the liquid secreted by the salivary glands, takes part in the wetting and predigestion of food. Saliva contains substances that act as buffers and neutralize the food mass. Saliva also takes part in the defence of the body by eliminating possible pathogens. Ruminants produce dozens of litres of saliva per day. Saliva is an essential part of the function of the rumen.

Minor salivary glands are located in the lining of the oral cavity and tongue. They excrete continuously by way of ducts directly to the oral cavity. The parotid, submandibular and sublingual glands are major salivary glands. They exist in pairs deep in the oral cavity wall and operate during the eating process.



Wild boar is monogastric and its digestion is based on enzymes secreted by digestive glands.

1.2.8.3 Ruminant digestive system

The production of animal protein in ruminants is based on their ability to digest cell wall carbohydrates and to convert them into proteins. Ruminants possess a four-compartment stomach. The four parts are the rumen, reticulum, omasum and abomasum. The first three form a so called fore-stomach. The abomasum is the equivalent of the monogastric stomach.

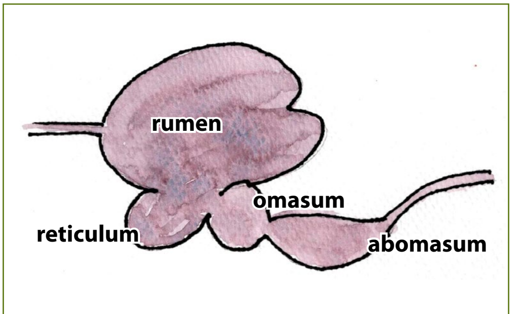
Ruminants store the swallowed feed to the fore-stomach and, when they are at rest, return the food through the reticulum to the mouth for chewing. In the mouth, food is broken down and mixed with saliva. This process is called rumination. Ruminants spend most of their time eating and ruminating.

Plant food is broken down in the rumen and reticulum by fermentation caused by microbial (bacteria, protozoa) action. As a result of the microbial food breakdown, gas is produced in the rumen. It is released by belching. This releases greenhouse gases, especially methane, into the atmosphere.

The outcome of the microbial fermentation of carbohydrates are volatile fatty acids (60% acetic acid, 10-15% butyric acid, and 20-25% propanoic acid) that form over two thirds of the energy the animal needs. Most of the fatty acids are already absorbed into the bloodstream through the rumen wall.

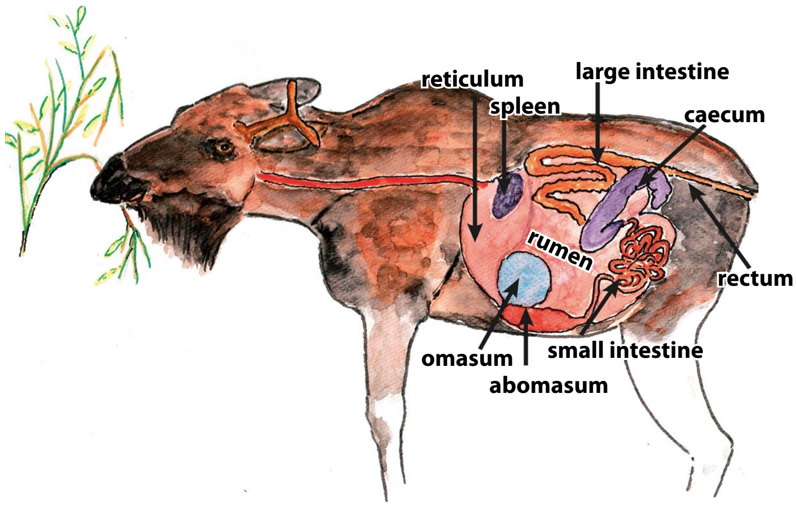
The microfauna residing in the rumen use nutrients from the digested feed for their own growth. For instance, 2 to 4 kg of microfauna are found in a cow's rumen.

The digesta that contains microfauna, broken down into liquid form in the fore-stomach, continues to the abomasum aided by the contractions of the rumen. The rumen pH is so low (acidic) that the microbes die and the protein nutrients they contain are absorbed in the intestine, in the fashion of the monogastric digestive system. Thus the microbes are part of the nourishment of the ruminants, and they get most of the protein they need from the microbes. As the fore-stomach microfauna are able to produce proteins during their



The four stomachs of a ruminant.

The ecological niche of the moose is based on its ability to digest the cell wall carbohydrates of plant cells due to the activity of the rumen microfauna (Photo: Aija Kukila).

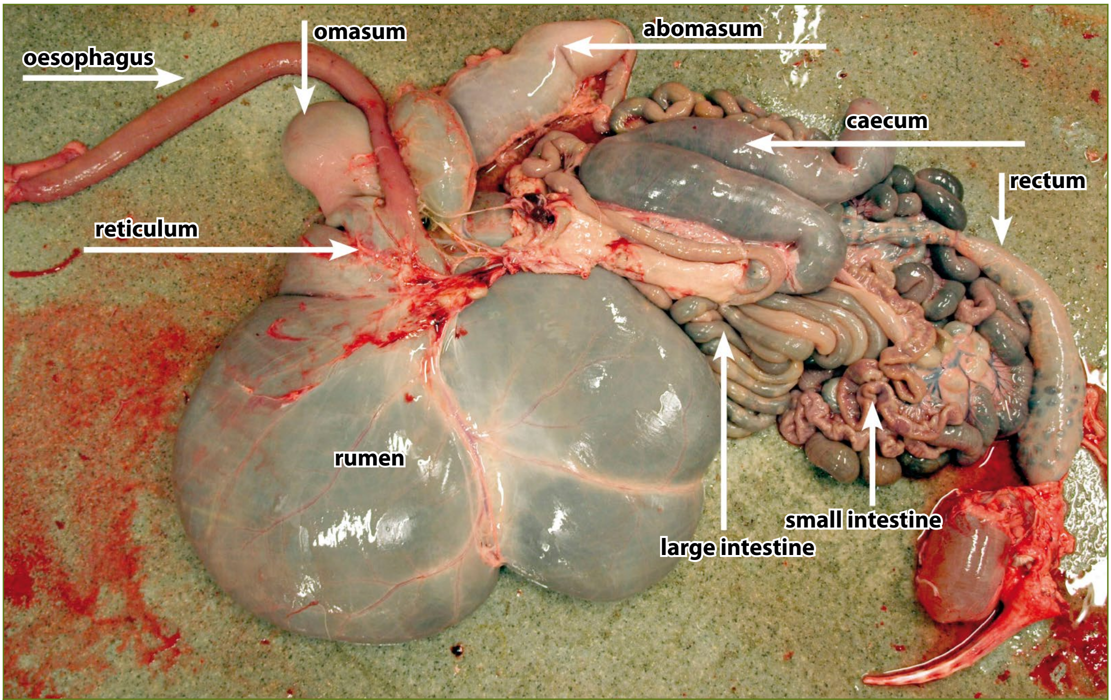


The microbes of the fore-stomachs use the cellulose of plant cells as energy source.

growth and multiplication, unlike with monogastrics, the ruminant feed does not need to contain all the proteins they need.

Ruminants are classified by their foraging behaviour into three main groups: grazers, browsers and intermediate grazers. The cow is a typical grazer. The elk and the roe deer are browsers, and reindeer are classified as intermediate grazers. The browser diet consists of fresh, quickly digested plant parts. The rumen of browsers is less developed, but they have a larger caecum and colon, and larger salivary glands. Saliva acts as a buffer against the acidity of the rumen. These characteristics compensate for the underdevelopment of the rumen.

In winter, the digestion of the reindeer and forest reindeer functions almost as in monogastrics. Under natural conditions, their winter diet consists of easily digested lichen and tree lichen, and



The cervid fore-stomachs comprise reticulum, rumen and omasum.

therefore their rumen stays nearly dormant in winter. The efficient rumen microbes and liver destroy the toxins which lichens contain.

The rumen is the most important by function, and is the largest by volume of the fore-stomachs. It contains microbes, bacteria and protozoa that break down the cellulose of plants and produce fatty acids. Toxic compounds are also broken down in the rumen. The lining of the rumen is covered with finger-like projections called papillae. They increase manifold the absorption surface of the rumen wall.

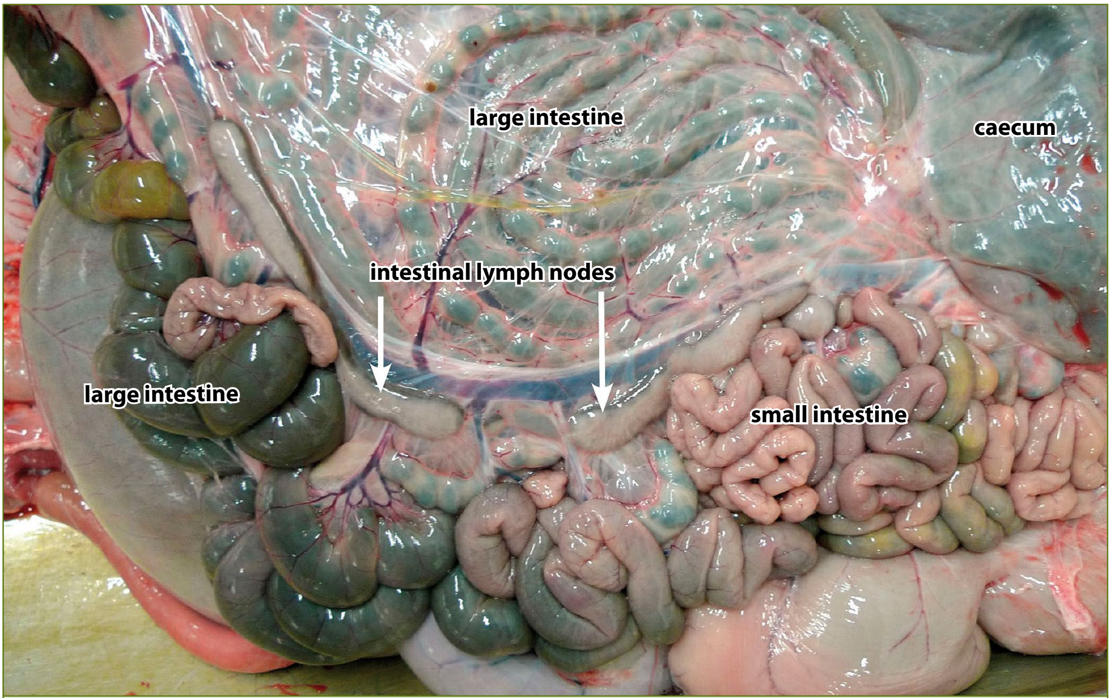
The reticulum is lined with ridges that form a honeycomb pattern. It is the place where cud is formed and returned to the mouth.

The omasum is muscular and folded. It has a laminated, leafy structure; filters digesta into smaller-sized particles.

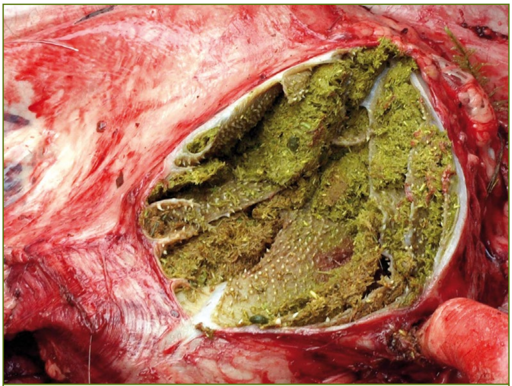
The abomasum is equivalent to true stomach. It produces enzymes that break down proteins. Its pH is acidic, around 2.5. The acidity kills bacteria and pathogens, and breaks down minerals.


The rumen papillae multiply the surface active in absorption of nutrients.


The honeycomb structure of the reticulum.



The structure and function of the intestines is similar in ruminants and monogastrics.

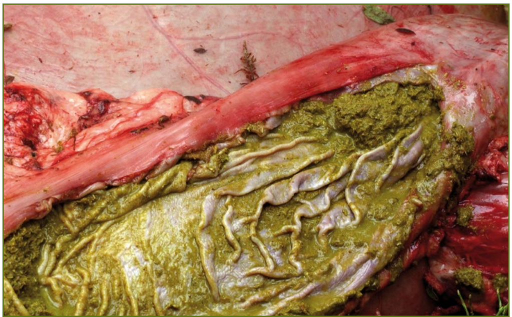


The leafy structure of the omasum.

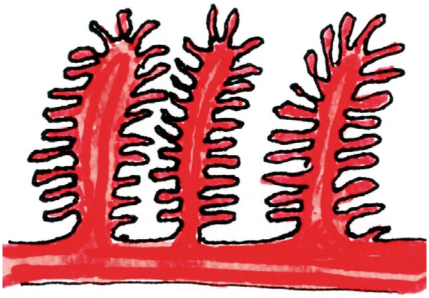
The intestine is divided into the small intestine, caecum, large intestine and rectum.

The small intestine is winding and cavernous. It comprises duodenum, jejunum and ileum.

In the small intestine, the mechanical and chemical processing of digesta continues. The contractions of the smooth muscles in the intestine wall, peristalsis, propel food down the digestive tract. The small intestine has a large absorption surface and its structure is folded. The inner wall of the small intestine is lined with finger-like projections, villi. Their surface is covered with small microvilli.



The folded inner surface of the abomasum.



The villi increases manifold the area of nutrient absorption.

The caecum is located at the junction of the small intestine and the colon. It is a closed sac whose function is mainly the absorption of water. The caecum of cervids, horses, hares and rodents functions, much like the rumen, as the place where cellulose is digested. It is considerably large in size.

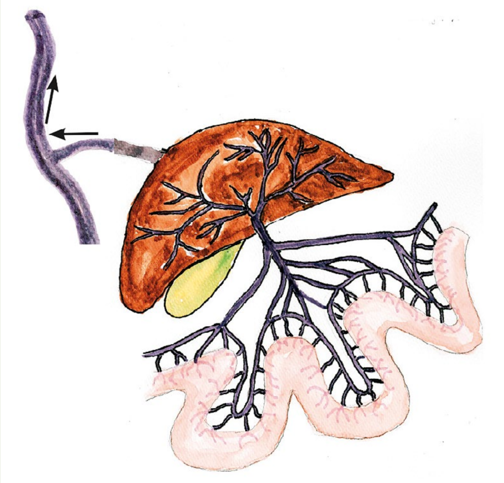
The colon still has microbial activity. In the colon, the progression of digesta has already slowed down, and water is extracted from solid wastes and absorbed.

The rectum functions as the storage site of faeces. Species-specific stools develop there.

The anus has two sphincters, one involuntary and the other voluntary.

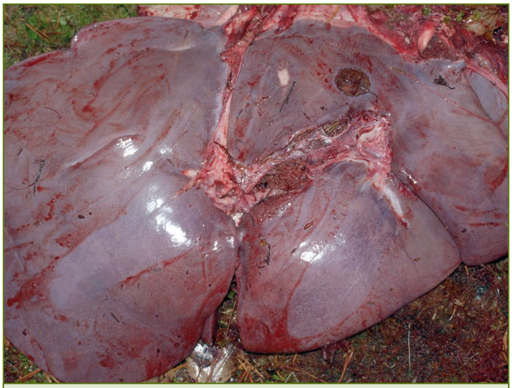
The liver is the largest gland of the body. It plays an important role in the digestive system. Its convex upper surface lies against the diaphragm. The part that lies against the digestive system is concave.

Oxygenated blood flows to the liver through the common hepatic artery. Nutrients absorbed in the intestines are brought to the liver through the portal venous system. The liver regulates blood sugar and amino acid levels, stores glycogen, blood, vitamins and iron. The liver also destroys bacteria and toxins from the blood stream. Bile is produced by hepatic cells. Bile passes through bile capillaries to the common bile duct and gall bladder (where bile is stored). Bile aids in digestion via the breakdown of lipids (fats). Cervids do not have a gall bladder.



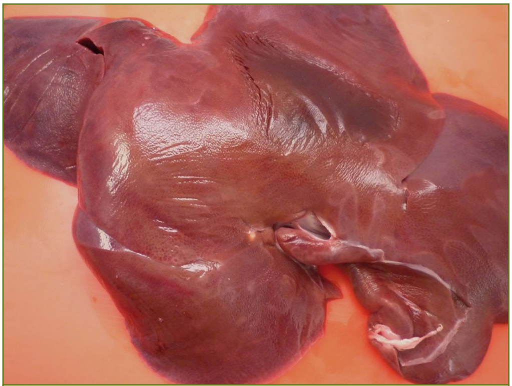
Nutrients absorbed in the intestines are brought to the liver via the portal venous system. In the liver, bacteria and foreign substances are retained from the bloodstream and glycogen is synthetized and stored as an energy reserve.

View into the abdominal cavity. Top: the muscular peripherial part of the diaphragm, below the tendineous centre, then the convex, diaphragm side of moose liver.

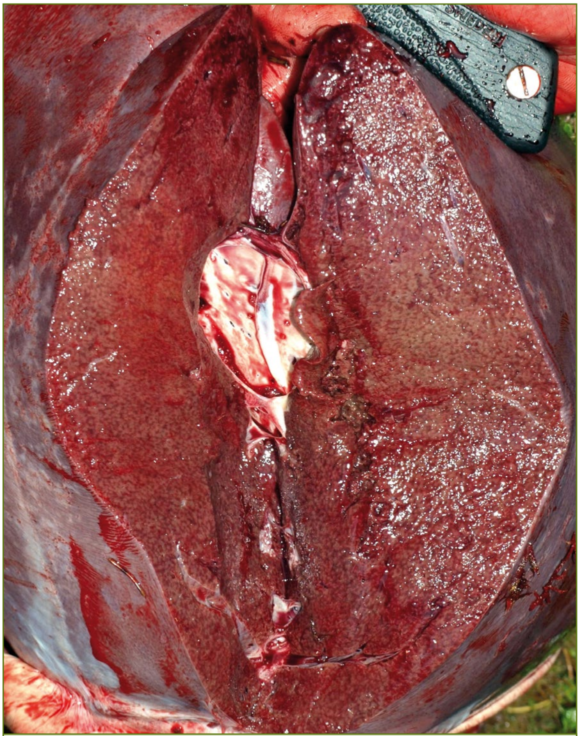


The concave side of the liver that lies next to the digestive system. Cervids do not have a gall bladder.

Bear's liver (visceral side) and gall bladder.



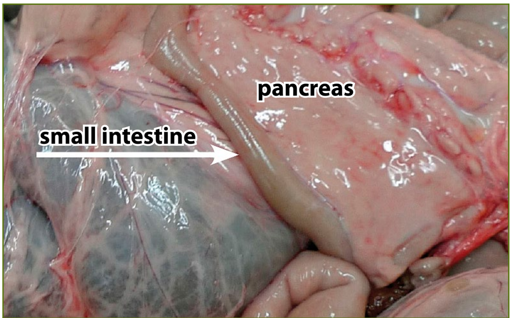
Normal liver of roe deer (Photo: Peter Paulsen).



Moose's split liver exposing bile ducts.

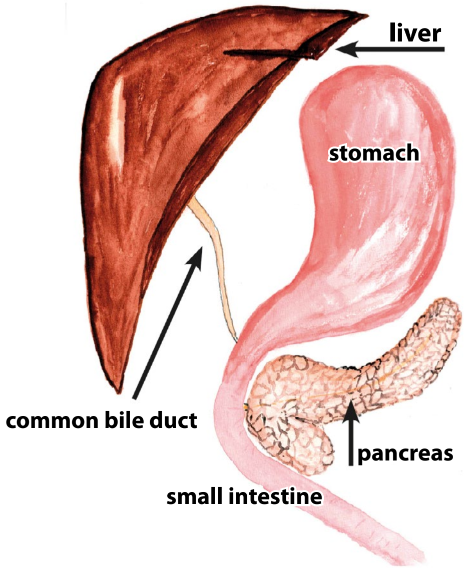
The pancreas lies at the starting point of the small intestine. It is both an exocrine and endocrine gland. The exocrine part of the pancreas, circa 98% of the entire pancreas, secretes digestive enzymes that assist in the breakdown of starch, proteins and lipids in the intestines (amylase, trypsin, chymotrypsin, lipase and phospholipase).

The enzymes pass through the pancreatic duct to the duodenum. The pancreatic duct secretion neutralizes the acidic chyme from the stomach.



Pancreas lies near the starting point of the small intestine.

The endocrine part accounts for only a few per cent of the total mass of the pancreas. It is made up of numerous cell clusters called the islets of Langerhans all over the pancreas. They secrete hormones (glucagon and insulin) that regulate the blood sugar level, and growth hormone. Glucagon releases energy from stores to be utilized by the body. Insulin stores energy into cells. The weakening or ending of insulin secretion leads to diabetes, the remaining of glucose in urine, as it is not stored in hepatic or muscle cells.



The pancreas excretes digestive enzymes via pancreatic duct to the starting point of the small intestine.

1.2.8.4 The digestive system of hares and rabbits (Lagomorpha)

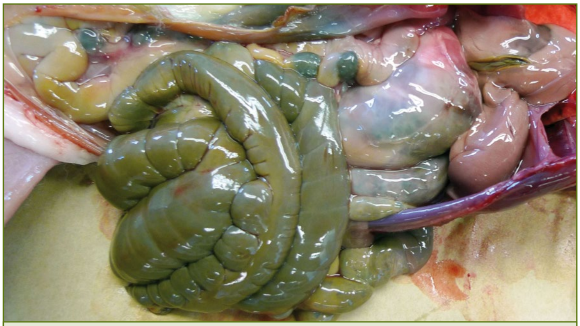
The caecum of hares is large and functions like the rumen in ruminants. It contains microfauna that breaks down plant fibres.

Lagomorphs eat their food 'twice'. They produce two kinds of faeces: Small, dry pellets, are the actual faeces. Whereas soft, moist pellets (caecotrophe) originate from the caecum. These pellets still contain nutrients and thus are re-ingested and digested.

The absorption of nutrients occurs in the beginning of the digestive tract, in the small intestine.

Hares eat their caecotrophe directly from the anus, usually at night. After that they produce small, dry pellets, the actual faeces.

The hare eats faeces, caecotrophes, directly from the anus. The breakdown of food occurs mainly in the caecum, which functions like the rumen. As nutrients are absorbed in the small intestine that comes before the caecum in the digestive tract, the hare has to re-ingest and re-digest his food.



Hare's caecum is large in relation to the size of the animal. It functions like the rumen in ruminants.

1.2.8.5 The digestive system of birds

Birds do not much comminute food in their mouth. The swallowed food goes through the oesophagus to the crop, which is an enlargement of the oesophagus. In the crop, food is softened and prepared for feeding the young.

Food passes from the crop to the proventriculus, which is the thick and soft walled part of the stomach in front of the muscular stomach called gizzard. It is lined with numerous glands that secrete digestive enzymes.

The proventriculus functions as the place for storing and softening food.

The muscular stomach, gizzard, is the rear part of the stomach where the grinding of food occurs facilitated by swallowed stones (in mammals, this is the task of the teeth).

The lining of the proventriculus has three layers: a thick, muscular outer layer, a glandular layer, and innermost a hard, horn-like layer.

Digestion continues in the small intestine aided by enzymes. Nutrients are absorbed from the small intestine. Undigested food mass travels to the cloaca, from where it is defecated as faeces.

The parts that comprise the digestive tract of birds are the crop (1), proventriculus (2), gizzard (3), small intestine (4) and cloaca (5). The stones in the gizzard perform the function of teeth in mammals.

1.2.9 Urinary system

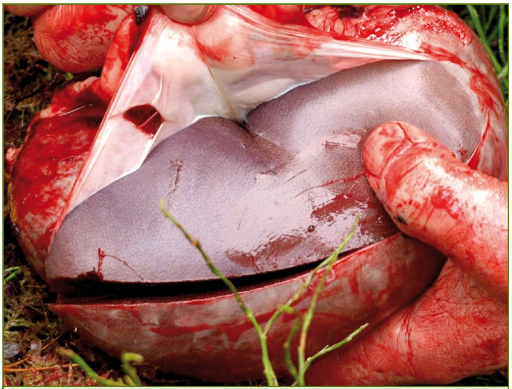
The urinary system comprises upper and lower urinary tracts. The upper urinary tract consists of kidneys and ureters. The lower urinary tract consists of the urinary bladder and the urethra.

Kidneys are located on both sides of the spine. They are protected by the ribs and back muscles, and the renal capsule made up of connective tissue and a layer of adipose tissue. The location of the right kidney is usually more frontal than the left. Together with the liver, kidneys remove waste from the body. They function as the filter of solid, water-soluble waste products of the protein metabolism.

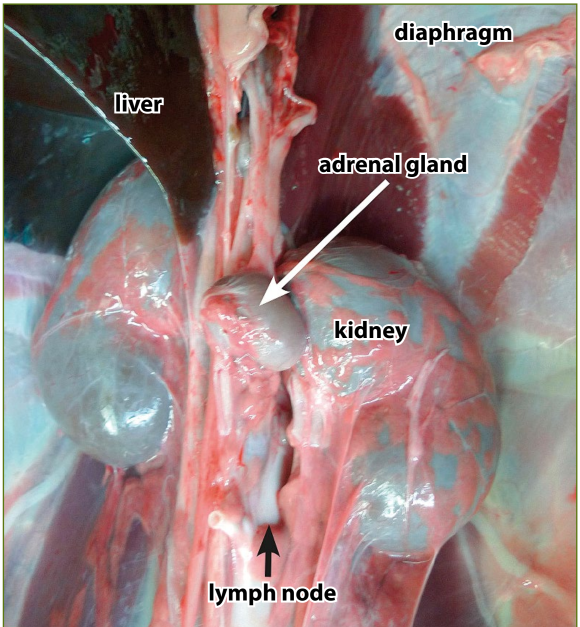
Kidneys maintain the fluid balance of the body by regulating the level of salt (mainly sodium).

The ureters are two tube-like structures that propel urine from the kidneys to the urinary bladder.

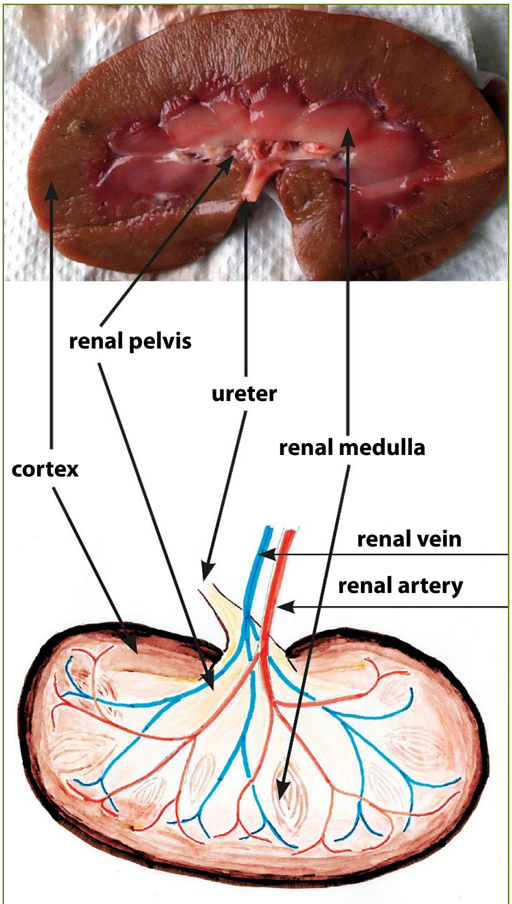
The urinary bladder is a sac-like organ where urine is stored. The bladder wall is made of connective tissue and involuntary muscle tissue. However, voluntary control of urination is possible, mainly with the external urethral sphincter.



Kidneys are surrounded by renal capsule.



Kidneys. The right kidney is usually more frontal than the left.

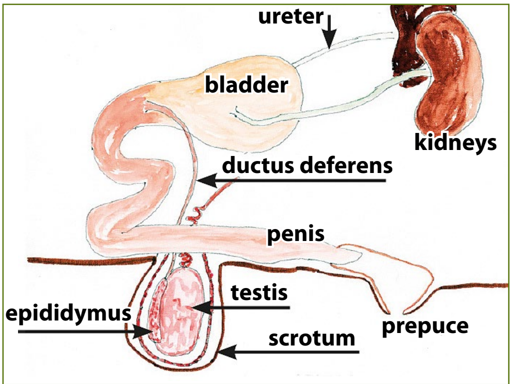


The structure of the kidney.

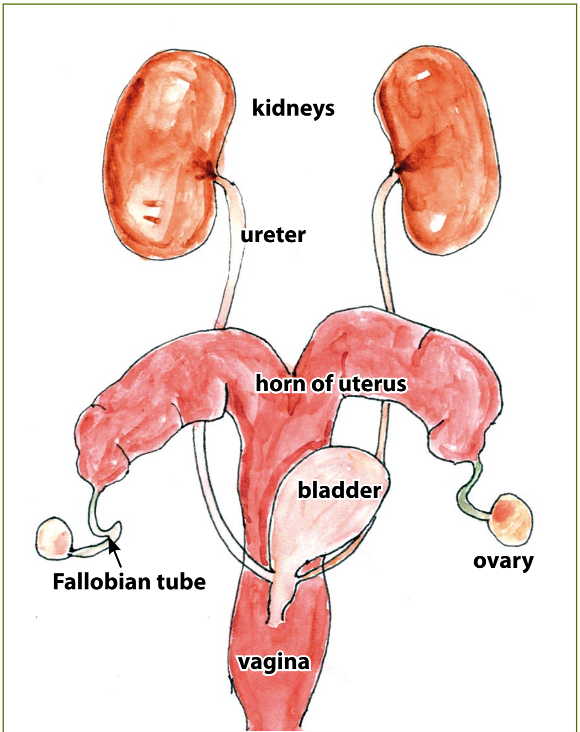
1.2.10 Sexual organs

Sexual organs are gender-specific organs, of which most are involved in reproduction. The male sexual organs comprise the penis, which introduces sperm to the female sexual organs. Some animals, such as canines and the bear, have a bony structure inside the penis, the so called penis bone. The testes located in the scrotum produce sperm that are stored in the epididymises. The vas deferens transports the sperm to the urethra. The prostate secretes fluid that nourishes the sperm.

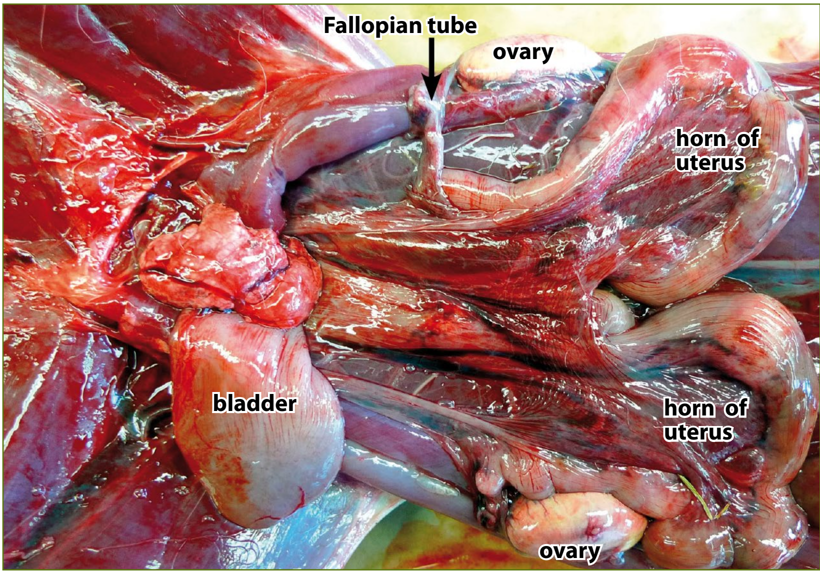
The female sexual organs include the labia, clitoris, vagina, uterus, Fallopian tube and ovaries.



Male sexual and urinary organs. The bear, like the canines, has a penis bone inside the penis.



Female sexual and urinary organs.



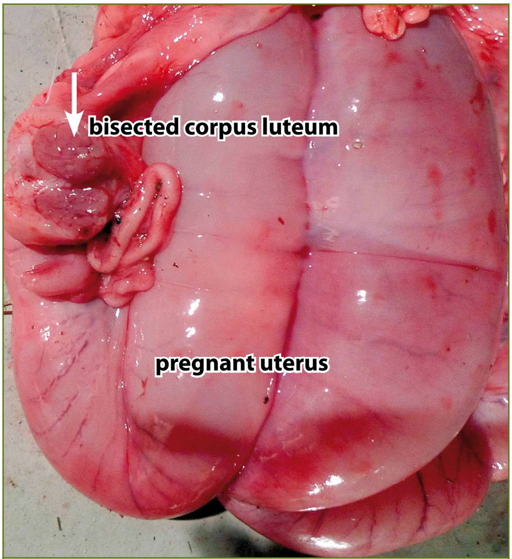
Both hare and moose have a bipartite uterus. Pictured here a pregnant hare's uterus. Urinary bladder, Fallopian tube (uterine tube), ovary, horn of uterus, ovary.

Reproduction

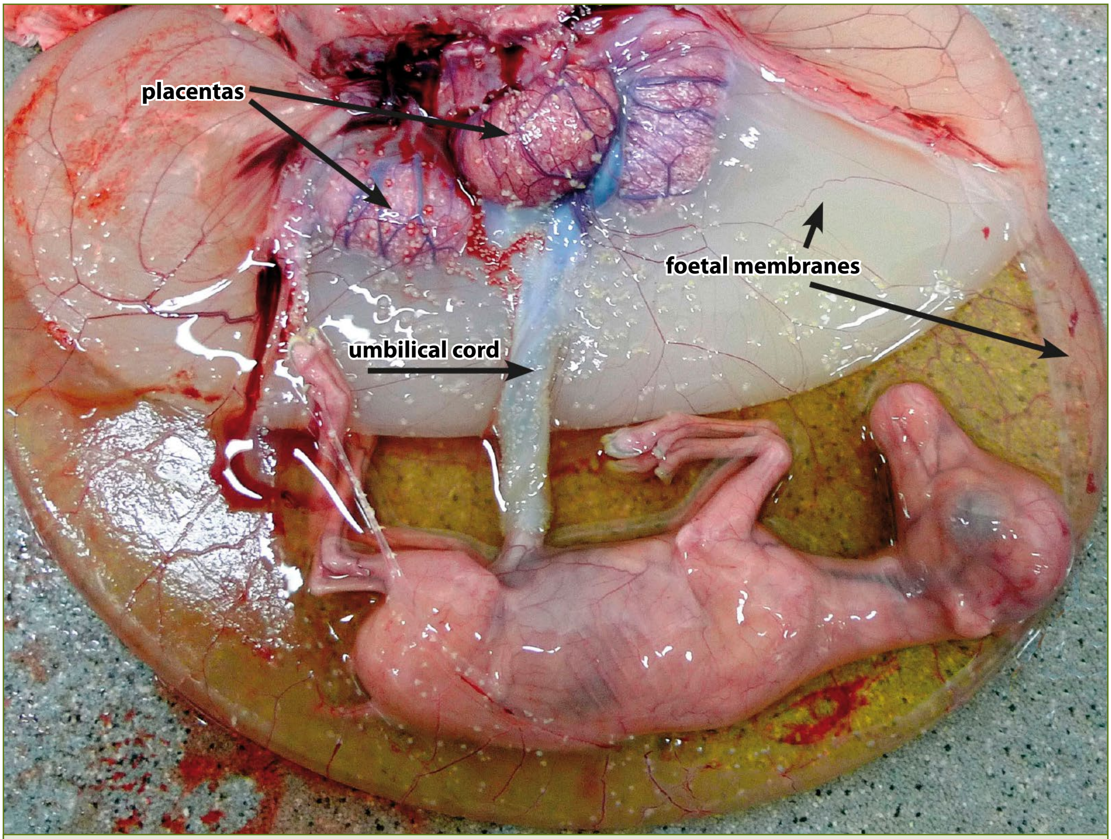
The reproduction of animals is tied to seasons. Calving takes place during the season when the chances of survival of the offspring are optimal, mostly in spring.

During the breeding season, the female ova develop fertile and copulation occurs. At other times, the ovaries that produce ova lie dormant.

When the male spermatozoon and the female ovum, both containing a single set of chromosomes, fuse, a zygote (fertilized egg) is formed. Half of the genetic material of the zygote comes from the male and the other half comes from the female. Some animal species, e.g. the bear and roe deer, have delayed implantation. After fertilization the egg remains in a state of suspended growth. After a certain period, the fertilized egg undergoes cell divisions and the development of the foetus begins.



Pregnant cervid uterus. A hormone secreted by corpus luteum maintains pregnancy.

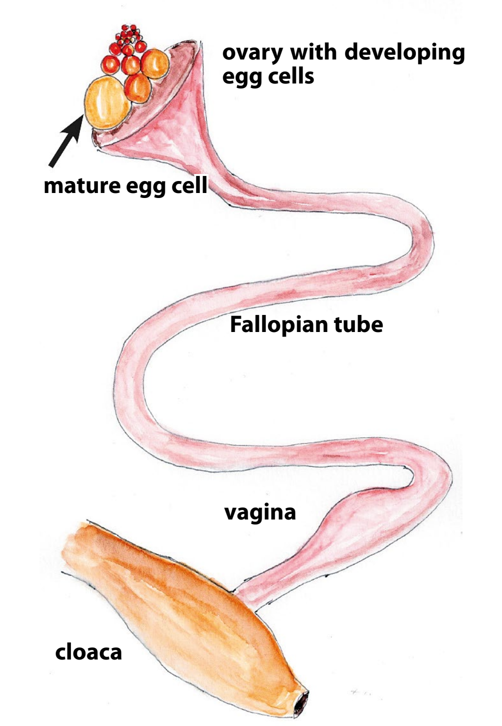


Approximately three-month-old cervid foetus.

The fertilized egg travels down the Fallopian tube to the uterus and implants on its wall. Foetal development begins with cell division.

After the ovum is released, a corpus luteum develops to its place. The hormone produced by it, progesterone, maintains pregnancy. A placenta develops between the embryo and the uterine wall. The embryo is protected by foetal membranes that contain amniotic fluid. The foetus is connected to the placenta by umbilical cord through which all foetal maintenance occurs, including nutrient and oxygen intake.

After the foetal development ends, the corpus luteum degenerates and the secretion of progesterone stops. This triggers birth.



Sexual organs of female bird.

Female birds have only one ovary, but male birds have two testes. During non-breeding season the avian sexual organs shrink considerably. The fertilized ovum travels to the long oviduct that works like a conveyor belt. The egg white, shell membranes (two), shell and finally colours are added to the egg at various parts of the oviduct.

The finished hard-shell egg travels via the vagina to the cloaca and is laid.

Inside the egg hatched by the mother, the yolk sac provides energy for the young to develop. After a few weeks the chick hatches by breaking the shell of the egg with its beak.

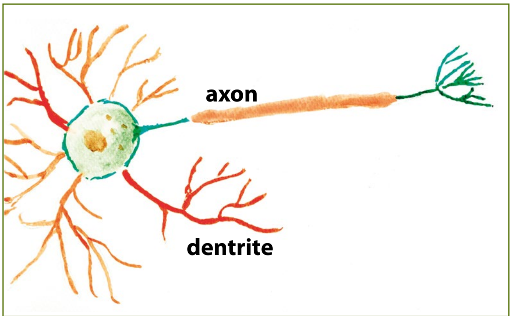
1.2.11 Nervous tissue and the nervous system

The nervous system is the central and fast regulation system of the body. Nervous tissue is made up of nerve cells, glial cells and connective tissue. Nerve cells do not undergo cell division after birth. Nerve cells possess a cell nucleus, several dendrites that conduct stimulation and a longitudinal structure, often several dozens of centimetres long, conveying electrical impulses to other cells (axon).

Nerve impulse is an electrical impulse conducted by the nerve cell membrane to muscles and glands. The nerve impulse is transmitted along axons to cells and target tissues. The nervous system is divided into the central nervous system (CNS) and the peripheral nervous system (PNS).

The CNS contains the brain and spinal cord.

The PNS includes the cranial and spinal nerves. The cranial nerves emerge directly from the brain. The spinal nerves emerge from the spine.

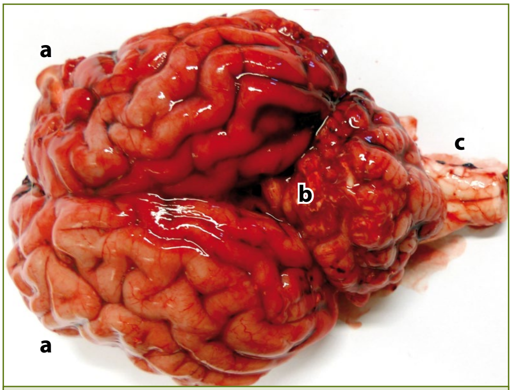


Nerve cell.

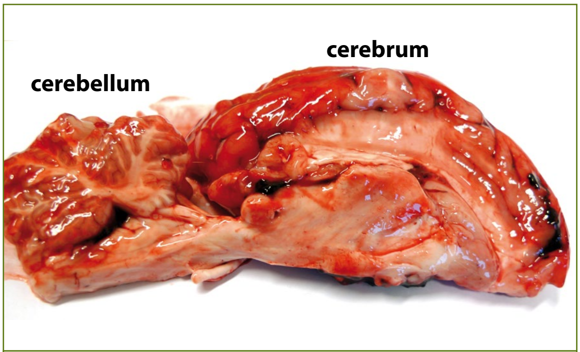
The cerebrum includes two cerebral hemispheres (frontal, parietal, occipital and temporal lobes). The brain receives and works information, and regulates behaviour and many vital functions. The cerebral cortex of the cerebrum is in charge of cognitive functions and sense perception as well as learning and memory.

The cerebellum coordinates muscle movements and maintains the equilibrium of the body.

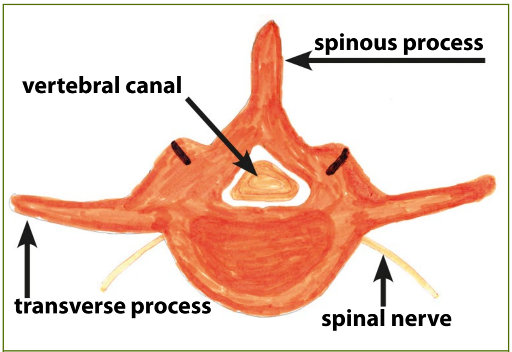
The spinal cord extends down the spine well protected by vertebrae. It transmits signals between the brain and the PNS. Spinal nerves branch out from the spinal cord.



Cerebral hemispheres (a), cerebellum (b) and medulla oblongata (c).



Longitudinal section of cerebrum and cerebellum.



Cross-section of vertebra and spinal cord.

The sensory nerve fibres of the PNS transmit information from sensory neurons to the CNS. Motor neurons carry signals from the CNS to the muscles. Cranial nerves such as the acoustic and optic nerves are also part of the PNS.

The PNS is divided into voluntary (somatic) and involuntary (autonomic) nervous system.

The somatic nervous system controls the movements of skeletal muscles.

The autonomic nervous system controls the functions of the cardiac and smooth muscles, and affects the secretion of glands. It controls heart rate, respiration, perspiration and the functioning of digestive organs. Autonomic nervous system is further divided into sympathetic (SNS) and parasympathetic (PSNS) nervous system. Activity of the SNS results in consumption of the energy reserves of the body, whereas the PSNS functions help the body to recover.


Sympathetic nervous system acts in situations of crisis, e.g. fight-or-flight situations.

The nervous system is the central and fast regulation system of the body.

Parasympathetic nervous system is active while the animal is sleeping, resting or digesting.

1.2.12 Endocrine glands

In addition to the nervous system, endocrine glands form the central regulation system of the body. The endocrine system connects the brain to organs via signal molecules called hormones. They regulate the metabolism, growth and development, and reproduction and state of mind.

Hormones are carried to their target tissues by blood. Therefore their effect is slower than that of the nervous system.

Endocrine glands (1 = the pineal gland produces melatonin, which regulates the circadian rhythm and reproductive cycle of the body; 2 = the pituitary gland (hypophysis) secretes hormones that regulate reproduction and growth; 3 = the thyroid secrets thyroxine, which regulates the growth and, in adults, the metabolism; 4 = the thymus produces thymosin, which is a hormone affecting the immune system; 5 = the pancreas produces metabolic hormones such as insulin and glucagon; 6 = the adrenal gland secretes stress hormones, noradrenaline and adrenaline, which affect the state of the metabolism, and hormones that have an effect on osmoregulation; 7 = the female ovary secretes sex hormones such as oestrogen and progesterone; 8 = the male testes secret sex hormones such as testosterone).

1.2.13 Exocrine glands

The excretion of the exocrine glands travels to the target tissues by way of ducts. Animals have only few sweat and sebaceous glands. Sweat glands exist mainly in the snout (muzzle) and tail, but they do not have much effect on the animal's thermoregulation. Their excretion provides protection against bacteria. Sebaceous glands are located in the legs and feet, in the snout and around the anus. The excreted sebum protects and softens the skin. Sebaceous glands are important in intra-species communication, i.e., they can be called scent glands.

The sebaceous glands of the hair follicle oil the hair and keep the fur shiny and waterproof.

For birds, especially water birds, the function of sebaceous glands is important: they make plumes and feathers waterproof and insulating. In the event of an oil spill, the structure of the sebum is broken, feathers and skin get wet and the bird quickly freezes.


Interdigital gland.


Mammary gland is the largest gland of the body.


Lacrimal gland.

1.2.14 Structure and function of the skin

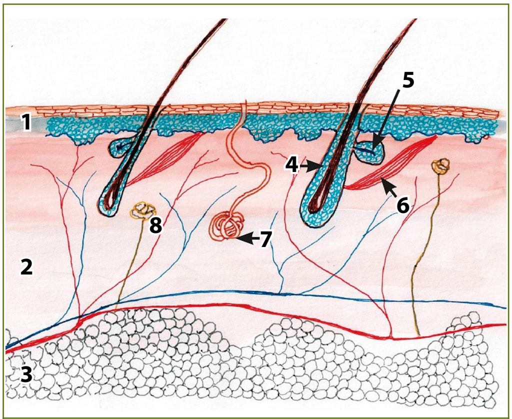
By structure, the skin is layered. The outermost layer is the epidermis and below it is the dermis. Below the dermis lies the hypodermis. In addition, skin has other organs such as sweat and sebaceous glands, nails and hairs.

Skin protects the body against chemicals, ultraviolet (UV) radiation and wear and tear. It takes part in evaporation control and thermoregulation. The skin provides protection against bacteria and other pathogens. Skin also transmits sensations (touch, pain, heat and cold).

Fur consists of guard and down hair. Hair grows from the epidermis, where the hair root and follicle as well as the arrector pili muscle are located. Guard hair are coarse and contain air compartments that ensure good insulation. Down hair are thin and curled and form an insulating under wool.

All hair of cervid calves are hollow and thin. They grow adult fur in autumn. Adult fur is renewed annually: moulting begins in spring and continues until August. The winter fur is thicker and contains more down hair.

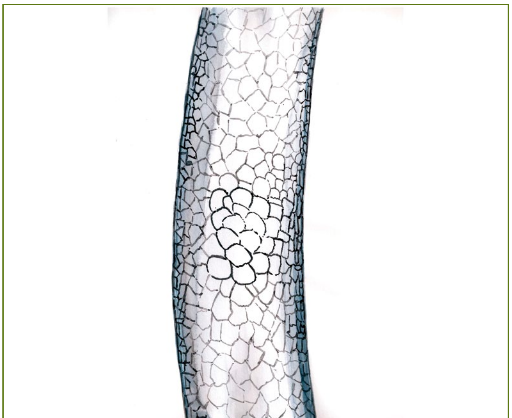
Between individuals, there is great variation in fur colour. The thickness of the fur also varies. The reindeer, adjusted in the arctic tundra, has roughly 1,700 guard hair and 6,000 down/under hair per each square centimetre. The elk has 200 guard hair and 750 down/under hair per square centimetre, but its large size compensates for cold stress.



Skin structure: epidermis (1), dermis (2), subcutaneous tissue (3), hair follicle (4), sebaceous gland (5), arrector pili muscle (i.e. erection of hair) (6), sweat gland (7) and sensory corpuscule (8).

Bird feather is a keratin formation equivalent to the reptile scale. Feathers insulate birds from water and cold temperatures. Their coloration is an important protective colouring or signal. Vaned flight feathers are


The frizzy down hair is located at the root of guard hair.


The insulating structure of a guard hair.

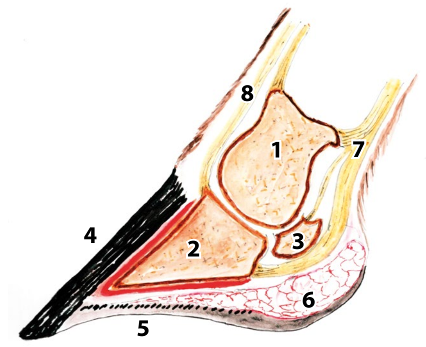

Cervids renew their fur every year (Photo: Arto Juntunen). Calf hair changes into adult hair in the autumn. Pictured here a wild forest reindeer doe with her fawn.


Winter fur is thicker than summer fur (Photo: Arto Juntunen).

sturdier than down feathers. The remiges (primaries and secondaries) and retrices are light, flexible and strong. The fine down of birds is the basis of their thermal insulation. Every year, birds replace their old, abraded feathers with new ones (moulting).

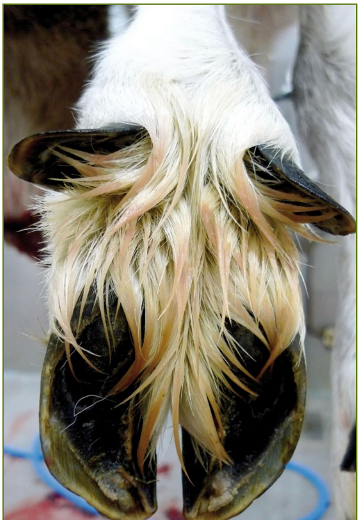
Hoofs consist of toes (claws) and accessory toes (dew claws). The hoofs are covered by keratin (nail). The keratin is attached, and with its lamellar structure protects the corium, which is rich in blood vessels and nerves. The hoofs are constantly worn down by use, and they grow continuously from the base, the coronary band.

Reindeer, Finnish forest reindeer and even moose are able to splay their claws and dew claws in order to reduce the surface pressure on snow. This helps the animals to survive in snow-covered regions. The white-tailed deer or red deer has not adapted to snowy conditions. Their hoofs are narrow and they cannot be splayed.

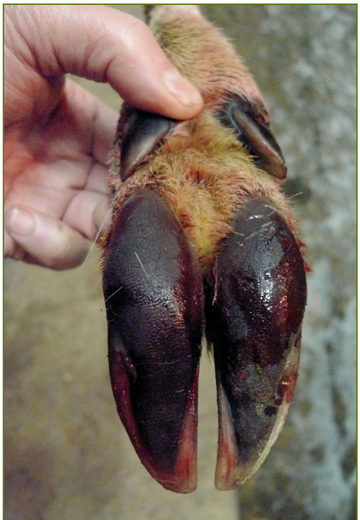


Moose's cloven hoof: digital bone (1), coffin bone (2), sesamoid (navicular) bone (3), hoof wall (4), sole (5), digital cushion (6), flexor tendon (7) and extensor tendon (8).

Moose's cloven hoof and dew claws form a good bearing surface in snowy conditions.



Finnish forest reindeer can splay its cloven hoofs and dew claws on deep snow.



The hoofs of white-tailed deer are small and cannot be splayed.

Finnish forest reindeer’s large hoofs and long legs are adaptations to thick (deep) snow (Photo: Petri Timonen).

Thermoregulation of animals

Animals have to adapt to circadian as well as seasonal changes in temperature and humidity. Depending on the region, these changes can be so pronounced that, in addition to behaviour of the animal, specialized anatomical structures or fundamental changes in metabolism are required.

Northern animal species have adapted to survive great seasonal changes in temperature. Cold, arctic winters require an insulating fur coat that grows even thicker in winter.

Fat stored under the skin functions as additional insulation and source of heating energy in winter. In some species, the layer of fat can be several centimetres thick.

Hibernators as well as other animal species slow their body functions in winter. During the critical spring months, the slower body functions save energy and ensure heat production for the central functions of the body.

The fur is thin in the lower parts of the extremities of even-hooved ungulates. When the weather is cold, animals can constrict the blood vessels carrying blood to the extremities, and let their feet cool. This decreases heat loss. The animal is able to let its extremities, mainly composed of membranes and tendons, to cool down until the temperature difference between the still functional extremities and the core of the body is as much as 30 °C. Cool venous blood returning from the limbs is also warmed by conduction from the warm blood flowing in the arteries next to them.

Svalbard reindeer (*Rangifer tarandus platyrhynchus*) prepare for winter by collecting a layer of fat under the skin. The layer can be as thick as eight centimetres.

In hot weather, bears as well as moose find their way to cooling waters.

Birds can warm their feet by pulling them up into their feathers and by fluffing their feathers. Northern wildfowl handle the freezing conditions by burrowing into the snow.

Hot weather conditions can be an even harder strain on arctic animals than the cold. Animals have only few sweat glands, and therefore they do not hold a significant role in thermoregulation.

Body temperature raised from physical activity is reduced by panting. The wide surface of nasal turbinates is important in evaporative cooling. Heat is conducted to air also from the thin-haired legs and growing velvet antlers. Many mammals and birds cool off by finding their way to wetlands and water.

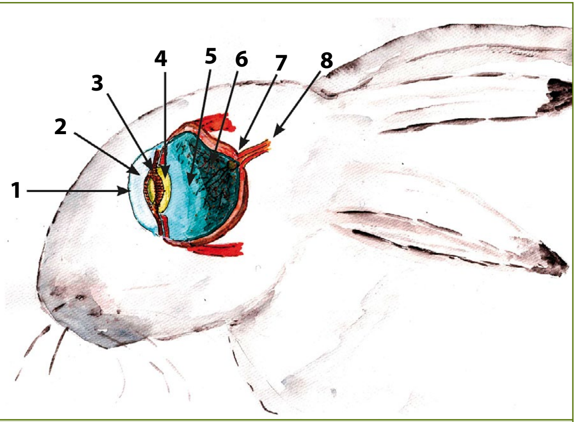
1.2.15 Senses

Senses provide information from the environment and the state of the body. Senses are divided into physical and chemical senses. The physical senses comprise sight, hearing, touch and the detection of heat and cold. Taste and smell are chemical senses.

1.2.15.1 Sight

In mammal game animals, vision is not very well developed. It is common that for them, moving targets are more easily distinguishable. For birds, sight and hearing are the most important senses. The eye is protected by eyelids, tear ducts and conjunctiva.

Visual perception occurs when light is focused by a lens to the photoreceptor cells of the retina, rods and cones. Sensory cells transmit the stimuli via the optical nerve to the brain where an image is formed.



The structure of the eye: cornea (1), anterior chamber (2), iris (3), lens (4), vitreous body (5), retina (6), sclera (7) and optical nerve (8). Tapetum lucidum is a layer located behind the retina. It causes a green or blue reflection in cervids and canines, and contributes to night vision.

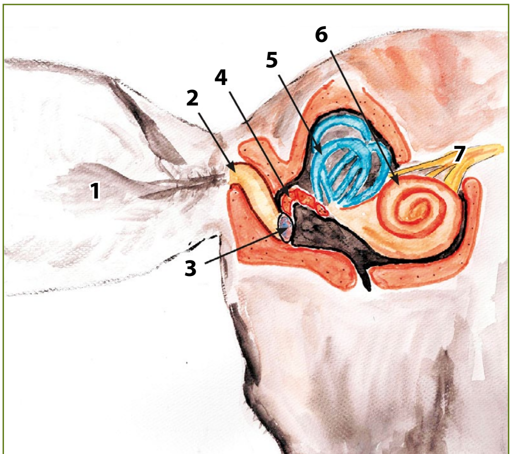
Birds have excellent vision and good hearing.

1.2.15.2 Hearing

The ear is the organ that receives sound and aids in balance. Game animals as well as birds have good hearing. The external ear comprises the auricle, which collects sound waves and conducts them to the flexible tympanic membrane, which is made to vibrate by the sound waves. The tympanic membrane transmits the vibrations to the auditory ossicles in the middle ear. Auditory ossicles amplify and conduct the vibration to the cochlea in the inner ear.

The cochlea is filled with fluid. The sensory cells inside it are irritated by the vibration and send impulses via the auditory nerve to the brain, where they are interpreted as sounds.

The vestibular organ and kinesthetic sense of the head are bound in the inner ear. The fluid-filled semicircular canals react to head movements like a spirit level and function as organs of balance.



The structure of the ear: external ear (1), external auditory canal (2), tympanic membrane (3), auditory ossicles (4), vestibular organ (5), cochlea (6) and acoustic nerve (7).

1.2.15.3 Smell

Smell is the most important sense of many mammal species. Their nostrils are large. The nasal cavity is long and divided by a cartilage septum. Wide-ranging olfactory epithelium is located on the surface of the nasal conchas. The nasal conchas made of cartilage increase manifold the surface area of the olfactory epithelium. The olfactory epithelium responds to the odour molecules in the air and transmits an impulse to the brain. In game animals, the olfactory bulb of the brain is well developed.


Wide-ranging olfactory epithelium is located on the surface of the nasal conchas in the long nasal cavity.

The snout (rhinarium) is a hairless, moist area around the nostrils. It is part of the mammal sense of smell. The moose rhinarium is a small, triangular area between the nostrils.

The tongue has an abundance of taste buds (Photo: Linda Laaksonen).

The snout is a hairless and moist area around the nostrils of mammals. It is part of the olfactory system.

1.2.15.4 Other senses

The primary function of taste in game animals is to monitor the quality of food. The tongue is especially rich with taste buds.

Receptors of touch and temperature are located in the skin. They are nerve endings, tactile hairs and sensory corpuscles.

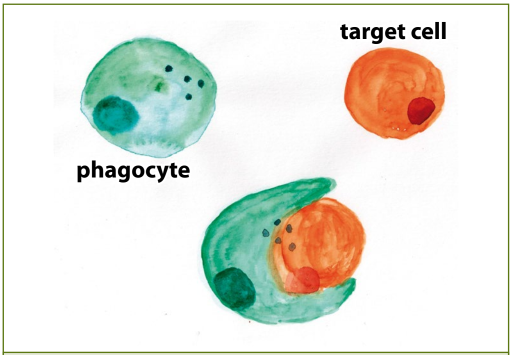
Stretch receptors are located in internal organs and sense, e.g. the fullness of the intestines.

1.2.16 Immunity

Immunity refers to the ability of the body to shield against pathogens. Immunity can be divided into natural and acquired tolerance.

Natural (non-specific) immunity prevents pathogens from entering the body or spreading inside the body. This does not involve learning. These are, e.g. healthy skin and its natural acidity (low pH) which mechanically and chemically stop pathogens from entering the body. Bacteria trying to attach on the skin or to colonize the surfaces of the digestive tract have to compete with the established resident 'natural' flora ('house flora'). Mucus production in the mucous membranes of the respiratory tract and sexual organs prevents the multiplication of microbes. The cilia of the pulmonary airways remove impurities.

The feathers are part of natural resistance. They can be damaged in oil spill accidents, for instance.



Phagocytes chase pathogens in the bloodstream and tissues and destroy them by 'eating' them.

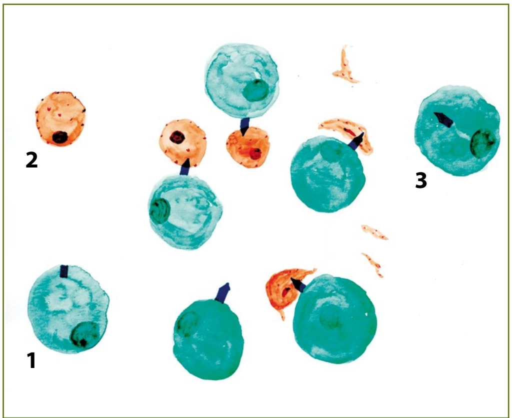
The microbes that are swallowed in the food are attacked by acids in the stomach and digestive enzymes in the intestines. This destroys most microbes. In ruminants, the microbes of the rumen destroy foreign microbes. The flow of urine, secretion of tears, and coughing and sneezing remove microbes and impurities. The secretions of the body often contain components that destroy bacteria.

White blood cells called phagocytes (monocytes and granulocytes) are also part of the natural immunity. They are able to 'eat' pathogens that try to enter the body. They are common in the bloodstream, but they can also follow pathogens to tissues via blood capillaries. In addition, blood and tissues have specific proteins that are able to destroy foreign microbes. These are referred to as the complement system.

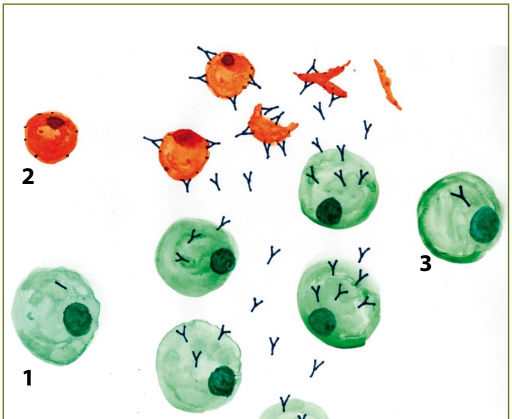
Acquired immunity is based on T and B lymphocytes that have specific sensors against microbes. When a B or T cell is faced with a microbe they recognize, rapid cell division occurs. Recognition is not based on the microbe as a whole, but on certain (surface) structures, so called 'antigen'.

B cells produce soluble antibodies (immunoglobulins) to the bloodstream. Their function is called humoral immune response.

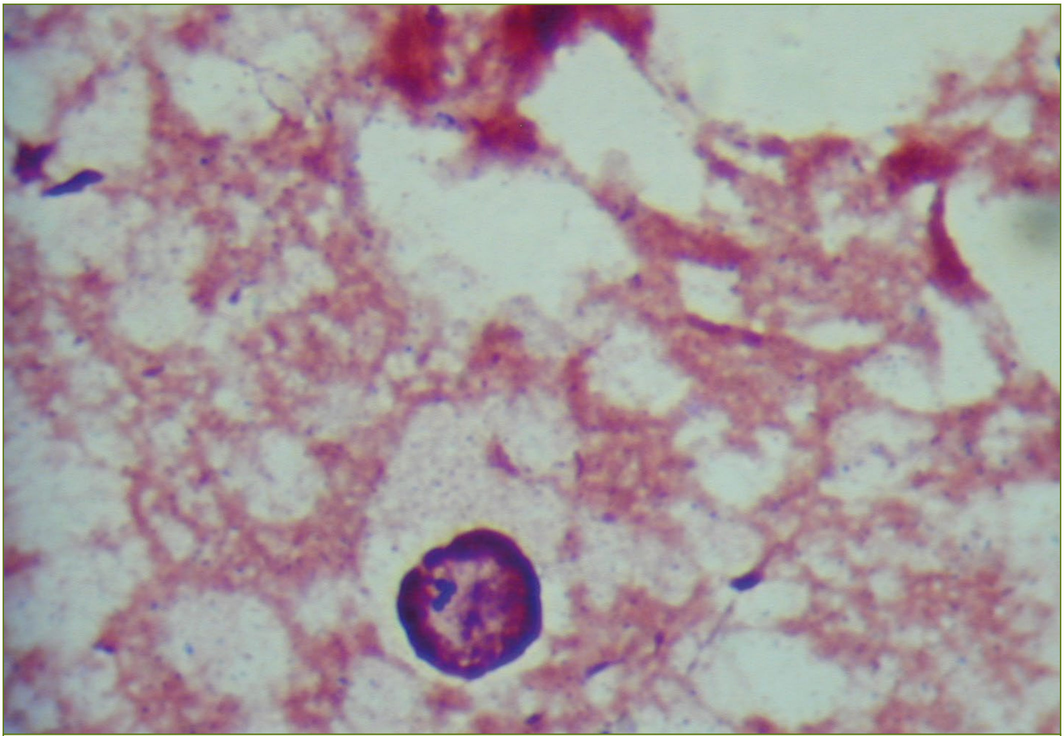
Killer T cells destroy pathogens in the body mechanically. Their function is called cell-mediated immunity. An encounter with a pathogen creates so called memory cells, which make the onset of rapid immune response possible, if the microbe in question is again found trying to enter the body. This mechanism



T cell (1) destroys the pathogen or diseased cell (2). What remains is a memory cell (3), which gives a fast response if a 'known' pathogen tries to enter the body again.



B cell (1) identifies the pathogen (2) and starts to produce antibodies that destroy the pathogen. A fast response memory cell remains (3).



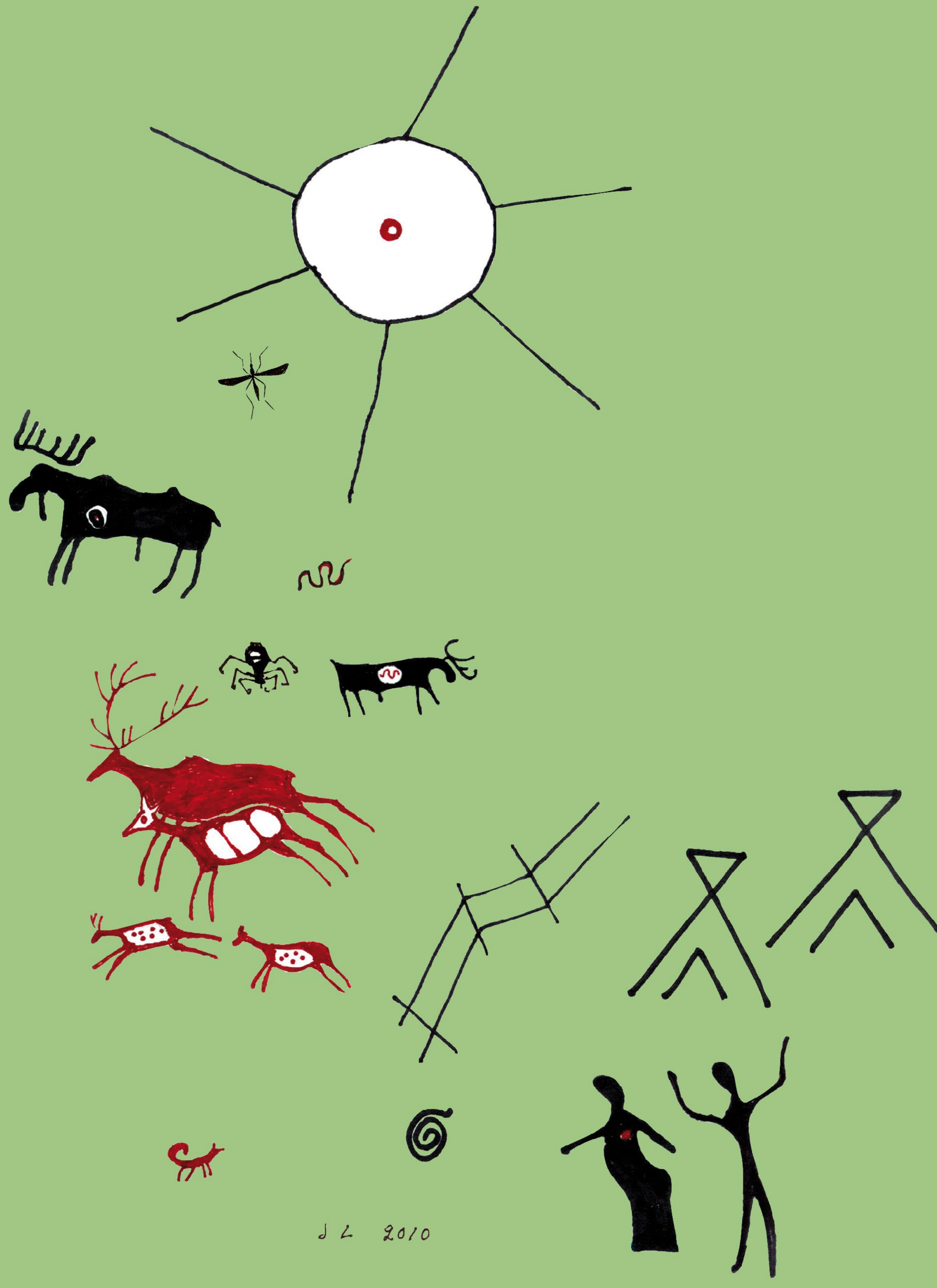
Microscopic picture of the exudate in an inflammated joint (Photo: Peter Paulsen). Small violet particles are bacteria, and the larger round violet object is a granulocyte, i.e. a white blood cell active in combatting the bacteria.

is what vaccination is based on: either killed or weakened pathogens or parts thereof are administered to the body.

The formation and finding of antigens in the body is utilized in the diagnosing of diseases and charting their distribution. This is important when the spreading of dangerous and controlled diseases is monitored.

Sometimes the body's immune response can be too strong. Then the tissues or organs of the body are damaged. In autoimmune diseases, the immune system attacks the cells of the body and damages them. The responses can be harmful to the organism. This occurs, e.g. in situations of allergic or hypersensitivity reactions.

Allergy is a disorder of the body, which occurs when the humoral immune system reacts to harmless substances of the environment. These substances are called allergens. Hypersensitivity is a condition when many parts of the immune system produce harmful reactions to substances of the environment.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2. Diseases of game animals

Diseases and parasites are part of the healthy ecosystem of wild animals. There is usually no need for man to intervene in the cycle of their lives. Nature follows its own system of disease treatment and health care. A 'healthy' animal is usually not one free from pathogenic bacterial, viral and parasitic agents, but one in which the presence of the agents does not cause changes in behaviour or major alterations in organs. This means that bacteria or viruses can be 'arrested' in lymphatic structures or thrive in ecological niches, e.g. a certain section of the intestines ('symptomless carriers'), and be released due to a weakening of defence mechanisms during stress, wounding or death. Also, handling of the carcass and organs of hunted game can cause the spread of pathogenic agents.

Nature and ecosystems are under increasingly more stress, often caused by man. Climate change and the changes it causes in the natural environment of game animals, agriculture and forestry, the fragmentation and chemicalization of the environment, overly dense populations, contacts with production animals, and even game animal feeding can be factors that bring strain on animals. Additional continuous stress, strong infection pressure, or weakened resistance caused by chemicals can set the scene for pathogens to conquer the defence mechanisms of the body and cause disease outbreak.

The pathogenic agents may have a very simple life cycle, or may require different hosts for completing certain phases of their life cycle. Hosts may be bound to certain habitat qualities (e.g. snails for the parasitic liver flukes). Sometimes such complicated cycles prevent pathogens from spreading to different regions. Changes in climate, increase of traffic and of rapid transboundary/intercontinental movements of goods ultimately facilitate regional spread of pathogens. Sometimes it is just careless behaviour of people.

Several new animal pathogens spreading in Europe are transmitted by blood-sucking insects. It is presumed that the changing climate assists in the spreading of these diseases. Animals know no boundaries between countries. Migrating and roaming animals can carry pathogens over long distances, in case of migratory birds even for thousands of kilometres. Many of these animal diseases are transmissible to people or production animals, and some of them have an effect on the hygienic quality of foodstuffs obtained from game animals.

One dangerous group is formed by easily transmissible, often viral animal diseases. New pathogens can be fatal in areas where animals have not come in previous contact with them, and therefore have low resistance against them.

New diseases can be harmful to ecosystems, their diversity, and to entire wild animal populations. New pathogens can also have a major economic impact. For instance, they can pose a threat to many northern indigenous peoples, whose livelihood is greatly dependent on the nature and wild animals.

Diseases whose causative agents can be transmitted from animals to humans are called zoonoses. Zoonoses are caused by viruses, bacteria, parasites and fungi. It has been estimated that 60% of human pathogens are zoonotic, and that 75% of new diseases appearing in the human population originate from animals. Not all pathogens are zoonotic, but some may either be easily transmissible among animals, and/or cause severe symptoms or may be transmitted from wild animals to farm animals and vice versa.

Due to this, systematic follow-up of animal health and early detection of pathogens found in them is important. Attentive hunters are in key position in this work.

Sauli Laaksonen and Peter Paulsen, **Hunting hygiene**
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The detection and control of zoonoses as well as diseases transmissible between farmed and wild animals are cornerstones to ensure not only safe food, but also to assure 'food security', i.e. the provision of adequate amounts of food. At global level, the OIE (World Organization of Animal Health; www.oie.int) defines which diseases must be monitored and provides records and reports of disease outbreaks. At national level, legislation has to address detection, management and reporting of the diseases. In order to control diseases, each stakeholder has to know about his duties.

Very often, different pathogenic agents can cause similar symptoms. With exception of some parasites, the detection of the agent or of a specific immune response to the agents requires laboratory techniques.

As regards to hunters, this means that hunters must:

- be able to detect abnormities in the behaviour of the animal, and on carcass and inner organs;
- follow hygiene rules during evisceration and handling of game in order to prevent or minimize risk of infection by zoonotic agents or transmission of agents;
- know the main symptoms of communicable animal diseases (laid down in national legislation), in order to be able to inform authorities in case of suspect.

If you shoot or meet a diseased animal:

- use disposable protective gloves;
- use a protective mask;
- do not cut or slice altered organs or tissues;
- wash your hands and clothes with hot cleaning solution and, when necessary, disinfect them;
- do not give the meat or organs of an infected animal to dogs or other animals;
- if there are several dead or infected animals, always contact the authorities responsible for game animal health.

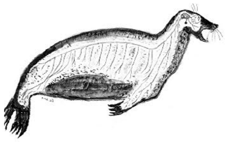
Be cautious and use protective clothes when handling animals which are apparently very sick or found dead (Photo: Jasna Prodanov-Radulovic and Radoslav Dosen).

How to interpret the symbols in Chapter 2:

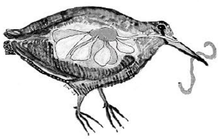
Virus, bacterium or parasite can be present or cause disease in cervids.

Virus, bacterium or parasite can be present or cause disease in bears.

Virus, bacterium or parasite can be present or cause disease in wild boars.



Virus, bacterium or parasite can be present or cause disease in seals.



Virus, bacterium or parasite can be present or cause disease in birds.

Virus, bacterium or parasite can be present or cause disease in hares.

Virus, bacterium or parasite can be present or cause disease in humans.

Virus, bacterium or parasite is a dangerous zoonosis.

Virus, bacterium or parasite can be present or cause disease in canines.

2.1 Diseases caused by viruses

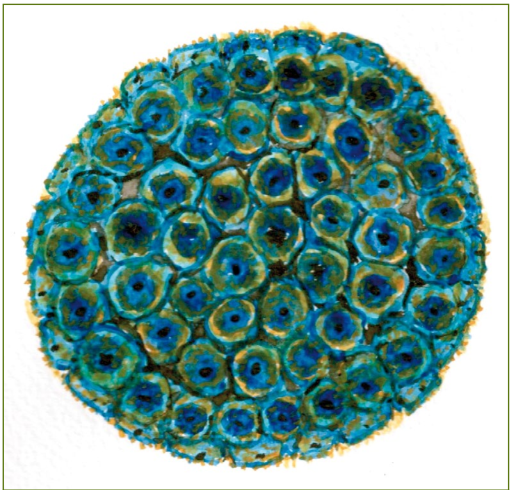
Viruses are smaller than bacteria, and they can only be seen by an electron microscope. Viruses do not have a cell structure or metabolism of their own. Inside them is either a DNA or an RNA filament, which contains genetic information.

In order to multiply, viruses require a host cell. When a virus detects its host cell, it penetrates to it. The genome of the virus begins to regulate the metabolism of the cell, and the cell begins to produce copies of the virus. When the cell dies, viruses are released and proceed to penetrate new cells.

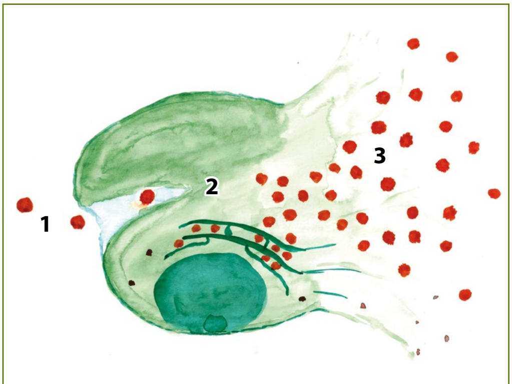
Viral diseases are caused by tissue destruction, breakdown of target tissues, and released virus and cell toxins. In context of virus infections, secondary bacterial infections are common. Together, these factors can cause a vasomotoric shock, which is often lethal in wild animals.

Viruses are often host-specific. Animals, plants, fungi and bacteria have their own viruses. Not all viruses are hazardous. The mammal body, e.g. in the mucus of the intestines, hosts viruses that take part in the defence system of the organism. These viruses are called phages, and they specialize in destroying pathogenic bacteria trying to enter the body. Some viruses, such as influenza viruses, have a good ability to transform via mutations that occur in the virus genome. Therefore, it is difficult to vaccinate against them. Viruses cause most of the easily transmitted domestic animal diseases that are officially controlled. They are spread via smuggled meat or animals, unheated processed meat products, and untreated animal skins.

Several hazardous viruses use blood-sucking insects as vectors of transmission, and many diseases caused by them can appear first in wild animals. Some of these diseases can have a significant effect on our game animal populations as well as on our livestock economy. Therefore, follow-up and early detection of them is especially important. The follow-up and diagnosis of virus diseases in wild animals is based on antibody monitoring, e.g. from blood samples, or demonstration of the virus in tissues or excretions.



Viruses do not have a cell structure or metabolism of their own.



Virus enters the target cell (1). The genome of the virus starts to regulate the cell metabolism, and the cell begins to produce copies of the virus (2). When the cell dies, viruses are released (3) and start penetrating new cells.

2.1.1 Foot and mouth disease (FMD)

Agent: Aphthovirus.

Prevalence: Foot and mouth disease (FMD) is an acute and perhaps the most contagious and globally significant infectious disease of cloven-hoofed animals. FMD is also globally present in wild cloven-hoofed animals, which often are carriers and transmitters of the disease to production animals. FMD is transmissible to wild boars and cervids such as the reindeer. At the time of writing, the last outbreak of FMD in the European Union was reported in 2011 (wild boar in Bulgaria).

Transmission: The viral infection can be transmitted directly from one animal to another, or indirectly, e.g. through clothing or contaminated feed or farming equipment. The virus is also transmitted in aerosol form, as small droplets carried by wind, and it keeps well in the environment. Foot and mouth disease can easily spread from one country to another through meat, pelts, foodstuffs or carrier animals.

Symptoms: Fever, lack of appetite, excessive drooling and limping. High mortality rate is also linked to the disease.

Findings: Signs of general inflammation. Blisters and lesions inside the mouth, on the muzzle and on the limbs.

Control: The disease is an officially controlled animal disease. Foot and mouth disease can spread through animals or uncooked foodstuffs of animal origin, and through hunting trophies such as pelts. Biosecurity and following the import regulations of animals, foodstuffs and products of animal origin is especially important when areas are visited where food and mouth disease is prevalent.

Many African, Middle Eastern, Asian and South American wild ruminants are foot and mouth disease virus carriers and infect production animals (Photo: Susanna Pesonen). The disease is endemic in these regions.

Risk of human infection and protective measures: Food and mouth disease is not contagious for humans.

Is it safe to eat the meat? The meat of a diseased animal must not be eaten or given to animals. Authorized officials will dispose of diseased animal carcasses.

Keep in mind: Similar changes occur in other easily spreading diseases, also found in game animals:

- Cattle plague (Rinderpest, RP), almost eradicated by vaccinations;
- Malignant catarrhal fever (MCF);
- Pox and other viral agents causing the formation of vesicles or papules in the mouth.

The early symptoms of a mouth disease caused by cervid pox viruses can resemble the symptoms of foot and mouth disease.

2.1.2 Bluetongue (BT)

Agent: Orbivirus.

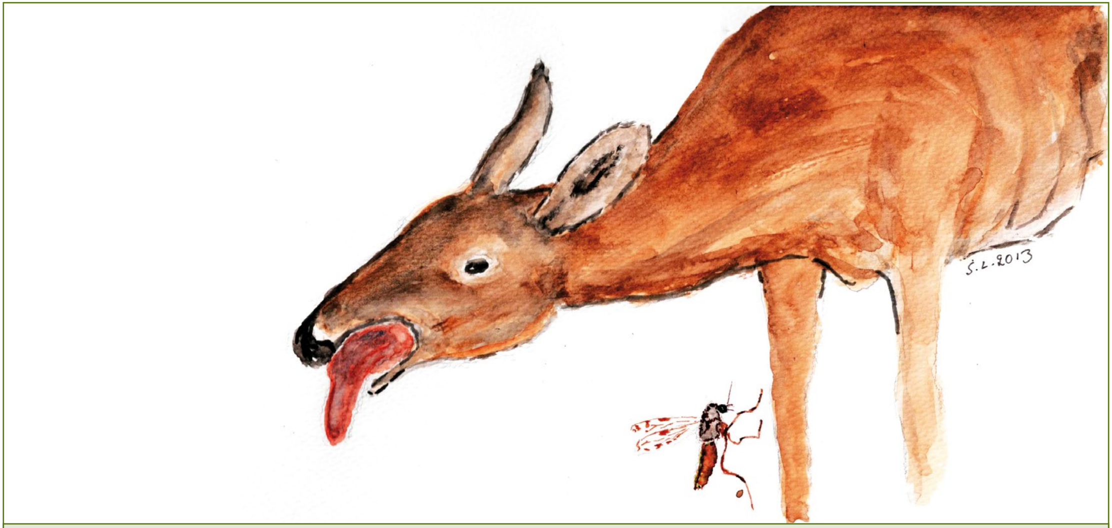
Prevalence: Bluetongue (BT) is a midge-borne disease found both in wild animals and in ruminant production animals and camels. The disease originated in Africa, from where it has spread to the north. Bluetongue is prevalent in various regions of Europe, also in Scandinavia.

Transmission: The bluetongue virus is transmitted from one diseased animal to another by blood-sucking midges (*Culicoides*), so transmission is possible in the north only during the warm seasons. Direct animal-to-animal infection is possible through sperm, or to new-borns through milk. Asymptomatic cattle that carry the virus are important in maintaining the infection. It is possible that wild even-toed ungulates, such as white-tailed deer, can carry and spread the disease.

Symptoms: Typical symptoms are difficulty in breathing and a cyanotic tongue caused by lack of oxygen. Diseased animals suffer from ocular and nasal discharge, drooling and ulceration of the mouth. Redness of the coronary band, lameness and unwillingness to stand up are also common symptoms. In wild cervids, the clinical picture fluctuates from high mortality to asymptomatic carrier animals.

Findings: General inflammation, swelling of the neck and/or head especially around the eyes and muzzle. Subcutaneous bleeding and bleeding into the skin are typical.

Control: Bluetongue disease is a communicable animal disease. Preventive measures include restriction of importation of animals and semen, and pre-entry testing of imported animals. It is also possible to control the disease by vaccinations. As the agent can be also carried by wild ruminants, it is important to monitor the disease both in wild animals and in livestock.



Bluetongue disease is transmitted by midges. The disease got its name from the bluish tongue resulting from laboured breathing.

West Nile disease is transmitted by mosquitoes.

The mosquito-borne West Nile virus can be contagious for animals and humans.

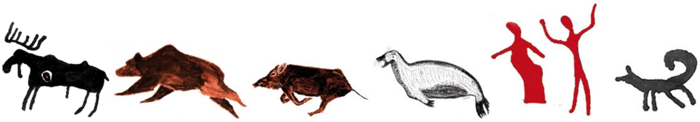
Risk of human infection and protective measures: Bluetongue disease is not contagious for humans.

Is it safe to eat the meat? The meat of a diseased animal must not be eaten or given to animals. Authorized officials will dispose of diseased animal carcasses.

Keep in mind:

- Epizootic haemorrhagic disease (EHD) is closely related to bluetongue disease and their symptoms are similar. EHD has been the cause of deer deaths in the USA since the 20th century. The white-tailed deer is sensitive to the disease, and mortality rate can be 50%. EHD can also cause disease in cattle but is rarely fatal.
- The mosquito-borne West Nile virus (WNV) is prevalent in tropical and temperate regions, North America included. The disease is spreading to the north. The disease mainly infects birds, but it is also contagious for humans, horses, dogs and cats. Lethal outbreaks have been reported in cervids, especially in white-tailed deer. Reindeer and Finnish forest reindeer are also regarded as susceptible to the disease.

2.1.3 Rabies



Agent: neurotropic lyssavirus.

Prevalence: Rabies is an acute and feared virus disease affecting almost all mammals, humans included. The disease is prevalent worldwide. Rabies causes death to tens of thousands of people every year.

Transmission: Transmitted through the saliva of infected animals, e.g. by bites or through handling of infected animals. Airborne transmission is also possible through the respiratory system, e.g. in bat caves.

Symptoms: Presented in an aggressive, provocative form, when the infected animal is restless, moves aimlessly and tries to bite everything around it. However, more common is the silent form of the disease, when the animal is ill and exceptionally tame. At the same time it presents drinking difficulty, weakness of back limbs, drooling and foaming of the mouth, and partial paralysis of the tail. Infected even-toed ungulates often bellow and paw the ground. Once the symptoms begin to show, the disease is always fatal.

Findings: Diagnosis can be done by a microscopic analysis of a dead animal's brain and by demonstrating the virus.

Rabies is contagious for almost all mammals, humans included. The symptoms in ruminants are drooling, bellowing and pawing the ground.

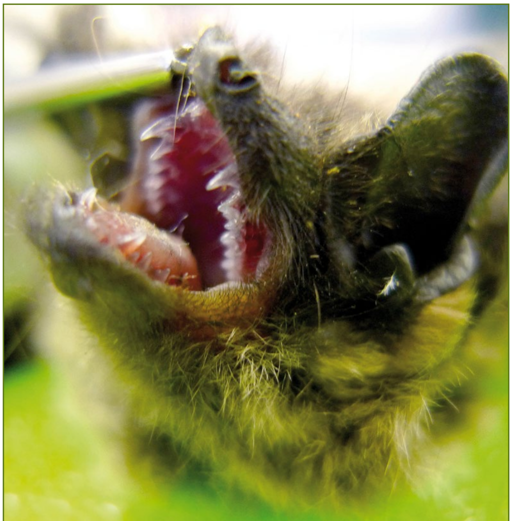
Control: Rabies is a statutorily controlled, dangerous animal disease. Suspected cases of rabies must be reported. Dogs used in hunting must be vaccinated against rabies at regular intervals. Wide-ranging bait vaccinations of wild animals are carried out in some regions in Europe. Continuous monitoring of diseases of small predators is important.

Always report suspected rabies to the municipal veterinary surgeon.

Risk of human infection and protective measures: Rabies is a dangerous zoonosis which causes more than 55,000 human fatalities annually. Protection is especially important when handling dead animals, particularly small predators. The disease can be transmitted by a lick or bite from an infected animal, or the exposure of a person's skin, eyes, nose or ulcers to the saliva of an infected animal. In case of rabies suspicion, always maintain caution. Do not approach an animal suspected of rabies. Do not touch diseased bats or dead animals without protection. If you are travelling abroad, beware of stray dogs even if they seem friendly. People working in risky professions or areas can be protected against the disease by vaccinations.

Is it safe to eat the meat? The meat of an infected animal must not be eaten. The animals are disposed of by the authorities.

Keep in mind: If you have to shoot an animal suspected of having rabies, do not shoot to the head as the diagnosis can only be done from the brain.



Do not touch diseased or dead bats.

Hunting dogs must be regularly vaccinated against rabies.

2.1.4 Chronic wasting disease (CWD)

Agent: Chronic wasting disease (CWD) is not caused by a virus or bacterium but by a misfolded protein molecule ('prion'), which can endure external conditions extremely well. The disease is part of the same group as the bovine spongiform encephalopathy disease.

Prevalence: Chronic wasting disease is one of the TSE group diseases (transmissible spongiform encephalopathy), which are dangerous to humans and animals. The disease has spread among North American cervids since the 1970s. It is prevalent in both farmed and wild cervids. The white-tailed deer is regarded as especially susceptible to the disease. CWD has to date not been diagnosed in animals in the European Union.

Wasting and central nervous system symptoms are typical in chronic wasting disease.

Transmission: The origin and mode of transmission of the CWD prion is unclear. It can be transmitted from mother to calf, or indirectly from pastures and food contaminated by the excretions of infected animals. It seems that feeding grounds contribute to the transmission of the disease.

Symptoms: CWD progresses slowly. Diseased animals lose weight, show behavioural changes, symptoms of a damaged central nervous system and weakened vital functions. The disease is fatal.

Findings: Causes sponge-like degeneration of the brain and wasting of the infected animals. The prion is demonstrated by laboratory tests.

Control: CWD is one of the diseases in TSE group that prevail in animals and humans. The disease is controlled by transfer restrictions issued for infected areas, eradication or thinning of infected populations, compulsory meat inspections, wide-ranging collection of samples by hunters, and follow-up studies. Ending artificial feeding of game reduces gathering/crowding of game and thus, reduces likelihood of transmission of this – and various other – pathogens.

Risk of human infection and protective measures:
- There is no indication on possible transmission of CWD to humans.
- In the regions of North America, where the disease is endemic, animals are tested for the CWD prion before their meat is used for consumption. In addition, authorities have issued detailed instructions of protection for handling cervid game before test results are available, and of the procedure regarding dead or infected cervids.

Is it safe to eat the meat? The meat of an infected animal must not be eaten. Infected carcasses are disposed of in disposal facilities.

Keep in mind:

- Never offer meat-rich material, such as leftovers, at cervid feeding grounds.
- In Sweden, an undefined moose wasting disease called Alvsborg disease has claimed the lives of some 1,500 moose since 1985. The symptoms of the disease include diarrhoea and wasting, and there are several theories on the origin of the disease. The theories of origin vary from a multifactorial mechanism related to overly dense populations to an oversupply of molybdenum (Mo) and relative lack of copper (Cu) in nutrition. Various viruses are also suspected of being the cause of the disease.

Warts are most commonly presented in young moose. Along with the development of antibodies, warts normally disappear on their own.

Plentiful presentation of warts in adults is a sign of weakened immunity. Secondary, generalized bacterial infections may render the meat unfit to eat.

2.1.5 Fibropapillomatosis

Agent: Papilloma viruses, but also other possible causes.

Prevalence:

- Warts are viral diseases of the skin or mucous membrane. They are benign tumours that can originate in connective tissue. Warts are found in almost all vertebrates, humans, fish, reptiles, birds and mammals. The causative agents are quite species-specific. In wild animals, they are most common in cervids, especially in young under 2-year-old moose.
- Along with age, the animal gradually develops antibodies against the wart virus, and in most cases, warts disappear by themselves in about a year from their appearance.

Transmission: Wart viruses are transmitted by direct contact between animals, or possibly by insects.

Symptoms: No typical symptoms, generally warts do not trouble the animal. Profuse number of warts and secondary bacterial infections may weaken the animal and inflict alterations in its general condition.

Findings:

- Warts appear in the skin of cervids as firm, cauliflower-like growths of 1-15 cm in diameter that contain plenty of connective tissue. The surface can be smooth or coarse. Warts can be attached to the skin tightly or by a thin stem.

- Warts are presented as single protuberances or sometimes clusters, mainly located in the head and upper extremities, but also elsewhere in the body. Sometimes there can be bleeding and bacterial infections.

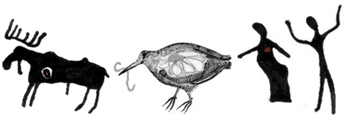
Control: No control measures are required.

Risk of human infection and protective measures: Animal wart viruses are not contagious for humans.

Is it safe to eat the meat? The alterations reside in the skin. The altered parts are removed. The meat is safe to eat, if the muscles or internal organs show no signs of a generalized infection.

Fibroma (papilloma) in red deer. Changes are usually only in skin and the underlying tissue is undamaged (Photos: Peter Paulsen).

2.1.6 Pox



Agent: Pox, parapox and herpes viruses, some of them are common in production animals, especially sheep.

Prevalence: Poxes are a group of viral diseases that cause alterations in the head, mouth and mucous membrane area. The disease is common in reindeer, and outbreaks occur almost annually. The viruses can also be contagious for and cause mortalities in other cervids. The disease is most commonly prevalent in winter. Pox viruses cause contagious and often lethal skin diseases in birds.

Transmission: The infection can occur through direct contact or via infected excretions, e.g. via feed on feeding grounds. The disease can also be transmitted from production animals to wild animals or vice versa, e.g. from sheep on common pastures.

The early symptoms of pox infection are drooling and discharge from the eyes, and small ulcers in the lining of the mouth.

Symptoms: At first a diseased animal shows difficulty to eat and weakened appetite, increased secretion of saliva, and also discharge from the eyes. Later, food begins to accumulate to the cheeks and they expand, the animal is feverish. Secondary bacterial infections are common. If untreated, the disease and especially the secondary bacterial infections are often lethal.

Findings:

- Cuts and wart-like formations in the lips and mouth membranes are typical findings in the early stage of the disease.
- Later, ulcers and inflammation occur in the digestive system, especially in the rumen. The virus opens gates to the body for bacteria. This causes secondary infections that can infect the whole body.

Control:

- Good hygiene must be maintained at game feeding grounds. Icy or coarse-strawed hay can harm the lining of the mouth and set the scene for viral infections. Dense animal populations increase infection pressure.
- The number of cross-infections are reduced by avoidance of contact between domestic and wild animals, e.g. by proper fencing of pastures.

As the disease progresses, the animal is feverish and secondary bacterial infections are common.

Bacterial infections can be lethal to the animal.

Risk of human infection and protective measures: Some causative agents of pox lesions, are transmissible to humans and cause wart-like, festering and hard-to-heal alterations especially in hands and arms. Always use disposable gloves when examining an infected animal.

Is it safe to eat the meat? Properly cooked meat (70 °C) is safe to eat, if there are no signs of a general infection. The altered parts and areas are removed. If the animal shows signs of a general infection, the meat must not be eaten or given to other animals.

Pox viruses can be contagious for humans, use protective gloves.

2.1.7 European brown hare syndrome (EBHS)

Agent: Calicivirus.

Prevalence:

- Acute and easily transmitted viral disease of the European brown hare and mountain hare that has existed in Europe since the 1980s. European brown hare syndrome (EBHS) is one of the most common causes of hare mortalities.
- The disease is most prevalent in spring and summer. Morbidity can be up to 100% of the population and the disease can cause great local mortality, especially in adult hares. The disease is not contagious for rabbits.

Transmission: Easily spread, apparently through the infected excretions of diseased hares.

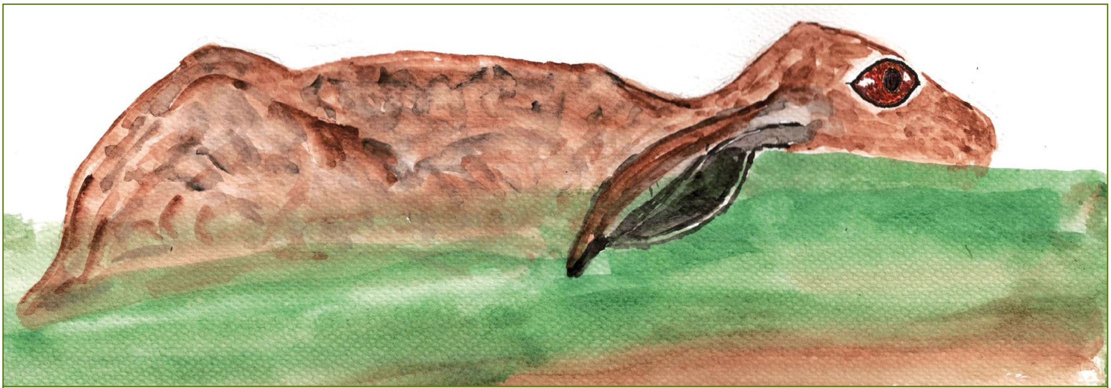
Symptoms: An infected hare is immobile, woozy and fearless. Sometimes nervous symptoms are shown, and then the hare goes round in circles or moves strangely. Death follows a few days after symptoms are shown. Sometimes the disease is acute and no symptoms are shown before death.

Findings: General infections, gangrenous inflammation of the liver and typical alterations related to it, sometimes an enlarged spleen. Diagnosis is confirmed by antibody tests or demonstration of the virus genotype (PCR).

Control: It is not possible to control the disease in the wilderness. Infection pressure is increased by dense hare populations.

Risk of human infection and protective measures: The virus is not contagious for other animals or humans.

Is it safe to eat the meat? The meat of an infected animal must not be eaten.



A diseased hare is woozy and has lost its fear of humans.

Keep in mind:

- Do not touch diseased or dead lagomorphs/hares without protection, and do not give them to dogs.
- Rabbit haemorrhagic disease (RHD) is a worldwide disease of rabbits caused by a Calicivirus. The disease appeared in Europe also in 1980s from Asia and it affects only wild and domestic rabbits. The virus is easily spread by direct contact or by secretions; insects may also transmit the virus. The agent causes haemorrhages in inner organs and hepatitis. The disease is most common in winter or in spring and in adult rabbits and can cause high morbidity and mortality in rabbit populations.

2.1.8 Swine fever (classical; CSF)

Agent: Pestivirus, which stays infectious for months in pork and pork products.

Prevalence: Swine fever is an extremely contagious and dangerous disease of domestic pigs and wild boars. The disease is endemic in Asia and in Central and South America. In the 1990s, outbreaks have occurred in piggeries in several European countries. In Finland, the last outbreak of the disease was in 1917. In recent years, wild boars have been the most common source of infection in the EU area. In Europe, the disease is also found in Russia and certain Balkan countries.

European wild boars are carriers of swine fever virus. They are asymptomatic, but infect domestic pigs.

Transmission: European wild boars that carry the virus but are not usually infected by it are often the source of infection for domestic pigs. The virus is easily spread through vectors or infected excretions of diseased pigs.

Symptoms: Classical swine fever (CSF) can be acute or chronic. The pig is lifeless and stiff and does not eat. It has high fever, conjunctivitis, diarrhoea and red spots in the skin. The animal dies within a few weeks. The mortality rate can be up to 90%.

Findings: General infection, intestinal infection and bleeding in the skin presented as red spots. The diagnosis is done by demonstrating the virus or its antibodies.

Control:
- The disease is an officially controlled animal disease. In livestock, it is easily spread through an infected pig, or through pork and pork products (e.g. salami), humans, other animals, objects and vehicles.
- The virus endures heating and smoking well, and therefore it remains especially in fermented meat products. Importing of uncooked meat products or untreated trophies is a great risk, this refers not only to commercial operations, but also to hunting tourism, when game meat (products) are taken as 'souvenirs'. It is important to prevent contact between domestic pigs and wild boars.

Risk of human infection and protective measures: Swine fever is not contagious for humans.

Is it safe to eat the meat? The meat must not be eaten. Infected animals are disposed of by the authorities.

2.1.9 African swine fever (ASF)

Agent: Asfivirus.

Prevalence: African swine fever (ASF) is an easily spread, serious animal disease, whose symptoms resemble those of classical swine fever. The disease is endemic to Africa. In Europe, infections are found in Sardinia and the Caucasus region, and since the early 2010s in the neighbouring area of Finland near St. Petersburg and the Kola Peninsula. More recently, cases in the EU have been reported (Estonia, Lithuania, Poland).

Transmission: The disease is contagious by direct or indirect contact to vectors, or by feed infected by the virus. The virus can also be transmitted by ticks. The virus is maintained by asymptomatic African wild boars which infect pigs. Infected European wild boars show typical symptoms. ASF can be spread from country to country through meat or uncooked meat products and pelts.

Symptoms: The symptoms are high fever, cyanosis, apathy, loss of appetite. Respiration is fast and laboured, discharge from the eyes and nostrils is also observed. Pigs show central nervous system symptoms, bloody diarrhoea and haematomas in limbs and ears. Within a week of the first symptoms, diseased pigs die. The morbidity and mortality rate can be 100%.

Infected European wild boars show typical symptoms (Photo: Jasna Prodanov-Radulovic and Radoslav Dosen).

Findings: General infection and haematomas of the extremities are typical symptoms. The diagnosis is done by demonstrating the virus or antibodies against it.

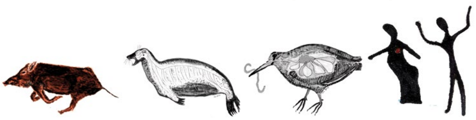
Control:

- The disease is an officially controlled animal disease. The disease is fatal to European domestic pigs and wild boars.
- Uncooked or fermented meat products or meat or untreated trophies should not be imported from the distribution areas of the disease. The virus can also be spread by hunting clothes and by vehicles in which hunted wild boars have been transported.

Risk of human infection and protective measures: The disease is not contagious for humans.

Is it safe to eat the meat? The meat must not be eaten. Infected animals are disposed of by the authorities.

2.1.10 Avian influenza (bird flu)



Agent: Several types of influenza A viruses. Viruses are differentiated by two virulence factors (Haemagglutinin H, and Neuraminidase N); highly pathogenic ones are distinguished from low pathogenic strains.

Prevalence:

- Influenza A viruses are prevalent in humans and several animal species such as birds, pigs and horses, but not in ruminants.
- It is currently assumed that all influenza A viruses originate in waterfowl that maintain viral strains. If the influenza viruses of humans or various animal species infect a pig simultaneously, new combinations of influenza viruses can originate. New viral mutations can also occur when human and avian viruses merge.
- Avian influenza viruses are primarily bird pathogens. All species of birds can be infected. Most avian influenza strains do not infect wild birds. When the viruses come to contact with poultry, they cause avian influenza of an extremely high mortality rate. The H5N1 virus is highly pathogenic also for wild birds.

A diseased bird is apathetic, it has respiratory symptoms and diarrhoea, and its feathers are dirty.

Transmission: A great number of viruses are secreted via the respiratory tract or via excrements and they stay in the environment for a long time. The virus can be transmitted directly through contacts between animals, or through infected feed, water, tools and clothing. Asymptomatic, infected wildfowl, migratory birds, water birds and caged birds can spread the disease from one country and continent to another. It is possible that migratory birds spread the influenza virus.

Symptoms: Typical symptoms include lethargy, loss of appetite, decrease of egg laying, diarrhoea, respiratory symptoms, swelling of the head (and in poultry especially the comb), and high mortality.

Findings: General infection. The diagnosis is done by demonstrating the causative agent, its virulence and antibodies.

Control: Avian influenza is an officially controlled animal disease. Attempts are made to prevent the transmission of the disease to poultry by keeping the poultry indoors during spring migration. Regular monitoring of viruses in the wilderness, e.g. from stool samples, is important.

It is currently assumed that all influenza A viruses originate in waterfowl that maintain the viral cycle and can transmit the virus from one country and continent to another.

Risk of human infection and protective measures:

- For instance, type H5N1 and H7N9 influenza viruses and many other group A viruses are transmissible to humans and can cause serious illness. However, the disease is not effectively contagious for humans, and those who have been infected caught the disease in close contact with infected poultry, e.g. during poultry slaughtering.
- H5N1 virus is contagious for cats, but likely not for dogs. Mass mortalities of birds must always be reported to authorities. It is justifiable to use protective measures.

Is it safe to eat the meat? The virus is killed at 70 °C. Infected animals are disposed of by the authorities.

Keep in mind:

- Newcastle disease is a statutorily controlled, easily transmissible avian virus disease (Newcastle disease virus; NDV). The symptoms resemble those caused by avian influenza. The susceptibility of avian species to the disease varies. Chickens and turkeys are most susceptible. Among game birds, waterfowl do not usually get ill, but they can be asymptomatic carriers and transmitters. Pigeons have their own virus strain, which causes mortalities. If you discover mass deaths of birds, always contact the competent authorities.
- Swine influenza (SIV) is a disease of the respiratory tract of pigs, caused by several types of swine A influenza viruses. The virus type H1N1caused a pandemic in humans in 2009. The disease was described for the first time in the USA in the early 20th century. In addition to North and South America, the disease is endemic in European and Asian countries. People are still presenting symptoms of a flu caused by this virus. The disease has been identified in various animal species such as pigs, turkeys and ferrets. In animals, symptoms have mainly been mild and the source of infection has often been a human. As a precautionary measure, people with flu-like symptoms should not take part in looking after pigs. The pathology of swine influenza infection in wild boars is not known. The role of wild boar in the circulation of SIV is also unclear although studies suggest that SIV actively circulates in the wild boar populations.

2.1.11 Schmallenberg virus

Agent: Orthobunyavirus that spread in Europe, first discovered in Germany in 2011.

Prevalence: The disease is prevalent in ruminant livestock in several European countries including Fennoscandia. First lambs deformed by the virus were born in Finland in early 2013. In Europe, antibodies have been found often from wild cervids and bisons.

Transmission: The virus is transmitted by blood-sucking insects. It is spread by blood meals from one diseased, infected animal to another. Especially midges, but possible also mosquitoes, transmit the disease during the warm season. It is possible that wild ruminants are carriers of the disease.

Symptoms:
- Symptoms in cattle are mild, temperature and diarrhoea as well as fall in milk yield have been shown. Sheep and goats are asymptomatic.
- The symptoms are most visible if an animal is infected during pregnancy. The result is the transmission of the virus into the foetus, where it causes malformations and premature births. Typical foetal malformations are bent limbs or spine and different degree malformations of the brain. There is no information on the progress of the disease in wild ruminants.

Diagnosis:
- Infected animals present no typical findings by which the disease can be identified conclusively. Infection is diagnosed by demonstrating the virus in the excrement, tissues or blood of an infected animal, as well as in aborted foetuses or foetal membranes.
- Antibodies can be identified in blood samples. Diagnosis is done by demonstrating the genotype of the virus in samples of tissue or blood.

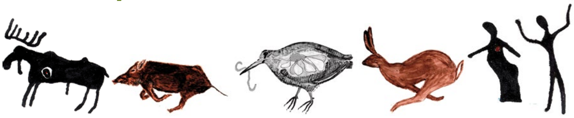
Abortion is an alarm signal both in wild animals and in livestock. When handling aborted foetuses, always take protective measures.

Control: Testing of imported animals and active monitoring of the disease in wild and domestic ruminants are measures for preventing the spreading of the disease.

Risk of human infection and protective measures: There are no reported cases of human infection and the risk is considered low. When handling aborted foetuses, always protect yourself with adequate protective clothing.

Is it safe to eat the meat? The meat of an infected animal must not be eaten.

2.1.12 Hepatitis E virus (HEV)



Agent: Hepatitis E virus (HEV), with several genotypes.

Prevalence: Originally considered to be associated with poor hygiene conditions in Asia and Africa, but now detected in domestic pig and wild boar populations in Europe. The virus can be carried also by birds, rabbits, ruminants.

Transmission: Viruses are excreted via faeces, esp. from infected piglets. Humans may contract the disease via consumption of contaminated food or water, or handling of infected tissues without hygienic precautions.

Symptoms: No changes in behavior or alterations in inner organs of infected game are to be expected. In humans, a non-chronic hepatitis may develop.

Diagnosis: Diagnosis requires laboratory testing (antibody detection or virus detection in the acute phase of the disease).

Control: No specific controls measures are in place now.

Risk of human infection and preventive measures: Infection route can be faecal-oral or by ingestion of food or water contaminated by faeces. No specific preventive measures exist, but using of disposable gloves to protect hands, or frequent washing of hands and safe meat preparation techniques are recommended.

Is it safe to eat the meat? The meat of an animal with confirmed infection must not be eaten. As it is possible that 'healthy' animals carry the virus, the usual measures during handling, preparation and processing meat from game must not be neglected.

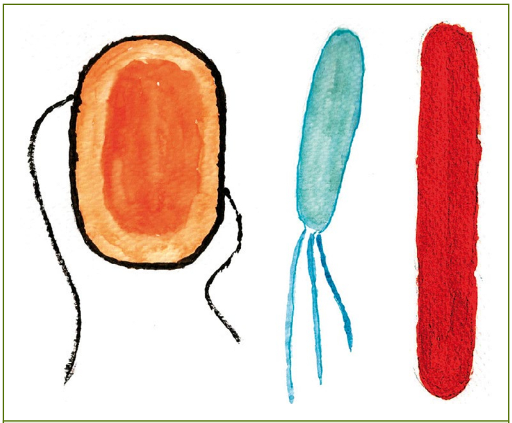
2.2 Diseases caused by bacteria

Bacteria are the smallest organisms that reproduce by dividing independently. When a bacterium divides, two identical clones are formed. The size of bacteria varies from 0.5 to 750 μm (micrometer). They are surrounded by cellular wall, which maintains the shape of the bacterium. Bacteria have no nucleus or actual organelles except for ribosomes. On the surface of bacteria, there may be flagella that make them motile.

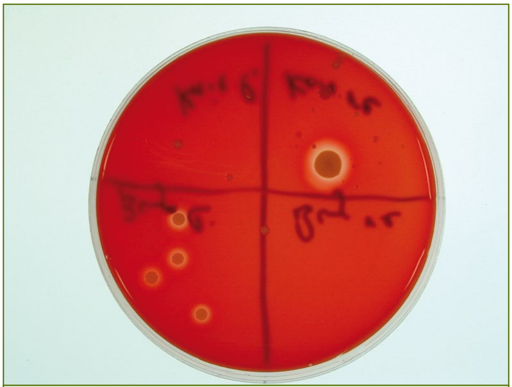
In order to survive, some bacteria need oxygen and some require anaerobic conditions. Thus, bacteria are classified into those that require oxygen, the so called aerobic bacteria, and those that do not need or even stand oxygen, the so called anaerobic bacteria.

Bacteria can also be classified on the basis of shape: spherical bacteria are called cocci and rod-shaped bacteria bacilli.

Bacteria do not have a nucleus or actual organelles.



Bacteria are classified according to shape into, e.g. spherical bacteria called cocci or rod-shaped bacteria called bacilli. Their surface may contain flagella.



Haemolytic bacteria. The clear halo around the colony indicates that the bacterium is able to lyse red blood cells, which is an indicator for pathogenicity (Photo: Peter Paulsen).

In addition, bacteria are grouped according to their chemical characteristics, such as stainability, into Gram negative and Gram positive bacteria. Today, bacteria are mainly classified on the basis of their genotype.

Most bacteria are non-pathogenic, i.e., they do not cause disease. There is a great number of bacteria in the skin, mucous membranes and intestines of animals and humans (10 times the number of their own cells). This is called the normal flora of the body. The normal flora protect the organism, take part in digestion, and maintain the activity of the immune system, at the same time helping the immune resistance work against pathogenic bacteria. Normally the only tissues that are sterile, or free from bacteria, are muscle, bone and nervous tissues and blood.

Bacteria are transmitted by direct contact with diseased or dead animals, or through their excretions.

Bacteria can also be transmitted via asymptomatic carrier animals or blood-sucking insects (vectors). Several pathogenic bacteria are resident in the intestines and they are excreted to the environment via faeces. Faeces-contaminated food and drinking water may be sources of infection. Many bacteria survive well in the environment, some even for decades in dormant spore form.

Some pathogenic bacteria are extremely virulent and almost always cause serious diseases. For humans, such bacteria are, e.g. anthrax and tularaemia bacteria. However, most pathogen bacteria are so called opportunistic pathogens. They cause a disease under suitable predisposing conditions, for instance, when an animal is starving or burdened with parasites, or when the weather is unfavourable. Infection pressure is also increased when the number of diseased animals is high and the population is dense.

The disease-inducing ability of bacteria may be based on how they proliferate in the target tissue, and how they spread all over the body. At the same time, they cause tissue damage and strong, either local or general inflammatory reactions in the body that may, in serious cases, lead to a state of shock. Other bacteria produce toxins in a favourable environment, such as anaerobic conditions in a tissue. The clinical picture is dependent on the bacterial strain and the quality of the toxins the bacteria produce. Some bacteria produce toxins in the environment or in foodstuffs, and disease occurs, e.g. after consumption of contaminated food or water.

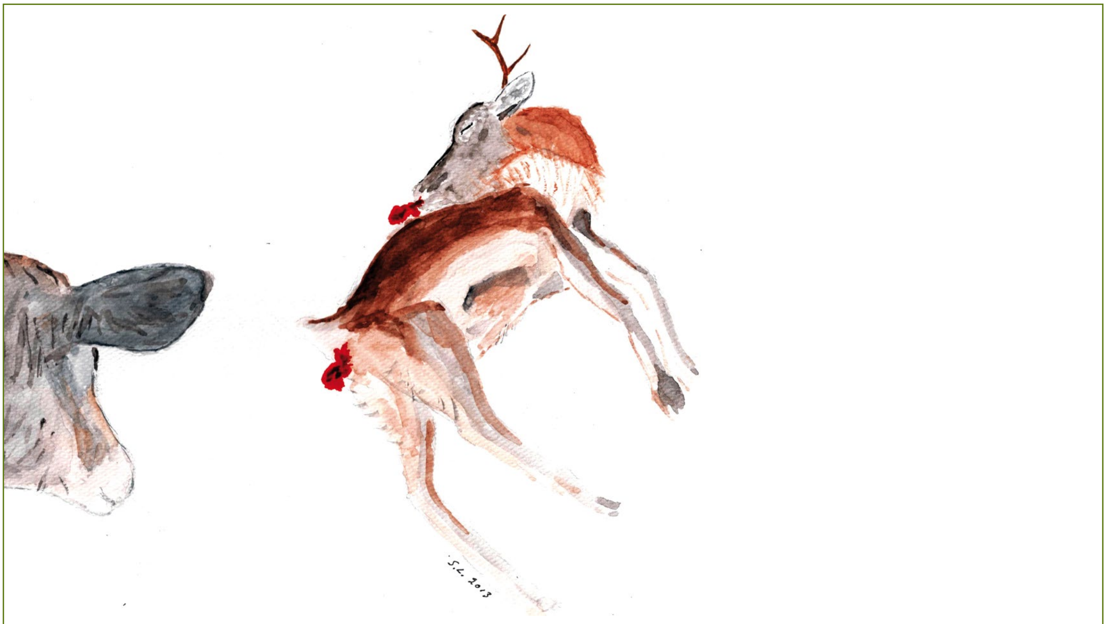
Antibiotics are used in the treatment of bacterial diseases of both humans and domestic animals. Bacteria have a genetic ability to mutate and develop strains that are resistant to antibiotics. This, together with poorly planned treatment or mass use of antibiotics, has caused great problems in the health care of humans and animals.

2.2.1 Anthrax

Agent: An endospore-forming bacterium, *Bacillus anthracis*.

Prevalence: Anthrax is an acute disease which is lethal to many animal species. Epizootics, sometimes very wide-spread, occur ubiquitously in wild ruminants. Anthrax is prevalent all over the world. Cattle and wild ruminants such as bison, moose and deer species are most susceptible to the disease. Wild boars are resistant to the anthrax bacterium, but they can become carriers if they eat an animal who has died of the disease. The bacterium is also used as a biological weapon.

Transmission: Animals may become infected by anthrax spores in the meat, carcass, pelt or excretions of an animal who has died from the disease. When in contact with oxygen, the bacteria quickly form spores. The spores can survive dormant and infectious for decades. When the soil is worked, the spores may surface and cause infections. Infection can also be transmitted through air, digestive tract, open wounds or blood-sucking insects.



In summer 1911, anthrax killed more than 100,000 reindeer within a short period of time in Siberia.

Symptoms: If the infection is peracute, it results in the death of an animal without preceding symptoms. Otherwise, typical symptoms include swelling of the neck and grinding of teeth, stomach pains, staggering walk and severe, bloody diarrhoea and bleeding from body orifices.

Findings: Findings include bloody discharge from nostrils and anus. The entire body and vital organs present signs of death caused by intoxication; haemorrhaging in mucous and serous membranes, lymph nodes and under the skin, and enlarged spleen. There is no rigor mortis. Diagnosis is based on microscopic examination of a blood sample and identification of the anthrax bacterium.

Control: Anthrax is a dangerous zoonosis and one of the dangerous and controlled animal diseases. In case of anthrax suspicion, a veterinary surgeon must always be sent for. If the carcass is opened, the formation of spores begins. Spores are spread from the carcass to the environment and stay infectious for decades. The carcasses of diseased animals are disposed of in destruction facilities. Production animals can be vaccinated against the disease.

Risk of human infection and protective measures: People can become infected directly from handling a diseased animal or from eating poorly cooked flesh of a diseased animal. Infection is transmitted also by air, e.g. through infected animals or their pelts. Blood-sucking insects can also spread the infection, if they have had a blood-meal from a diseased animal. Careful protection is always important when handling animals which have died on their own accord. When travelling abroad, it is advisable to be careful if you handle pelts or pelt souvenirs, such as drums.

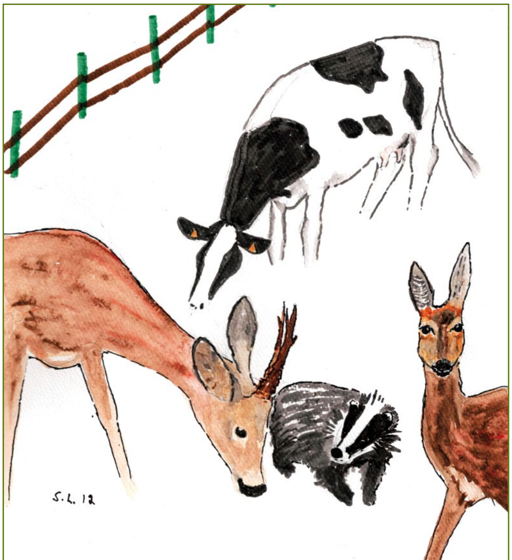
Is it safe to eat the meat? The meat of an infected animal must not be eaten. Its carcass must not be handled. The carcass is disposed of by authorities.

2.2.2 Bovine tuberculosis (TB)

Agent: *Mycobacterium bovis* bacterium.

Prevalence:

- Tuberculosis (TB) is a globally prevalent, chronic disease of humans and many animal species. In addition to cattle, deer are very susceptible to the infection. The disease can also be prevalent in wild boar, badgers, dogs and cats.
- Tuberculosis is found in farmed and wild cervids and reindeer in Europe, North America and Asia. Badgers, deer and wild boar have an important role as carriers of the disease. Free-roaming cats may also carry the disease. Around ¾ of EU member states are officially classified



In areas where tuberculosis is prevalent, the badger is regarded as one of the most efficient spreaders of the disease.

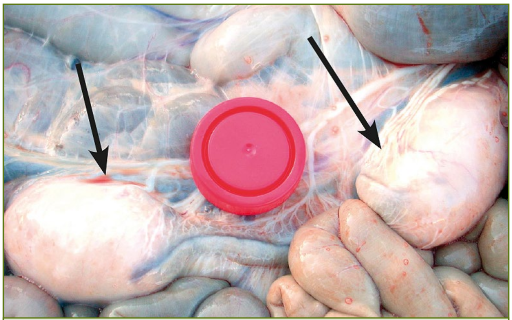
as free from bovine tuberculosis but TB is feared to emerge to wildlife.

Transmission:
- The bacterium is transmitted by inhalation of aerosols or airborne droplets, or from mother to calf through the placenta or milk. The bacterium may also be transmitted through food: it has been demonstrated that the infection of white-tailed deer is spreading from feeding grounds.
- Formerly, unpasteurized milk was a common source of human infection.

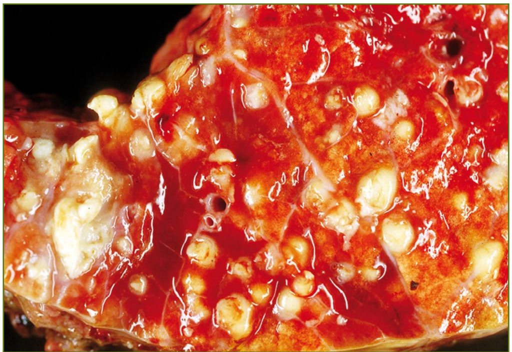
Symptoms: Initially, the disease is treacherous and presents few symptoms. Later, the diseased animal shows symptoms such as wasting, shortness of breath and a hacking cough.

Findings: Enlarged lymph nodes found locally or everywhere in the body. Calcified granulomas (tubercle) in lymph nodes and organs as well as in the membranes of abdominal and thoracic cavities. The animal is gradually wasting.

Control: Tuberculosis is a dangerous zoonosis and it is one of the dangerous and controlled animal diseases. A tuberculosis test is required from imported even-toed ungulates. Production animals and farmed cervids are controlled regularly. Smuggled, untested ruminants pose a risk of spreading the disease. The prevention of



The intestines of a deer with intestinal lymph nodes enlarged by tuberculosis (Photo: Christian Gortazar).



Tuberculosis granulomas, or tubercles, in a deer's lungs (Photo: Christian Gortazar).

A mandibular lymph node of a wild boar, with TB lesions that are quite structured and starting to calcify (Photo: SaBio-IREC, Spain).

Chronic tuberculosis in the lungs of a red deer (Photo: Peter Wäsenberg). The nodules are calcified.

contact between wild animals and livestock in TB risk areas is necessary. Early detection is important because when the wildlife is infected with TB, it is difficult to eradicate.

Risk of human infection and protective measures: Bovine tuberculosis is contagious for humans. In the prevalent areas of the disease, unpasteurized milk or unheated products thereof must not be used. Use protective gear if you handle game animals. A thorough meat inspection is required.

Is it safe to eat the meat? It is not safe to eat the meat. Carcasses are disposed of by authorities.

Keep in mind: Avian tuberculosis is caused by *Mycobacterium avium*. The disease is globally prevalent in wild and farmed birds. The disease is contagious for pigs, sheep and cervids. Human infection is rare. Infections in wild animals are usually individual cases, but in farm conditions morbidity and mortality can be high. High animal density, poor hygiene and deficient feeding assist in the outbreak of the disease. The disease is chronic, and alterations are best shown in adult birds: symptoms include wasting, lethargy and loss of muscle mass. Typical pale nodular lesions are formed in various organs and sometimes in the skin. The size of the nodules varies from a few millimetres to several centimetres.

2.2.3 Paratuberculosis (PTB, Johne's disease)

Agent: *Mycobacterium paratuberculosis* bacterium, which survives well in harsh conditions and remains in the environment for long periods of time.

Prevalence: Paratuberculosis (PTB) is one of the most widespread and problematic contagious and chronic disease affecting both wild and farmed ruminants.

Transmission: The disease is transmitted through animal stools to food, drinking water, waterways, and to the teats of breastfeeding mothers, for instance. Asymptomatic carrier animals are a problem.

Initial phase of PTB in a red deer calf showing granulomatous enteritis (Photo: SaBio-IREC, Spain).

Symptoms: The disease has a long incubation period. Animals develop chronic watery diarrhoea and they waste. The clinical picture includes roughening of the hair coat and swelling under the jaw. The disease is often lethal for young deer.

Findings: Chronic infection and severe folding and thickening of the mucous membrane of the intestines is discovered. Making a definitive diagnosis is difficult and takes time. It is based on the demonstration of antibodies or pathogenic bacterium by cell culturing or using genetic methods.

Control: At feeding grounds, feeding from the ground must not be organised in such a way that food can be contaminated by animal stools. Protective measures include also restrictions of animal importation and the prevention of contact between wild animals and livestock. It is also important to monitor the diseases of livestock and wild ruminants.

A red deer intestine and associated mesenteric lymph nodes, which contain neutrophilic material and represent typical abscess-like lesions often found in red deer, likely due to oral infection of PTB (Photo: SaBio-IREC, Spain).

Risk of human infection and protective measures: As far as is known, the disease is not contagious for humans. There are, however, some similarities to Crohn's disease in humans, and *M. paratuberculosis* might be a co-factor for this human disease.

Is it safe to eat the meat? The meat of an infected animal must not be eaten. Heating destroys the bacterium.

2.2.4 Brucellosis

Agent: Bacteria of the genus *Brucella*.

Prevalence: Brucellosis is a disease which causes miscarriages in cattle, pigs, wild boar, hares, sheep, dogs and cervids, and in marine mammals such as seals and whales. The disease is also contagious for humans. The disease is globally and locally prevalent among wild animals and livestock in Europe, North America and Asia.

Brucella bacterium causes miscarriages in both domestic and wild animals.

Transmission: Brucellosis is a highly contagious disease. It is transmitted by secretions, urine, miscarried foetuses, foetal membranes or milk of an infected animal. It can also be transmitted by dogs, rats, insects or vehicles. Animals which have suffered from the disease may become carriers and spread the disease for several years.

Symptoms: Causes abortions, fertility problems and limping.

Findings: Chronic infection of both female and male animals' sexual organs causes damage in the uterine wall and testicles. This results in inflammation of foetal membranes and testicles. Another common symptom

A caribou infected by brucellosis, showing symptoms of arthritis and limping (Photo: GNWT Environment and Natural Resources, Canada).

is arthritis. The diagnosis of the disease relies on the demonstration of the bacterium and its antibodies.

Control: Brucellosis is classified as a controlled, dangerous animal disease. Checks of imported animals are important. The situation regarding brucellosis in production animals is constantly monitored. It is important to prevent contact between wild animals and livestock in risk areas.

Risk of human infection and protective measures:
- The disease can be transmitted to humans and cause a serious disease: undulant fever, headache, weakness and even death. The bacterium is extremely virulent, e.g. in aerosol form through respiratory tract or mucous membranes and eyes.
- In prevalent areas, the hygienic handling of game animals and safeguarding during slaughtering as well as avoiding the use of unpasteurized milk products is important. Dead marine mammals must not be touched without protective gear.

Is it safe to eat the meat? The meat of an infected animal must not be handled. Infected animals are disposed of by authorities.

Brucellosis causes chronic infection in sexual organs. Pictured here is a testicle of an infected wild boar (Photos: Christian Gortazar).

2.2.5 Clostridia

Agent: Genus *Clostridium* bacteria. Clostridia cause among domestic and wild animals a great deal of severe diseases worldwide. They are so called anaerobes, and they are found in the soil and in the intestines of healthy animals.

The bacteria of genus *Clostridium* form spores, which survive extremely well in the soil and waterways.

The diseases they inflict are caused by the toxins (endotoxins) they produce.

2.2.5.1 Botulism

Agent: The proliferation of *Clostridium botulinum* bacterium and the neurotoxin it produces in food.

Prevalence:

- Botulism is food poisoning caused by *Clostridium botulinum* bacterium. It can affect all animal species, including humans.
- Intoxications have been reported in fur animals, farmed cervids and cattle. In waterfowl, intoxication is known to be a common cause of mass mortalities in summer.

Transmission:

- The spores of *C. botulinum* bacterium are found everywhere. They proliferate under warm, anaerobic conditions (where there is no oxygen), and release neurotoxin into their environment. This can occur if, e.g. dead rodents get into food in feeding places. Decomposing plants and animal carcasses may also be the source of intoxication.
- Botulinum toxin can accumulate into the larvae of bot flies, which then infect the birds which eat them. Scavengers are infected from eating the flesh of dead animals which died from botulism.

Symptoms: Symptoms in animals include restlessness, teeth grinding, paralysed tongue, increased drooling, paralysis and death. Symptoms in humans include weakness, drowsiness, blurred or double vision, dilated pupils, dry mouth, difficulty breathing and talking, muscle weakness and death.

Findings: No specific findings. Diagnosis from recently died animals or foodstuffs is made by demonstration of botulinum toxin.

Contaminated home-made canned foods are the most common source of botulism in humans.

Botulism is a common cause of mass mortalities in birds. In marshy beaches, decomposing plants and waste originating from animals form favourable conditions for toxin formation.

Control: It is not possible to control the disease in the wild. In game feeding, feed hygiene and prevention of rodents getting into the feed can be significant. Providing mineral lick to cervids may reduce their inclination, induced by phosphorus-poor diet, to eat dead animals or bones.

Risk of human infection and protective measures: Contaminated preserves (for instance, home-made canned food and partially cooked or fermented traditional food) are the most common source of botulism in humans, and in infants also honey that contains spores. Botulinum bacterium proliferates and produces toxins in anaerobic conditions, when the temperature is between 10 to 50 °C, pH higher than 4.6, and water activity over 0.93. When making canned foods at home, the inside (core) temperature of the food must be a minimum of 112 °C for at least 23 minutes. The finished preserve may also be heated before use. The destruction of botulinum toxin requires thorough heating in 80 °C temperature for 20 minutes, or in 85 °C temperature for 5 minutes.

Is it safe to eat the meat? The meat of infected animals must not be eaten or given to animals. Dead animals must be buried so that scavengers cannot get to them.

2.2.5.2 Tetanus

Agent: Neurotoxins produced by *Clostridium tetani* bacterium in the tissues.

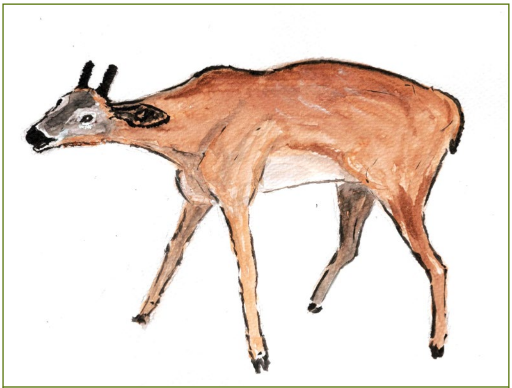
Prevalence: The disease is found in deer species and in production animals. Infections are sporadic and individual cases.

Transmission: The spores of tetanus bacterium are commonly found in the soil. The disease often enters the body through puncture wounds, which allow the entrance of spores into the wound channel. Spores can also enter the body through damaged digestive tract, e.g. as a result of rumen damage. An anaerobic state prevails in the wound channel, which enables the bacterium to proliferate and produce toxin.

Symptoms: It is typical that an infected animal is dull, it does not move but stands legs apart, in sawbuck posture. Muscle fibrillation and spasms occur. Spasms of the jaw cause a condition called lockjaw, which does not allow the mouth to open. The third eyelid is visible in the corner of the eye. In ruminants the rumen stops and fills with gas, which causes the animal to bloat.

Findings: Diagnosis is often based on preliminary knowledge, symptoms and findings as well as isolation of *Clostridium* bacterium from the wound.

Control: It is not possible to control the disease in the wild. Risk factors include providing unsuitably coarse food at game feeding ground, or, e.g. decomposed structures with nails. Production animals such as horses can be vaccinated against the disease.



Standing legs apart is typical for an animal infected with tetanus. In ruminants the rumen stops and bloats.

Dangerous clostridia can enter the body through puncture wounds or damages in the digestive tract. The bacterium produces toxins in anaerobic conditions. Careful protection is always important when dead animals are handled.

Risk of human infection and protective measures: The disease is not transmitted from infected animals to humans. Humans may catch the disease through puncture wound and animal bites, for instance. The disease can be prevented by vaccinations.

Is it safe to eat the meat? The meat of an infected animal must not be used by animals or humans.

Keep in mind: Another disease following puncture wounds or digestive tract damage is the so called gas gangrene ('blackleg'), which is found in game and production animals. The disease is an acute condition caused by several types of *Clostridium* bacteria (*C. septicum*, *C. chauvoei*, *C. perfringens*, etc.) The disease has high mortality rate, often already before the appearance of visible symptoms. The symptoms include depression, absent-minded behaviour, and springy, high-stepping and unsteady movements. Crackling sounds (gas) in the swelling under the skin as well as necroses of skin and muscle are typical. The disease also causes blood to change into tar-like form, and bleeding from bodily orifices.

2.2.5.3 Enterotoxaemia

Agent: The proliferation of *Clostridium perfringens* bacterium and the powerful toxins produced by them in the intestines. *C. perfringens* is common in the soil.

Prevalence: Found in production animals, reindeer and game animals due to, e.g. too carbohydrate-rich diet or rapid change of diet.

Transmission: Overfeeding of carbohydrates exposes ruminants to acute intestinal poisoning. Especially a rapid transition from fibre-rich feed to abundant carbohydrate feed causes elevated acidity in the rumen. Acidic conditions are favourable for the replication of *C. perfringens* bacterium, and toxins are absorbed from the intestines to the body.

Symptoms: An infected animal may present central nervous system symptoms and balance disturbances of varying severity. Diarrhoea is a common symptom. There are also fatalities.

Giving easily digestible carbohydrate-rich feed to game animals poses a risk of intestinal poisonings caused by *Clostridium* bacteria. Offering feed from the ground assists the spreading of parasites and other pathogens.

Findings: Findings of general toxaemia, severe inflammation of the intestines.

Control: The feeding of all wild ruminants must be started carefully with gradual changes. Maintain caution in providing carbohydrate-rich feed. Feed must be divided into as many feedings as possible and offered from many feeding grounds, to prevent the animals from overeating. Feeders that ration feed in several small batches are recommendable.

Risk of human infection and protective measures: The disease is not transmitted from animals to humans. Use protective measures when handling infected animals.

Is it safe to eat the meat? The meat must not be used as nutrition for humans or other animals.

2.2.6 Colibacillosis

Diseases caused by *E. coli* bacteria are mostly found in young animals. The most common symptom is intestinal infection and diarrhoea.

Agent: *Escherichia coli* bacteria, which are normally found in the normal flora of the intestines. Only some of the bacteria cause infections. For instance, in food and water studies, the presence of *E. coli* bacteria is considered an indication for faecal contamination.

Prevalence: *E. coli* bacteria cause a group of diseases mostly found in young animals whose immune resistance is still incomplete. These diseases are found in all mammal species. Farmed cervids are especially susceptible.

Transmission: The infection route from animal to animal is faecal-oral, for instance, infection is transmitted via contaminated feed or water. Disease outbreak usually requires predisposing factors, depending on the virulence of the bacterium. Dense populations, starvation and poor condition of mothers/dams set the scene for an outbreak of the disease.

Symptoms: Depending on the age of the animal and the bacterium strain, symptoms vary from sudden death to bloody or watery diarrhoea and central nervous system symptoms.

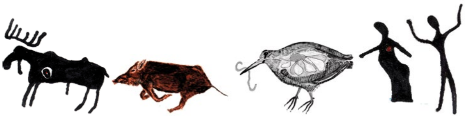
Findings: Infection of the intestines, general infection.

Control: Maintaining hygiene at feeding grounds is important. In game animal feeding, food must not be offered from the ground in order to prevent animal stools from contaminating it, and to prevent the occurrence of regionally dense populations.

Risk of human infection and protective measures:
- Shiga toxin-producing *E. coli* bacteria, such as EHEC bacteria, are common causes of severe human food poisoning. Ruminants may be asymptomatic carriers and spreaders of the bacterium. Wild animals, such as cervids and wild boars, may also be carriers of the disease.
- Human contamination can result from direct contact with the stools of an animal excreting the bacterium, or from contaminated, badly cooked meat, or from unpasteurized, contaminated milk. Common sources are also vegetables and sprouts irrigated with contaminated water, and contaminated swimming water. The bacterium causes a severe disease in humans. The elderly, children and people suffering from chronic diseases must avoid the above mentioned foodstuffs. If the bacterium is found in meat, it is a sign of bad slaughter hygiene.

Is it safe to eat the meat? The meat of an infected animal must not be used by animals or humans.

2.2.7 Salmonellosis



Agent: *Salmonella* bacteria. Although there are only two species in this genus, a vast number of serological variants (>2,500 serovars) are known. Often typhoidal Salmonellae are distinguished from non-typhoidal ones. The latter group is relevant for animals and can also be transmitted to humans.

Prevalence: Salmonellosis is prevalent worldwide. It causes intestinal diseases in all species, humans included. Salmonellosis is typically a bird disease. Wild boar is frequent carrier in some areas. In cervids, *Salmonella* findings are rare although they can be carriers. The gall bladder is the favourite spot of *Salmonella* bacteria. Cervids lack a gall bladder, which may explain the fact that salmonellosis is less significant for them.

Transmission: The infection is spread by faecal contamination of feed or drinking water by diseased or carrier animals. In birds, it is transmitted to the offspring also via eggs. The infection can be spread over long distances by birds or via vehicles, shoes, etc.

Symptoms: Symptoms depend on animal species, an individual's resistance, and the type of the *Salmonella* bacterium. Symptoms are more severe in young mammals and birds: they vary from sudden death to apathy, or to a disease with watery diarrhoea. Typical symptoms in birds are a tangled cloaca, swollen eyelids and tangled feathers, and often also central nervous symptoms.

In game feeding, it is important that animal faeces are kept from contaminating the food (Photo: Jasna Prodanov-Radulovic and Radoslav Dosen).

Findings: Most common findings include bloody intestinal infection and enlarged lymph nodes and spleen. In birds, the crop often gets thicker and its lining is covered with a cheesy layer. Diagnosis is based on the demonstration of *Salmonella* bacterium in the intestines or lymph nodes.

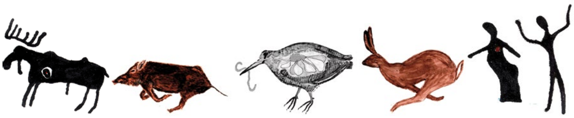
Control: Salmonellosis is a statutorily controlled animal disease. Its prevalence in production animals is monitored with follow-up programmes. Important precautions include game feeding ground hygiene and prevention of contacts between game and production animals. In bird feeding ground management, it is also important to maintain good hygiene and a correct method of feeding – stools must not be allowed to contaminate the food.

Risk of human infection and protective measures: The disease is zoonotic, and it is the second most common cause of human bacterial intestinal infections in the EU. In Nordic countries, the risk of infection from game meat is minute, but the infection is common in wild boar and deer in many other countries. Foreign travel is often the source of infection. The origin of human infection is often water, milk or meat, or vegetables irrigated with contaminated water. The most common source of infection is poultry. If salmonellae are found in meat, it is a sign of faecal contamination, which can result from, e.g. inappropriate slaughtering or carcasses being contaminated by bird faeces.

Is it safe to eat the meat? The meat of an infected animal must not be used by animals or humans. *Salmonella* bacterium is destroyed by heating.

Keep in mind: *Campylobacter* bacterium species are the most common cause of bacterial human intestinal infection in the European Union. The bacterium is found in both livestock and wild animals. Drinking water or foodstuffs can be contaminated by the faeces of asymptomatic carrier animals. *Campylobacter* findings in foodstuffs are a sign of faecal contamination, bad slaughter hygiene, contaminated irrigation water, or post-processing contamination in food preparation. Heating destroys the bacterium.

2.2.8 Yersiniosis



Agent: *Yersinia pseudotuberculosis* and *Y. enterocolitica* bacteria. They are bacteria that are common and survive well in the soil and bodies of water. *Yersinia* bacteria are, after *Salmonella* and *Campylobacter*, the third most common cause of human intestinal infections in Nordic countries.

Prevalence: The disease is ubiquitous. Both domestic and wild animals are carriers of the bacterium, without showing any symptoms. It is especially common in the intestines and tonsils of pigs and wild boar. The disease is typically found in young cervids. Epidemics have occurred also among farmed animals.

Transmission: The carrier animals of the bacterium are birds, rodents, hares, pigs, cattle and pets, in the intestines of which the bacteria live. Food or drinking water is contaminated by stools that contain the bacteria. The disease can also be transmitted by direct contact with carrier animals.

Yersinia bacterium is common in the digestion tract and tonsils of pigs (Photo: Jasna Prodanov-Radulovic and Radoslav Dosen).

Rodents such as lemmings can spread the *Yersinia* bacterium in their stools.

Symptoms: The disease mainly occurs in young animals. Outbreaks are dependent on predisposing conditions. The clinical picture includes depression, loss of appetite, withdrawal, and greenish and watery diarrhoea which turns bloody. In acute cases, death may occur without premonitory symptoms.

Findings: General blood poisoning and endotoxic shock. Enlarged lymph nodes and spleen, and pointlike bleeding in lymph nodes, heart, lungs and diaphragm are typical findings in yersiniosis.

Control: Game feeding hygiene is important, the food must not be contaminated by animal stools. Feed must be stored in such a way that rodents or birds cannot contaminate it with their stools.

Risk of human infection and protective measures: The disease is zoonotic. Children and young people are especially susceptible to it. Meat is contaminated by the bacterium through poor slaughtering hygiene or via faecal contamination by rodents, for instance. Human contagion may also occur through milk, or through drinking water contaminated by floodwater or sewage, or through vegetables irrigated with contaminated water. Maintaining good slaughtering and cooking hygiene is important. It is risky to be in too close contact with pets. After handling pets, good hand hygiene must be maintained.

Is it safe to eat the meat? The meat of sick animal must not be used by animals or humans.

Keep in mind: From the point of view of food hygiene**,** *Yersinia* bacteria are problematic, because they can also proliferate at refrigeration temperature.

2.2.9 Pasteurellosis

Agent: *Pasteurella multocida* bacterium.

Prevalence: In various game animal species, *Pasteurella* bacteria cause epidemics with high mortality rate. In Nordic countries, Pasteurellosis and outbreaks pertaining to it have been found in several cervids, such as reindeer, and muskox and hares. The disease is also found in livestock and chickens.

Stressful factors, such as overdensity of population or bad weather, are a prerequisite for the outbreak of pasteurellosis. Pictured here are Finnish forest reindeer bucks competing with each other (Photo: Arto Juntunen).

Transmission: *Pasteurella* bacterium is regarded as part of the normal bacteria of the upper respiratory tract. The bacterium is spread by aerosol, droplet and faecal transmission. The outbreak of the disease requires stressful and predisposing factors, such as poor state of nutrition, overexertion, overdensity of population, unfavourable weather conditions (heat, cold, rain) and great number of parasites.

Symptoms: Common symptoms include hanging of head, hanging ears, excessive salivation, and severe functional disorder of respiratory organs. In the acute form, death may occur in 24 hours.

Findings: Septic shock, with findings including pointlike bleeding, enlarged lymph nodes and spleen, and bleeding in lymph nodes, heart, lungs and diaphragm.

Control: Overdense regional game populations are a predisposing factor for the disease.

Risk of human infection and protective measures: The disease is not an actual zoonosis, although pasteurellosis can sometimes result from cat bite.

Is it safe to eat the meat? The meat of a diseased animal must not be eaten or given to other animals.

2.2.10 Necrobacillosis, foot rot

Agent: *Fusobacterium necrophorum* bacterium, which thrives in anaerobic conditions. Other pyogenic bacteria are often associated with the disease (*Actinobacillus*, *Actinomyces*, *Corynebacterium*).

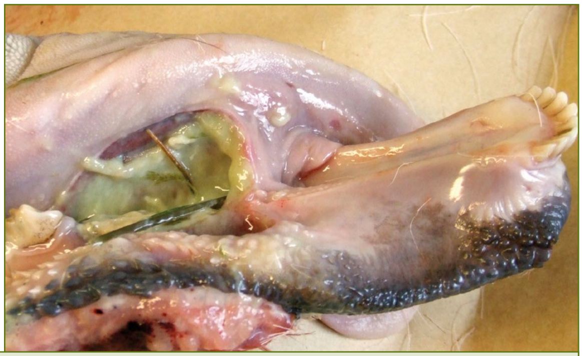
Prevalence: Ubiquitous disease. Causes necrotic infections in domestic and wild animals, sometimes also mass infections, especially in wet and cold summers or extremely hot summers. A common problem that affects farmed cervids and dense populations of wild cervids. E.g. in Nordic countries, necrobacillosis is a common disease for reindeer and moose.

Transmission:

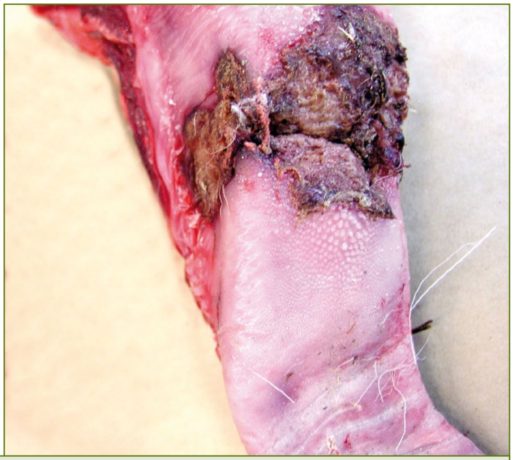
- Predisposing factors are required for the emergence of the disease. These include overeating of concentrated feed and increase of acidity in the rumen. Change of teeth or coarse, unsuitable feed can damage the lining of the mouth and rumen, allowing bacteria an entry into tissues.
- Overdense populations cause stress and increase the infection pressure. Dirty and muddy feeding grounds and cold and wet or hot weather set the scene for outbreaks of epidemics. The disease is often linked to pox viruses: the viruses open a gate for bacteria into the body.

Symptoms: Once the necrotic bacteria have entered tissues they begin to produce tissue-destructive toxins under anaerobic conditions. Infection in the head results in increased salivation, loss of appetite and inability to eat and chew. Hoof-area infections cause severe limping. The disease often causes starvation and death.

Findings: Lesions of the mouth are common in young animals. Other findings are swelling of the head and jaw, and festering and necrotic infection in the mouth, gums and tongue. A typical finding is also a foul smell in the inflammatory alterations caused by the bacteria. The disease often causes suppurative inflammation of the peritoneum (lining of abdominal cavity) and/or lungs. The bacteria that spread through the bloodstream cause abscesses in the liver, brain and lungs. The foot-affecting form of the disease causes necrotic infections in the hoof area that may spread to the leg bones.



Change of teeth or coarse, unsuitable feed can damage the lining of the mouth and open a gate for necrotic bacteria into the animal's tissues.



In anaerobic conditions, Fusobacteria produce tissue-destructive toxins. As a result, the tongue or jaw can sometimes come off entirely.

Control: Good general hygiene of game feeding grounds, correct method of offering feed, and the quality of feed are important factors in disease control. Game feeding sites must not be located in wetlands.

Wet and cold weather is favourable for foot rot (Photo: Mira Kukkola). In cervids, the disease may cause death by starvation, as the infected animals cannot move properly.

Roe deer hoof with severe foot rot (Photo: SaBio-IREC, Spain).

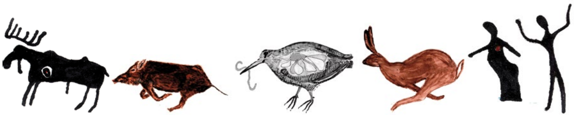
Mouflon hoof with severe necrobacillosis (Photo: Peter Paulsen).

Risk of human infection and protective measures: The disease is not an actual zoonosis. However, it is advisable to be careful when handling infected animals.

Is it safe to eat the meat? The meat of a diseased animal must not be eaten or given to other animals.

Keep in mind: Emerging severe hoof disease in elk (red deer, *Cervus elaphus*) in the USA, with lameness and severely deformed or missing hooves, necrosis and osteomyelitis, has been associated to *Treponema* spp. spirochetes and also to deficient low copper and selenium levels. The agent is present at least in European cattle.

2.2.11 Listeriosis



Agent: *Listeria monocytogenes* bacterium.

Prevalence: A ubiquitous bacterium commonly found in the soil and water as well as in the intestines of humans and many animals. Listeriosis is a disease affecting mainly cattle, sheep, cervids and hares. Wild mammals and birds are asymptomatic carriers. In humans, the disease causes severe food poisoning. Listeriosis can occur sporadically or as mass outbreaks in farmed and wild cervids and reindeer.

Transmission: Transmitted by spoiled or contaminated feed that contains *Listeria* bacteria. The disease can also be transmitted from mother to foetus through the placenta. In humans, it is transmitted via contaminated animals or food products, or from mother to foetus.

Symptoms: The disease causes various symptoms of the central nervous system, such as circling. Pregnant animals suffer from abortions, weak fawns and fawn mortality. The bacterium is a common cause of eye infections.

In cervids, listeriosis causes abortions and weak fawns.

Findings: General septicaemia findings and corneal infection (kerato conjunctivitis) are typical findings.

Control: Game animals must not be offered poor-quality silage at feeding grounds, and it should not be within their reach. For instance, old bales of green fodder in the forest are a risk.

Neurological symptoms, circling and eye infections are symptoms of listeriosis.

Risk of human infection and protective measures:

- In humans, *Listeria* bacterium causes food poisoning. The infection may be extremely serious for high-risk groups: the elderly, children and pregnant women. The infection causes meningitis, septicaemia and miscarriages.
- High-risk groups should avoid vacuum-packed, raw-cured and cold-smoked seafood, unpasteurized dairy products and soft cheeses. Good slaughter hygiene and correct temperatures in food storage are essential.

Is it safe to eat the meat? The meat of a diseased animal must not be eaten or given to domestic animals.

Keep in mind: *Listeria* bacterium is problematic in food industry. It is able to proliferate in refrigerated temperatures, and it can endure 20% NaCl. The bacterium also survives well in frozen or dried food products.

Contaminated or poor-quality (high pH) silage left in the forest is dangerous to game animals.

Listeria bacterium is able to proliferate in vacuum-packed raw-cured fish at refrigerated temperature.

2.2.12 Borreliosis, Lyme disease

Agent: *Borrelia burgdorferi* spirochaete bacterium, which is commonly found in the intestines of ticks.

Prevalence: No definitive knowledge of the effect of borreliosis in game animals exists, although it is known that livestock and dogs have been infected with it. However, game animals may be significant

Depending on gender, a tick requires two or three blood meals during its life (2 to 4 years). The first blood meal is needed in order for it to develop from a six-footed larva into an eight-footed nymph, and the second one to develop into an adult. Female ticks require a third blood meal before they lay eggs. During feeding, a tick may transmit many bacteria and viruses from wild animals, such as small rodents and cervids, to humans and other animals.

as a reservoir of the disease, as spirochaetes multiply in the blood of, among others, white-tailed deer and small rodents.

Transmission: The castor bean tick (*Ixodes ricinus*) and taiga tick (*Ixodes persulcatus*) are the main transmitters of the bacterium in Europe.

Symptoms: Causes acute and chronic symptoms in humans. At first, a local infection occurs, followed by flu-like symptoms later on. In the chronic stage, joints, muscles and heart are affected.

Findings: In the early stage of the disease, diagnosis is based on symptoms and clinical picture. In addition, a rash develops on the site of a tick bite. Later, the diagnosis is confirmed by elevated antibody content.

A family of castor bean ticks having a blood meal on the skin of a white-tailed deer.

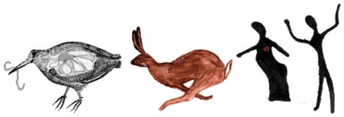
Control: The disease is prevalent in areas where ticks are commonly found. Dense animal populations, e.g. the deer populations of the Finnish Archipelago, maintain a voluminous tick population.

Risk of human infection and protective measures: Borreliosis is the most common infectious human disease spread by ticks in Europe. Protection from ticks by using insect repellents and protective clothing is important, as well as tick inspections after time spent outdoors, and the recognition of an infected bite. If the tick can be removed within 10 hours of attachment, infection is rarely transmitted. Pets must also be protected from tick attacks.

Is it safe to eat the meat? Borreliosis cannot be transmitted from ingested meat.

Keep in mind: Tick-borne encephalitis (TBE) is another human disease transmitted by the bite of several species of ticks. The disease manifests as encephalitis caused by the TBE virus, which is transmitted by tick saliva during a blood meal. It can also be transmitted through the non-pasteurized milk of infected goats, sheep or cows. The virus has three types which have different virulence. The disease causes severe flu-like symptoms that may result in lifelong and severe chronic problems and neurological disorder. The infection can be prevented by vaccination. After the disease, lifelong immunity occurs. In addition, the same precautions apply as under Borreliosis. However, removal of an attached tick does not help, as the virus is transmitted immediately after the bite.

2.2.13 Tularaemia, rabbit fever



Agent: *Francisella tularensis* bacterium, which survives well in the environment and in animal carcasses. The disease affects lagomorphs/hares and rodents, and it is easily transmitted to humans.

Prevalence: Found in hares, rodents and birds in the northern hemisphere. Cats may also be infected, but the likelihood of infection in dogs is small.

Transmission:

- In the wild, the disease is stored in small rodents that show no signs of disease. Tularaemia bacterium is extremely virulent.
- It is transmitted by arthropods: horse flies, black flies, mosquitoes, lice and ticks. The bacterium can also be transmitted through water, stools and infected animals. Epidemics quiet down in the autumn when insects die.

Symptoms: Tularaemia is lethal for hares and brown hares. An infected hare is often slow and tame, but normally the animal dies without premonitory symptoms. An infected animal dies within 2 to 10 days.

Findings: Findings of general infection in hares. Often also enlarged spleen, and liver showing small, light spots. Diagnosis is based on symptoms, typical alterations and analysis of antibodies.

Control: Animals that have died from the disease must be buried.

Risk of human infection and protective measures:

- The infection is transmitted to humans via direct contact with infected animals, or through blood-sucking insects. The disease may also be transmitted through wounds or the respiratory tract, or via inadequately cooked meat.

Tularaemia is a lethal bacterial disease for hares and brown hares. Moles are carriers of the disease.

Tularaemia causes blood poisoning in hares. Findings include necrotic hepatitis and splenitis manifested by light-coloured spots on the surface of the organs (Photo: SVA Uppsala, Sweden).

- The bacterium is virulent, and infection results from only a few bacteria. Mass contagion has occurred as a result of people drinking contaminated surface water.
- Human symptoms include a deep ulcer at the site of the insect bite, swelling of lymph nodes and prolonged fever. If inhaled, the bacterium causes pneumonia.
- Protection against insect bites is important in prevalent areas. A suppurating ulcer occurring at the site of an insect bite is the first sign of an infection.
- Do not touch diseased or dead hares or rodents without protection. In areas where the disease is prevalent, caution must be maintained in handling killed hares. Surface water must not be drunk unboiled. Possibility of an infection must be considered also in handling of hunting dogs.

Is it safe to eat the meat? The meat of an animal infected with tularaemia must not be eaten or given to animals. An animal who died from the disease must be buried.

Keep in mind: Epidemic nephropathy is a disease spread by small rodents. It is caused by a hantavirus called Puumala virus. The bank vole acts as the carrier of Puumala virus, spreading it into the environment in its excretions. Humans are infected through inhalation of dust from vole droppings. Direct transmission through, e.g. damaged skin is possible. The virus may survive in infectious form in the environment for a few weeks. Cases of epidemic nephropathy track with the vole population. The disease is most prevalent in autumn. The infection causes high fever, headache and intestinal symptoms. Impaired vision is common. Sometimes severe renal dysfunction and even shock occurs. The disease is confirmed by antibody tests from blood samples. After an illness, lifelong immunity occurs. There is a great number of globally prevalent vole-borne diseases caused by various hantaviruses. They are much more serious than the disease caused by the Puumala virus.

2.2.14 Leptospirosis

Agent: Bacteria of the genus *Leptospira*. Several types that are specific to various animal species exist.

Prevalence: *Leptospira* bacteria are ubiquitously found in rodents as well as in domestic and wild animals. The bacterium is more common in warm climates.

Transmission: These bacteria are a minor pathogen for wild animals. However, these animals may carry and excrete the bacterium and thus constitute a source for infection of humans and domestic animals. The bacterium finds its way to the kidneys and urinary tracts where it may cause a chronic infection and bacterial secretion. The disease is transmitted to other animals or humans by infected urine or water, or environment contaminated by it.

Symptoms and findings: Animal infections are often asymptomatic. Animals may show fever, blood in urine, abortions and fall in milk yield. Diagnosis is based on the demonstration of antibodies or a bacterial finding.

Control: Prevention of contacts between wild animals and livestock, domestic animals and pets, for instance, by fencing of paddocks. In paddocks, no-outlet ponds and slow-flowing streams, used by animals as watering holes, may be hotbeds of infection.

Risk of human infection and protective measures:
- Several types of *Leptospira* bacterium can be contagious for humans. Ulcers or mucous membranes of the eyes, mouth or nose may function as routes for the infection transmitted by animal urine contaminated water. The infection may also be transmitted directly from a diseased animal, such as a dog.
- Leptospirosis causes high fever, severe headache and muscle ache, stomach cramps, diarrhoea and vomiting.
- Surface water must not be consumed without heating. Swimming is not advisable at such beaches or slow-flowing waters that are located by the side of animal paddocks.
- If you travel with a dog to a disease prevalent area, it is worthwhile to get the dog vaccinated against the disease. The vaccine protects the dog from the infection. However, it can still be a carrier and transmitter of the *Leptospira* bacterium.

2.2.15 Q fever

Cause: A Rickettsia bacterium (*Coxiella burnetii*), which is smaller than normal bacteria but bigger than viruses.

Prevalence: The infection is commonly found in various mammals and birds worldwide. It is a disease affecting ruminants, dogs, cats, doves, and monkeys including humans. The bacterium has been found in wild ruminants, whose possible clinical picture is unknown.

Transmission:
- Q fever is transmitted by ticks. The infection is transmitted from animal to animal through blood meals. The infection may also result from milk, meat, urine, stools and bacteria-infested dust.
- Asymptomatic carriers excrete bacteria into the environment and milk, or to the birth canal mucus, and from there to dust. Wild animals such as moose, deer, wild boar, rats and rabbits may also excrete bacteria.

Symptoms: The animal loses its appetite and suffers from nasal discharge. Ruminal paralysis and bloating occur in ruminants. In addition, miscarriages, weak fawns and fertility disorders occur.

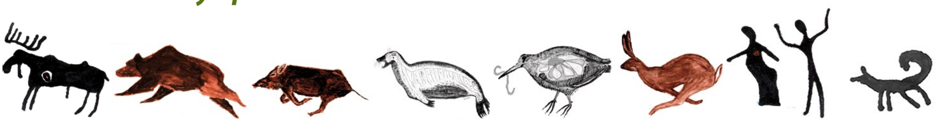
Findings: Diagnosis relies on detection of antibodies against the agent or of antigens.

Control: Avoidance of contacts between wild and production animals in, e.g. paddocks and feeding grounds.

Risk of human infection and protective measures: The disease is zoonotic and perhaps the most virulent of diseases, as it is possible for humans to be infected by a single bacterium. In humans, the disease causes fever and pulmonary infections. In Scandinavia, the infection is common in Denmark: connection has been made between the disease and frequent stays in the wilderness. For humans, the disease can be tick-borne. It can also result from unpasteurized milk, an infected animal's meat, urine, stools, and from exposure to bacteria-infected dust when skinning, for instance. In prevalent areas of the disease, protective gloves and clothing must be used when handling dead animals. Careless handling of aborted calves and afterbirth, and feline and canine foetal fluids is risky.

Is it safe to eat the meat? The meat of an infected animal must not be eaten.

2.2.16 Swine erysipelas



Agent: *Erysipelothrix rhusiopathiae* bacterium.

Prevalence: The disease is globally found in many species of domestic animals, such as birds, pigs, cattle, horses and dogs. In game animals, the disease has been documented in wild boars, bears, cervids including reindeer, seals and birds. The bacterium is also prevalent in fish and crustaceans.

Transmission: The bacterium occurs in excretions of infected animals. It may survive in soil and water for several weeks. The infection is transmitted through direct contact or indirectly, e.g. through feeding grounds or soil.

Symptoms: Pigs manifest symptoms such as loss of appetite, apathy, fever, and red, sharp-edged patches on the skin. In wild boars, swelling of the head area is a typical symptom. May cause sporadic deaths in wild animals. Mass mortalities of birds have been reported.

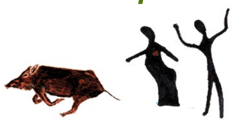
Findings: The chronic form of the disease includes symptoms such as necrotic cutaneous infection, inflammation of the inner layer of the heart, and arthritis. In acute, lethal diseases, findings of general blood poisoning are discovered.

Control: Game feeding ground hygiene and minimization of contacts between wild and production animals may prevent transmission of the disease.

Risk of human infection and protective measures: The disease is zoonotic and may be transmitted to humans through small skin lesions when handling an infected or carrier animal. The disease is regarded as occupational disease of slaughterers. Symptoms in humans are similar to symptoms presented by pigs. Good safeguard procedure includes good slaughter hygiene and relevant protective gear, such as disposable gloves.

Is it safe to eat the meat? Meat of diseased animal must not be eaten. Handling of carcasses or parts thereof must be done with care.

2.2.17 Streptococcal disease of swine



Agent: *Streptococcus suis* bacterium.

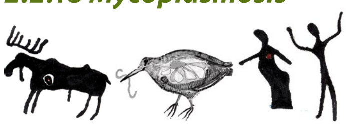
Prevalence: An important pig pathogen that is widespread everywhere, especially in countries of intensive pork production. The bacterium is also found in wild boars.

Symptoms and findings: The bacterium causes blood poisoning, inflammation of the lining of the brain (meninges) and the inner lining of the heart (endocardia) in pigs. The mortality rate is high.

Risk of human infection and protective measures: The disease is a serious zoonosis and may cause similar clinical pictures in humans and pigs. The clinical picture includes blood poisoning, meningitis and endocarditis. Human infection occurs from a close contact with infected or asymptomatic carrier pigs or their carcasses, or from meat processing. The infection is transmitted through, e.g. small scratches or skin lesions. Good work and hand hygiene must be maintained in the handling and skinning of wild boars, and also in using pork in cooking.

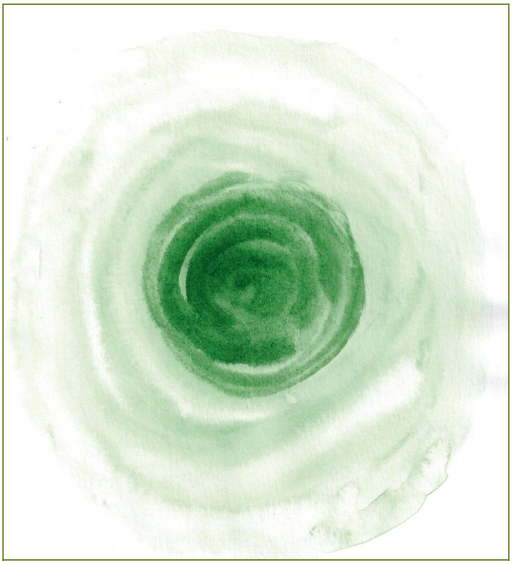
Is it safe to eat the meat? The meat of an infected animal must not be eaten.

2.2.18 Mycoplasmosis



Agent: Mycoplasmosis is caused by primitive, small mycoplasma bacteria that lack cell wall. Several species of mycoplasma exist. The species found in ruminants are, among others, *Mycoplasma bovis* and *M. ovis*, in birds *M. gallisepticum*, *M. meleagridis* and *M. synoviae.*

Prevalence: Acute and chronic diseases caused by mycoplasma bacteria are ubiquitously found in production animals. Infections have been reported in several farmed and wild animal species, including humans.



Mycoplasmae are primitive bacteria that lack cell walls.

Transmission: The bacterium is transmitted by direct contact or through food contaminated by excretions of infected animals, e.g. at feeding grounds. Predisposing factors, such as lack of food or overdense populations, further the transmission of the disease. The bacteria may also be vector-borne.

Symptoms: Causes acute or chronic respiratory infections. Symptoms include discharge from the nose or eyes, cough and loss of weight. High mortality epidemics among wild even-toed ungulates have been reported.

Findings: Inflammation of the lung (pneumonia) via the blood stream. Demonstrating the bacterium by conventional laboratory tests is difficult. Recognition of genetic material is often the most reliable method.

Control: Maintaining hygiene at feeding grounds, and avoiding the development of overdense populations.

Risk of human infection and protective measures: In humans, a connection between mycoplasma infections and lengthy respiratory infections is assumed. Mycoplasma are mainly species-specific, and the risk of human infection from animals is considered small. However, transmissions from close contacts with infected animals have been reported.

Is it safe to eat the meat? The meat of an infected animal must not be eaten.

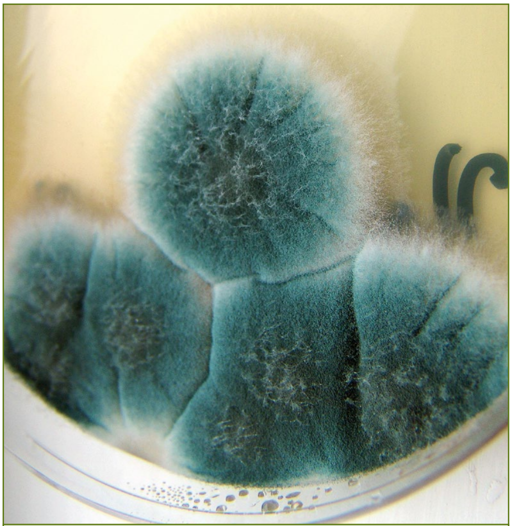
Keep in mind: Seal finger is a zoonotic infection, which can be contracted from handling seals or their pelts. The infection can result from bites or via skin damaged by sharp-edged bones. The infection causes a painful inflammation of cutaneous and subcutaneous tissue. The infection may spread to nearby joints and bones. Mycoplasma bacteria are regarded as the cause of seal finger. Previously the disease was treated by amputation of infected digits, but nowadays treatment by antibiotics is efficient.

2.3 Fungi: yeasts and moulds

Fungal cells are slightly bigger than bacteria, eukaryotic (i.e. they contain a nucleus), and structurally more complex than bacteria. Enclosed within chitin cell walls there is cytoplasm that contains organelles. The reproduction of fungal cells occurs by division, when either filamentous (moulds) or yeast-like (yeasts) structures are formed. Under unfavourable conditions, fungi can produce resilient forms called spores that persist for long periods in the environment. Spores can travel over long distances, spread via air, objects, or humans and animals.

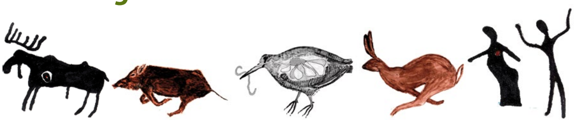
Fungi are found everywhere in the environment. Many of them carry an important economic role in food, bakery, pharmaceutical and brewing industries, among others. Some yeasts and moulds are pathogenic. They are commonly found in the environment, and they are usually opportunistic pathogens. Their virulence is low. They cause diseases when the resistance of an animal has been weakened by various stress factors such as overdensity, insufficient feeding or unfavourable conditions.

Fungal diseases are most common in farmed wild animals. For instance, fungi of the genera *Absidia*, *Aspergillus*, *Candida* and *Mucor* have been reported to cause infections in wild animals. Fungi may cause diseases by entering into tissues and reproducing in there. Another possibility is that fungi produce mycotoxins in food and cause intoxication to those that eat the contaminated food. It is assumed that mild autumns, when the ground is still unfrozen when the first snow falls, make living conditions more favourable to various fungi. On entering the body in food, the toxins possibly produced by fungi may cause a group of different symptoms that are often difficult to recognise.



Filamentous growth of *Aspergillus fumigatus* fungus on a Petri dish (Photo: Terje Josefsen).

2.3.1 Ringworm



Agent: There are several species of ringworm that can cause disease for animals and humans (*Microsporum gypseum*, *M. canis*, *Trichophyton verrucosum*).

Prevalence: Universally prevalent in domestic and wild animals as well as in humans. Infections have most often been reported in farmed animals, but ringworm is also found in wild cervids and carnivores. Asymptomatic carriers are common.

Life cycle and transmission: The fungus is transmitted by direct contact with diseased or carrier animals, or by resilient spores in the environment. Dense populations favour the transmission of the fungus.

Symptoms and findings: Ringworm forms round, hairless, slowly enlarging patches mostly on the skin of the animal's head and neck. At first the skin is red, but later it turns grey and scaly. Skin alterations may be widely spread. Symptoms are often more pronounced in animals that are young or suffer from some other diseases.

Control: Prevention of development of overly dense animal populations, and maintenance of feeding ground hygiene are useful means in reducing the spread of the disease.

In humans, ringworm causes red and itchy patches that do not heal easily.

Risk of human infection and protective measures: This difficult-to-heal infection can be transmitted to humans, e.g. when handling an infected animal. Symptoms are similar to those of animals, but the disease can be more severe. Typical alterations are red, itchy patches that can be dry or suppurating. Sometimes the rash area starts to heal from the centre, and ring-like alterations are shown. It is important to use protective gear when handling or skinning an animal with skin changes.

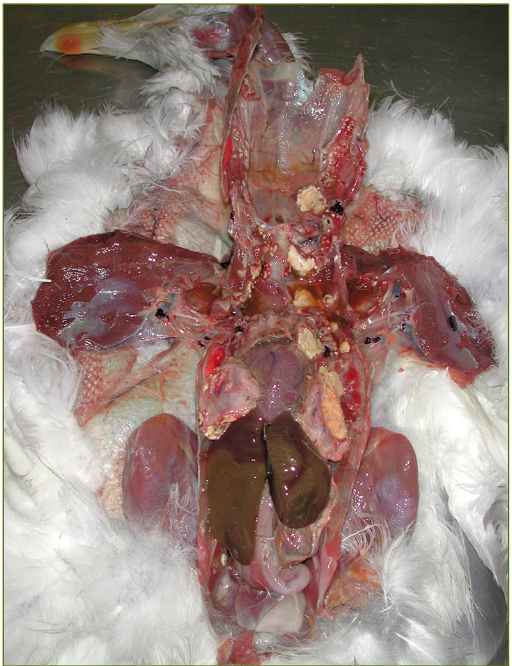
Is it safe to eat the meat? The meat is safe to eat. Altered areas are removed.

2.3.2 Aspergillosis

Agent: Aspergilloses are respiratory infections caused by fungi of the genus *Aspergillus* (the most common is *A. fumigatus*).

Prevalence: The disease is ubiquitously found in birds. Infection is most common in waterfowl, but cases may also occur in landfowl, for instance.

Life cycle and transmission: *Aspergillus* fungus is common in the natural environment, and it is typically found in decaying organic matter. Contagion occurs through spores produced by the fungus. Spores enter the respiratory tract where the fungus starts reproducing. Outbreaks are most common in autumn, and predisposing factors for the disease include a bird's young age, dense colonies, and, e.g. starvation or parasitic infections.



Fungal growth caused by aspergillosis (light areas) in a bird's air sacs (Photo: Norwegian Veterinary Institute, Norway).

Symptoms and findings: Aspergillosis can be acute or chronic. Typical symptoms include respiratory tract symptoms, difficulty in breathing, weight loss and drooping wings. The fungal infection may progress from the lungs and air sacs to the body and brain and cause central nervous symptoms. Cheese-like, light yellow alterations in the lungs and air sacs are typical findings.

Control: It is not possible to control this disease in the wild.

Risk of human infection and protective measures: Aspergillosis is regarded as a zoonosis that can infect people whose immune resistance is weakened. It is advisable to use a mask and rubber gloves when handling diseased or dead birds.

Is it safe to eat the meat? The meat of an infected bird must not be eaten.

2.4 Parasites

Parasites, and changes caused by them, are the most common findings that a hunter confronts in game handling. More often than not, the findings are harmless examples of the diversity of life and do not pose a threat to human health, although some exceptions do exist.

Parasitism is the most common form of life of all living organisms: the parasite lives at the expense of another organism, the host.

In general, parasitism is not beneficial to the other part of the symbiosis, the host, but a parasite is usually not fatal to its host. However, sometimes accidents can happen, for example when infection pressure is high, or immunity is weakened by starvation.

Some parasites, especially those whose life cycle involves intermediate hosts, may have an effect on the behaviour of the intermediate host animal, if it advances the parasite's life cycle, and make the animal more susceptible to predation.

It is important to distinguish between a parasitic infection, which practically all animals have, and a disease caused by parasites. The manifestation of disease is often directly comparable to the severity of parasitic infection.

Most parasites are specific to particular host animals and cannot proliferate in other species. Sometimes a parasite may jump from one host species to another, and then it is possible that the parasite causes harmful damage.

Parasites that inhabit tissues and spaces in the host's body are called endoparasites, and parasites that live on the skin, fur or near the host are called ectoparasites. Transmission of parasites from animal to animal occurs directly through eggs or larvae, or indirectly via vectors or intermediate hosts.

In order to complete life cycles, the intermediate host of many parasites must become the prey of the final host. The life cycle of the bear tapeworm (*Taenia arctos*) involves a moose that ends up as a meal for the bear.

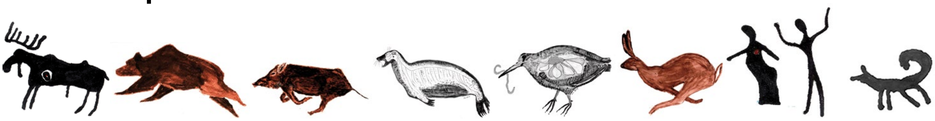
Parasites are divided into three groups, which in turn divide into various subgroups:

- **Protozoa** (Protozoa)
- **Worms**
  - Flukes (Trematoda)
  - Tapeworms (Cestoda)
  - Roundworms (Nematoda)
- **Arthropods** (Arthropoda)
  - Insects (Insecta)
  - Arachnids (Arachnida)
  - Tongue worms (Pentastomida)

2.4.1. Protozoa

Protozoa are primitive, unicellular and eukaryotic (having nuclei in cells) organisms. They absorb nutrients directly through their cell membrane from the environment. The size of the protozoa varies from 5 to 50 µm (even 1 mm). Protozoa are ubiquitous, and they include several pathogens.

2.4.1.1 Toxoplasmosis



Agent: The protozoan *Toxoplasma gondii*, whose primary host is the felid (cat) family.

Protozoa are primitive, unicellular and eukaryotic organisms. Many of them can move with slender protuberances called cilia.

Prevalence: Toxoplasmosis infection and the disease caused by it is globally prevalent in several domestic and wild animal species, such as cervids, wild boars and small mammals, as well as humans. Some 10 to 30% of the population, depending on the species, have had the infection.

Hosts, life cycle and transmission: Toxoplasma is a parasite of cats and felines. The sexual reproduction of the parasite occurs in the intestines of a cat. Felines shed infectious forms of the parasite (oocysts) in their faeces. Oocysts survive in soil for several months. Oocysts infect the intermediate host via food or drinking water contaminated by cat faeces. The asexual reproduction of the parasite occurs in the intermediate host. Toxoplasma forms small cysts in the muscle and nervous system and also in the liver and lungs of an intermediate host. When a cat eats parts of an intermediate host, such as a mouse, that contain toxoplasma cysts, the parasite's life cycle is completed.

Toxoplasma infection is transmitted to animals or humans through oocysts contained in the stools of an infected cat. Vegetables, root vegetables or drinking water may be contaminated by them. A cat gets the infection by eating a mouse, whose behaviour is more fearless due to the influence of the parasite.

Symptoms and findings: Toxoplasma infection does not cause visible symptoms in felines or the many intermediate hosts of the parasite, such as moose or deer. The parasite is a common cause of death in hares, and also some marine mammals are susceptible to the parasite. A markedly enlarged spleen is often discovered in hares. Diagnosis is based on the demonstration of the protozoa or antibodies against protozoa in tissues.

Control: The spread of the parasite is prevented by keeping cats from roaming free in the wild, on cultivated land or in cowsheds.

Risk of human infection and protective measures:

- Toxoplasma infection poses a risk to pregnant women. The parasite can transmit to foetus via placenta and cause developmental disorders, which can lead to blindness or underdevelopment of the baby's central nervous system. Some of the symptoms may occur later in life.
- Humans can be infected by eating undercooked meat that contains toxoplasma cysts, or from careless handling of raw meat. The infection may also transmit directly from the stools of a cat shedding toxoplasma oocysts, or via contaminated vegetables or soil.
- Infection prevention requires good hand and kitchen hygiene while raw meat is handled. Cysts are destroyed by cooking the meat to an internal temperature of at least 67 °C. Freezing destroys muscle cysts, but not oocysts that come from cat faeces. Pregnant mothers should avoid contacts with cats and should avoid handling cat litter. It is important to monitor the quality of irrigation water, and to wash and peel vegetables and root vegetables before eating. Letting cats roam free and hunt rodents increases their risk to be infected with the parasite and thus transmitting the infection.

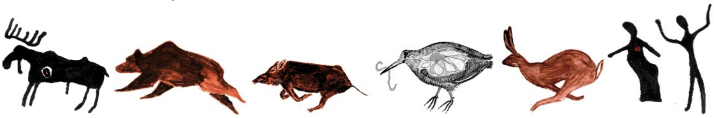
Infection can be transmitted by eating undercooked meat that contains toxoplasma cysts.

- Toxoplasma has been found in the milk of sheep, goats, cows, cats and mice and infection by ingestion of raw goat milk has been documented in humans.

Is it safe to eat the meat? The meat is safe to eat after it has been cooked. Remember to maintain good hand hygiene also in game handling.

Keep in mind: The protozoan *Neospora caninum* is closely related to toxoplasma. Its primary host is the domestic dog, which sheds infectious oocysts in faeces. Ruminants are intermediate hosts, in which asexual reproduction and formation of infectious tissue cysts occurs. The parasite is regarded as one of the most important causes of spontaneous abortions in cattle in the world. The parasite is prevalent also in cervids, but the clinical picture and symptoms caused by it are not known. Cross infections between domestic and wild animals are possible via dogs. The dog is infected via eating for instance an aborted foetus, afterbirth or uncooked meat that contains cysts.

2.4.1.2 Sarcocystosis



Agent: The protozoan *Sarcocystis*, of which there are several species.

Prevalence: The protozoan is globally prevalent in various mammals, birds and reptiles. In game animals, the parasite is commonly found especially in anseriformes (ducks) and cervids.

Hosts, life cycle and transmission: Carnivores are asymptomatic primary hosts of the parasite. They excrete infectious parasitic forms, oocysts, into the environment in their faeces. The parasite enters the intermediate host via faeces-contaminated food or water. After ingestion by the intermediate host, asexual reproduction and formation of cysts to the muscles occurs. When a carnivore eats meat that contains such cysts, it is infected and the parasite's life cycle is completed.

Symptoms and findings:

- Symptoms caused by the parasite are rarely noticed. Severe infection in skeletal or cardiac muscles may cause decrease in muscle mass and difficulty moving. It may even cause paralysis. The symptoms can make the animal weak and more vulnerable to predators, and thus assist in the life cycle of the parasite.
- The parasite forms infectious cysts (0.01 to 1 cm) in striated muscles. The cysts are oval in shape and look like rice grains. In ducks and in some species of cervids, the cysts are visible to the naked eye. In ducks they are usually located in pectoral muscles. Sometimes the cysts are calcified and make a scratchy noise when the meat is cut. Cysts in mammals are often small and a microscopic examination is required for the diagnosis.

Control: The infected animals are buried and feeding grounds for water fowls are established so that the stools of predators cannot contaminate them.

Risk of human infection and protective measures:

- Genus *Sarcocystis* includes zoonotic parasites. The risk of Sarcocystosis transmission from game meat to humans caused by these parasites is considered small, although cases where humans have been infected by raw deer meat have been reported.
- In birds, the outward appearance of cyst-infected meat usually causes it to be rejected already before cooking. The knowledge on this parasite is incomplete, but cooking makes the meat safe.

Is it safe to eat the meat? The parasite is destroyed by cooking. After that the meat is safe to eat.

In Europe, the primary host of avian *Sarcocystis rileyi* parasite is as yet unknown. However, two invasive alien species make good candidates, the raccoon dog (*Nyctereutes procyonoides*) rummaging lakesides in the Baltic countries and Finland, and the raccoon (*Procyon lotor*) in whose faeces sporocysts have been found (in the Czech Republic).

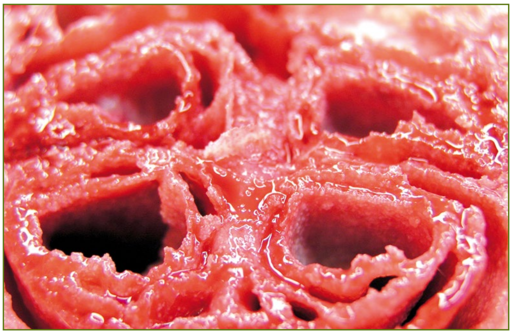
In ducks, *Sarcocystis* infection is shown as rice-like, light-coloured spots in the pectoral muscles (Photo: Valerie Dunkin).

Sarcocystis in the diaphragm of roe deer (Photo: Peter Paulsen).

2.4.1.3 Besnoitiosis

Agent: Protozoa of the genus *Besnoitia*, of which there are several species.

Prevalence: Ubiquitous parasite, prevalent in wild and domestic herbivores. *Besnoitia tarandi* is prevalent in reindeer, wild forest reindeer and caribou, and reported from mule deer and musk ox. *B. besnoiti* infect cattle, wildebeest, kudu and impala. Antibodies against *Besnoitia* species has been found in red deer and roe-deer.



Infectious cysts of *Besnoitia* parasite are formed in the intermediate host's conjunctiva (eyes), on the surface of nasal conchas and in subcutaneous tissue.

The likely host animal of *Besnoitia* parasite is a feline infected from preying on herbivores that have infectious parasitic cysts in their body.

Hosts, life cycle and transmission:

- The primary hosts are carnivores. The primary host of *B. tarandi* is unknown, but felines are regarded as suspects.
- The parasite reproduces sexually in the intestines of the primary host and produces oocysts to the host's faeces. They become infectious in soil. The herbivore intermediate host is infected by food. The parasite's asexual reproduction into infectious cysts occurs in the intermediate host's connective tissues, skin, subcutaneous tissues and blood vessel walls. When a carnivore eats an intermediate host animal, it is infected and the parasite's life cycle is completed. The link between the sylvatic and domestic life cycles is unknown. Insect vector is also suspected.

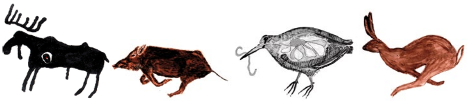
Symptoms and findings: No symptoms have been detected in the primary carnivore hosts. In intermediate hosts, a mild infection goes easily undetected. Chronic infection causes hairlessness and thickening of skin. Hard cysts of around 1 mm in size are formed in subcutaneous tissue, the conjunctiva of the eye, on the mucous membranes of the nasal conchas and in periostea covering bones. The cysts are calcified and cause a scratching noise when the meat is cut, or typically when the animal is skinned. This phenomenon is called 'sand reindeer' in Finland. Bleeding and secondary infections occur, and a severe infection leads to the starvation and death of the animal.

Control: Meat containing parasitic cysts must not be offered uncooked to domestic or wild animals.

Risk of human infection and protective measures: There is no known risk to human health.

Is it safe to eat the meat? If there are signs of a general disease, the meat should not be eaten. In other case, the meat must be thoroughly cooked.

2.4.1.4 Coccidiosis



Agent: Protozoa of genus *Eimeria* called coccidia, several species.

Hosts, life cycle and transmission: Coccidia are prevalent in several species of mammals and birds. Different animals have their own species of parasites that are not contagious for other species. Coccidia live in the intestines of their host animals and produce egg-like oocysts to their faeces. The oocysts become infectious in suitable environment. The infection is transmitted to another animal via faeces-contaminated food or drinking water.

Coccidia are transmitted directly by stools and cause disease especially in young hares.

Coccidiosis is a risk for farmed pheasants as well as for those caged for breeding (Photo: Mikaela Sauvala).

Symptoms and findings: The parasite reproduces in the intestines and damages the intestinal lining causing diarrhoea and intestinal dysfunction. Coccidiosis is a common cause of mortality in hares. In hares, severe infection causes dehydration, wasting and death. In summer, coccidia are sometimes prevalent in cervid fawns and can cause diarrhoea. Coccidia also cause mortalities in birds, especially in dense colonies.

Control: In dense populations, the transmission of the parasite increases and infection pressure grows. Consequently, coccidia may become a significant cause of mortality in young animals. Correct location and hygiene of game feeding grounds is important. The feed must not be contaminated by stools.

Risk of human infection and protective measures: Animal coccidiosis is not contagious for humans.

Is it safe to eat the meat? The meat of a diseased animal must not be eaten. The parasite is killed by cooking.

Keep in mind:

- The protozoa *Giardia* and *Cryptosporidium* are common causes of severe intestinal infections in humans. The infection is transmitted by water contaminated by the faeces of carrier animals or humans. Infection has also been found in several cervid species and beavers, among others. Some strains of the parasites are extremely virulent, only a few cysts may cause an infection.
- When travelling in areas where these parasites are prevalent and found for instance in municipal waters, only bottled drinks should be used. When hiking in the wilderness, natural water must be boiled at least for one minute, in order to kill the parasites.

2.4.1.5 Babesiosis

Agent: Protozoa of genus *Babesia*, several species, of which some are contagious for humans.

Prevalence: Earlier, bovine babesiosis was common, due to animals grazing in woodlands. Nowadays, *Babesia* protozoa cause a problem mainly in Australia, Africa, Central and South America, and the USA. The human disease is becoming more common also in Europe and North America.

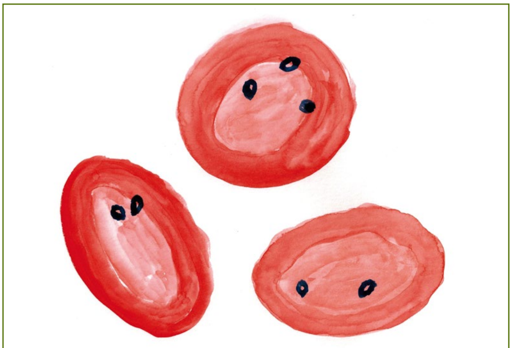
Hosts, life cycle and transmission: The parasite is transmitted by ticks (amongst others, *Ixodes ricinus* and *Ixodes persulcatus*). *Babesia* protozoa reproduce in the host animal's blood, inside the red blood cells, and break them. The parasite is transmitted to ticks through blood meals. When a tick takes its next blood meal, it infects a new animal with the disease.

Symptoms and findings: In cattle, the symptoms are fever, loss of appetite and, due to loss of red blood cells, quickened breathing, anaemia, blood in urine and enlarged spleen. The protozoan may cause similar symptoms also in wild animals and reindeer.

Control: In wild animals, disease control is not possible. Protecting production animals and pets from ticks during pasture season is a good way of preventing the disease.

Risk of human infection and protective measures: It is possible that various game species are the principal reservoir hosts for zoonotic *Babesia* species. As a result of a tick bite, several species can be transmitted to humans. The infection is often asymptomatic, but for immunocompromised persons the parasite may cause severe generalized diseases, the early symptoms of which resemble those caused by borreliosis. The disease can be avoided by using protection such as repellents or protective clothing against tick bites.

Is it safe to eat the meat? The parasite is not transmitted by eating meat, but only by tick bites.



Babesia parasites reproduce inside the host animal's red blood cells and break them. Symptoms include anaemia and blood in urine.

Today, babesiosis cases are not as frequent as before when grazing of cattle in woodland areas was more common.

2.4.1.6 Trypanosomosis

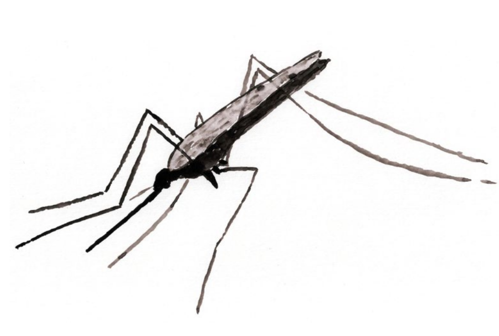
Agent: Protozoa of the genus *Trypanosoma*.

Prevalence:
- *Trypanosoma* protozoa are a significant group of pathogenic parasites that cause diseases in humans and animals in Africa and South America. In humans, the parasites cause a disease called sleeping sickness, and in ruminants a lethal disease called nagana.
- *Trypanosoma* parasites are found in wild ruminants, more specifically also in cervids and reindeer. However, the diseases they cause have not been reported in Northern Europe, and their importance in relation to the health of cervids is unknown.

Life cycle and transmission:
- The dangerous *Trypanosoma* species are transmitted by tsetse flies. The fly catches the infection via a blood meal it gets from an infected animal. Inside the fly, the parasite becomes infectious and when the fly has another blood meal, the infection is transmitted. The parasite may be transmitted from mother to foetus, and it may also be transmitted mechanically via infected blood, e.g. via horse fly or bat bites.
- The life cycle of the cervid *Trypanosoma* parasite is unknown. The parasite, capable of moving independently inside the new host, reproduces and is spread to the body via bloodstream.

Symptoms and findings: Local infectious reaction will develop at the location of the tsetse fly bite. After the parasite has spread to the body, the disease breaks. The course and symptoms of the disease vary greatly depending on the species, race and condition of the animal. In a susceptible animal, the result is gradual wasting, anaemia and weakness. If untreated, the disease is lethal. Findings include signs of general infection, swelling of lymph nodes, and deterioration of vital organs. The parasites can be identified via microscopic examination of a blood sample.

Trypanosomes cause severe diseases in Africa. Parasites have also been found from the cervids of Fennoscandia, but their significance or vector is unknown.



Vectors of the malaria parasite, *Anopheles* mosquitoes, are also found in Fennoscandia.

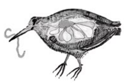
Control: In areas where the pathogenic *Trypanosoma* species are prevalent, the disease is controlled by protecting animals from insect bites, by controlling the number of vector insects, and by medical treatment of infected animals or humans.

Is it safe to eat the meat? *Trypanosoma* parasite can be transmitted via raw meat that comes from an infected animal. The parasite is killed by cooking.

Keep in mind: Malaria is one of the most serious health issues in the world. The cause of malaria, parasitic protozoa of the genus *Plasmodium* (Apicomplexa), are single-celled protozoa. The disease is transmitted from human to human by mosquitoes of the genus *Anopheles*, infected during blood meals. The parasite reproduces in the mosquito and, during the mosquito's next blood meal, is transmitted to a new host. The parasite travels to the liver and later to red blood cells, reproducing and taking over new cells. This results in cell destruction in the target organs and in symptoms, of which shivers and high fever are the most typical. The disease causes mortalities of hundreds of thousands of people every year, especially in southern Africa. Malaria was last found in Finland in the 1940s. *Anopheles* mosquitoes exist in Nordic countries, but the development of the parasite in the mosquito requires warm weather. Along with global warming, the conditions may become favourable for malaria in the north. In prevalent areas of the disease, it is important to take care of disease prevention.

Trichomonas parasite causes the gathering of cheese-like mass to the bird's gullet and crop (Photo: J. Christian Franson, National Wildlife Health Center, USA).

2.4.1.7 Trichomonosis



Agent: Protozoan parasite *Trichomonas gallinae*.

Prevalence: The parasite *Trichomonas gallinae* is a ubiquitously prevalent parasite of the respiratory tract of birds. The disease it causes is regarded as a plague of young doves, finches and passeriformes.

Life cycle and transmission: The parasite can be transmitted directly via an infected bird's oral excretions or through food contaminated by them for instance on bird tables or game feeding sites. It may also be transmitted from mother to chick during feeding, or to birds of prey via their catch. Asymptomatic carrier birds are considered a problem.

Symptoms and findings: The disease can be acute, and birds can die from it without premonitory symptoms. In the more chronic form, an infected bird presents increased mucous discharge from the beak, difficulties in breathing and diarrhoea. The bird loses weight, weakens and fades, and it can have difficulty of maintaining its balance. Greenish discharge or cheese-like mass is accumulated in the mouth, beak and crop. Death comes in a few weeks.

Control: Good feeding hygiene of game and small birds.

Risk of human infection and protective measures: The parasite is not contagious for humans, dogs or cats.

Is it safe to eat the meat? The meat of a diseased bird must not be eaten.

2.4.2 Flukes (Trematoda)

Flukes live in the intestines, liver, lungs, blood vessels or other organs of vertebrates. They are often flatted, and their size varies from a few millimetres to 5 to 6 centimetres. They have two suckers, and often also hooks.

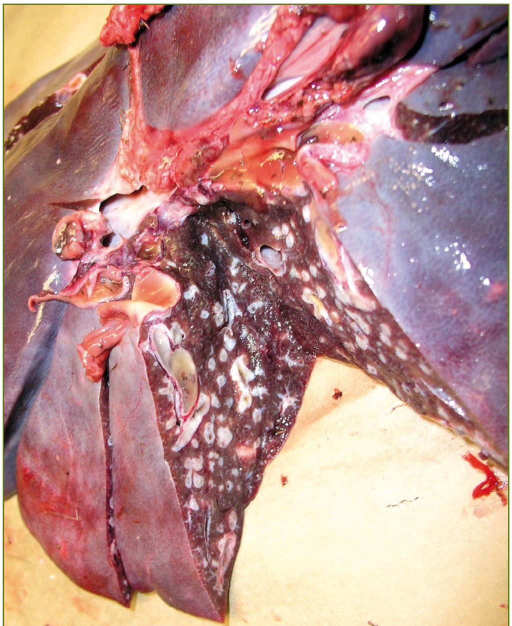
In general, the life cycle of flukes is indirect and involves one or two intermediate hosts. Several flukes that dwell in ducts such as the bile duct are severe pathogens. Many animal liver flukes can infect humans.

2.4.2.1 Liver flukes

Agent: The lancet liver fluke *Dicrocoelium dendriticum*, the common liver fluke *Fasciola hepatica*, the giant liver fluke *Fascioloides magna* and the cervid liver fluke *Parafasciolopsis fasciolaemorpha*.

Prevalence: Liver flukes are parasites of ruminants. As for other trematodes, the habitat characteristics and the prevalence of specific snail species or genera (i.e. the first intermediate host) are critical. Liver flukes are

Flukes are flat and have suckers in their mouths. Many of them, especially those which inhabit ducts, are serious pathogens.

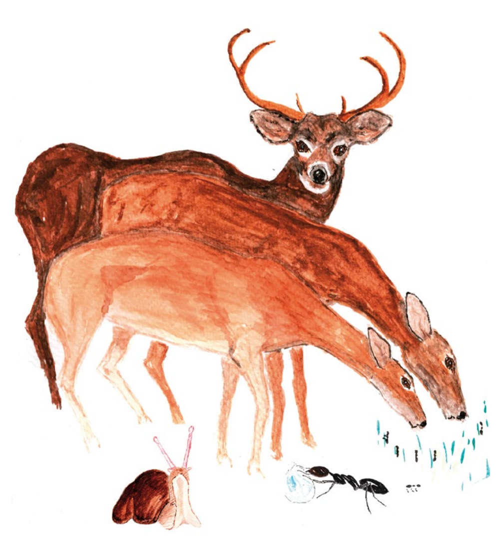


Cirrhosis caused by severe liver fluke infection in a white-tailed deer.

found in domestic and wild animals. Among Finnish game animals, certified findings of the lancet liver fluke and pathological changes caused by it have been reported in white-tailed deer. Symptomatic findings have been made in areas where the white-tailed deer population is dense. The 'giant' liver fluke has been reported to cause fatalities in red deer and roe deer in central Europe (e.g. floodplains around the river Danube in East Austria and the bordering regions of Hungary). There is some evidence that wild boar could carry this parasite and maybe contribute to the spreading of this agent.

Hosts, life cycle and transmission: The life cycle of the liver flukes, apart from the lancet liver fluke, is similar: adult liver flukes dwell in the bile ducts of ruminants. Parasites produce eggs to the gall, in which they travel to the intestines and, in faeces, to the environment. In wet environment, the eggs mature into freely swimming larvae that enter their intermediate hosts, snails or slugs, where the parasite reproduces asexually. Parasites emerge from the molluscs and attach themselves to blades of grass and other vegetation and form the infectious metacercarial stage. From there they are ingested by ruminants. The completion of the life cycle of the lancet liver fluke requires another intermediate host, an ant that catches the parasite from cysts excreted by snails. The parasite affects the behaviour of the ants in such a way that they climb to the tips of vegetation and are thus more easily available for ruminants to eat. Inside the ruminant, the liver fluke larva burrows through the intestinal wall and travels through liver tissue to the bile ducts.

Symptoms and findings: The appearance of symptoms depends on the severity of the parasitic infection. In a severe infection, flukes block bile ducts. This results in liver damage, increased amount of connective tissue in the liver, cirrhosis of the liver, and liver dysfunction. General, visible symptoms may include general apathy and loss of appetite, yellow colour of mucous membranes, and bloating of the stomach. Severe infection is lethal to the animal.



The life cycle of the lancet liver fluke includes two intermediate hosts, a snail and an ant. Eggs excreted by deer in their stools develop into larvae that enter snails. Ants are infected by cysts excreted by snails. Deer contract the infection by eating infected ants while grazing.

Control: It is important to avoid the formation of over dense cervid populations. Game feeding grounds are not to be founded in wetlands.

Risk of human infection and protective measures: People can be infected with animal liver flukes via larvae in water cress, for instance. The common liver fluke (*Fasciola hepatica*) has been reported to be spreading in Western Europe. Snails act as intermediate hosts for the parasite. Human infections of the lancet liver fluke are possible. The best prevention is keeping wild animals away from vegetable gardens, and careful washing of vegetables. Cooking destroys the infectious forms of the parasite.

Is it safe to eat the meat? Liver fluke infection cannot be contracted by eating meat.

Keep in mind:

- *Opistorchis felineus*, the cat liver fluke, also infects other fish-eating mammals, such as foxes and humans. Its intermediate hosts are freshwater fishes.
- A small fluke called rumen fluke (*Paramphistomum leydeni*, *P. cervi*) is found in reindeer and deer. The adult parasite lives attached to the lining of the rumen and produces eggs to the host's stool. Their life cycle is similar to that of liver flukes, with snails serving as intermediate hosts. Adult parasites are harmless to their hosts. In young animals, a severe infection may cause intestinal symptoms as the larvae travel under the intestinal lining.

2.4.2.2 Alaria

Agent: The flatworm *Alaria alata* (Europe). Other species have been found on other continents.

Prevalence: Adult stages, 3-6 mm long, of *Alaria alata* infest the intestines of wild carnivores and have been found in the wild carnivore populations (wolves, foxes, raccoon dogs) in nearly all parts of Europe; the adults are also found in dogs, but only rarely. Intermediate parasite stages (mesocercariae) in wild boar carcasses have been detected in a number of European countries, e.g. Germany, France, Austria, the Czech Republic, Hungary, Croatia, Bulgaria and Serbia.

Hosts, life cycle and transmission:

- Alariae are flatworms whose adult stages live in the intestines of (wild) carnivores. The life cycle of the parasite is similar to that of the flukes mentioned above. Several species are distinguished. The life cycle of *Alaria alata* involves specific freshwater snails as first intermediate hosts and tadpoles/frogs as second intermediate host.
- When infested tadpoles or frogs are consumed by birds, snakes or mammals, the infective stage (mesocercariae) may accumulate in the body of this new host ('transport host'), but will not develop into further stages (metacercariae). In wild boars ingesting infected amphibia the parasite will pass the stomach, migrate through the intestinal wall and move freely in the abdominal cavity, with a tendency to pass the diaphragm and enter the thoracic cavity. Parasites may migrate between muscle structures, and can be found either free-floating in the body cavities or in the connective, fat and glandular tissue of the head and neck or in muscles of the anterior body (also the diaphragm) – in contrast to *Trichinella*, this parasite has some affinity to connective tissue rather than to lean muscle. Mesocercariae have been detected in pigs in the 1880s, and later on (1915) in wild boar.
- Due to the life cycle and habitat requirements, there is both spatial and temporal clustering of this infection.

Symptoms and findings: The mesocercariae are at the border of visibility with the naked eye, so it is unlikely to detect the parasite upon visual inspection. They cause local inflammatory symptoms, but the infested wild boar will not show clinical signs of illness. The mesocercariae can occasionally be found in the course of *Trichinella* testing (artificial digestion), although there are more specific, yet not routinely applied detection methods (migration technique).

Alaria mesocercariae are very motile and change their shape during moving. This, a ventral and an oral sucker as well as the dichotomous internal structure are quite characteristic (Photo: Peter Paulsen).

Control: None in practice.

Risk of human infection and protective measures: There are very few reports on human larval alariosis through consumption of raw/undercooked meat. The meat species involved were frog (legs) and duck, and to date no case has been described in Europe or been specifically attributed to *A. alata*. The rise in wild boar population, the more frequent consumption and changes in meat preparation techniques could change this situation. Symptoms of human disease could be severe lung affections (when the mesocercariae migrate through lung tissue), including anaphylactic reactions, or affections of the eye (neuroretinitis). Mesocercariae can survive several weeks in chilled wild boar carcasses. However, heat processing or fermentation will inactivate the parasite readily.

Is it safe to eat the meat? Mesocercariae are considered potential foodborne pathogens. When mesocercariae are detected in the course of *Trichinella* inspection, carcasses should be declared unfit for consumption. It is assumed that freezing to -18 °C and heat processing to at least 60 °C internal meat temperature will inactivate the parasite.

2.4.3 Tapeworms (Cestoda)

Tapeworms are parasitic worms that live in the intestines of their host animal. They are usually long-lived and large, even several metres long worms. They anchor to the intestinal wall by their sucker-like head, and their typical structure is segmented.

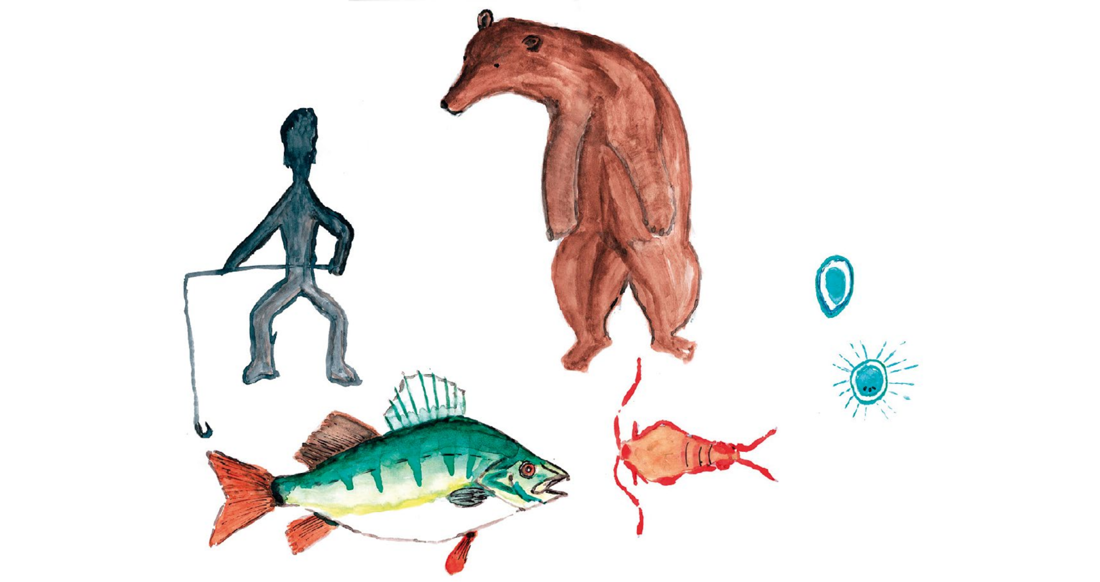
Tapeworms have lost their digestive tract. Their body is covered by tiny projections, microvilli, that absorb digested nutrients from the host's intestine. The segments of the worm are almost entirely filled by sexual organs, and they contain a large number of eggs.

Tapeworms are often large, flat and segmented worms. Each segment contains reproductive structures and is full of eggs.

Tapeworm life cycle is often complex and includes one or more intermediate hosts. Game animals have their own tapeworms whose adult forms dwell in their intestines. Herbivorous game animals often act as intermediate hosts for carnivore tapeworms. Tapeworms develop into infectious larvae in the tissues of their intermediate host. The larvae infect carnivores.

Keep in mind:

- The broad fish tapeworm (*Diphyllobothrium latum*) is the best known tapeworm. In addition to humans, many fish-eating mammals, such as dogs and cats, are the parasite's definitive hosts.



The broad fish tapeworm's life cycle includes two intermediate hosts, a plankton crustacean and a fish. Several animal species, such as the bear or human, can serve as definitive hosts.

- Adult broad fish tapeworm produces a large number of eggs in its segments. Once passed in stools into water, the eggs develop into freely swimming larvae. The larvae are ingested by plankton crustaceans.
- After a few weeks, a new larval stage develops in the crustacean. After the crustacean is eaten by a fish, the larva migrates into the muscles of the fish and develops into an infectious larva that is contagious for humans or animals.
- Humans may contract the infection by eating raw or undercooked pike, perch or burbot, or their roe. Raw-curing or cold-smoking does not kill the parasite. The parasite is killed by thorough cooking or freezing for 24 hours.

2.4.3.1 Tapeworms with herbivores as definitive hosts

Agent: Several species of tapeworms. Different animal species have their own tapeworms, but there are also species that can be found in several host animals.

Prevalence: Tapeworms that dwell in the intestines are common parasites in wild animals. Generally, a hunter sees them in young cervids (genus *Moniezia*) and hares (several species), if the animal's gut has been punctured during hunting or handling.

Life cycle and transmission: Adult parasites live inside the intestines and produce eggs to the host's stools in their segments. The life cycle of many wild herbivore tapeworms is not entirely known, but more often than not they require an arthropod as their intermediate host (a tick from the soil, for

Moose or deer tapeworms (*Moniezia* sp.) live inside the intestines (Photo: Kalle Lehtinen). They can be seen only when the bowel is burst.

example). After the intermediate host is ingested by the definitive host, the parasite's life cycle is completed.

Symptoms and findings: The infection is usually asymptomatic in adult animals. In young animals, a severe infection, or a great number of large parasites, can cause a decline of the host's general condition and make it more susceptible to other diseases.

Control: Dense populations must be avoided, as they increase infection pressure.

Is it safe to eat the meat? The meat is safe to eat.

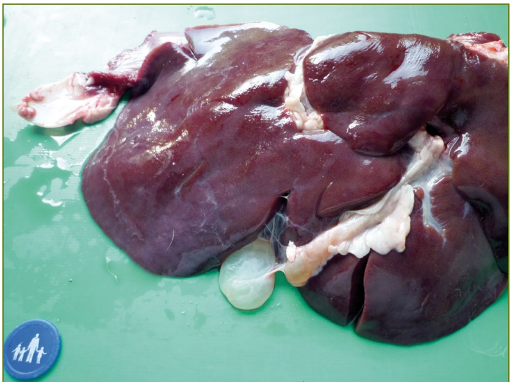
2.4.3.2 Tapeworms with herbivores as intermediate hosts

***Taenia hydatigena* (*Cysticercus tenuicollis*)**

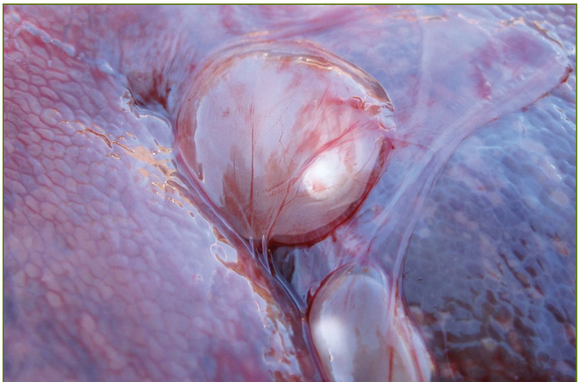
Agent: *Taenia hydatigena* tapeworm.

Prevalence: Ubiquitous parasite.

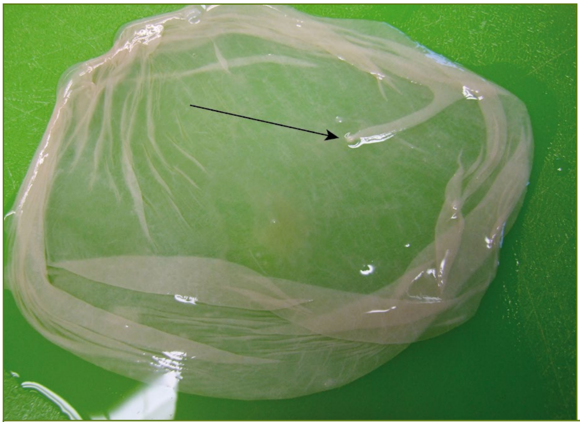
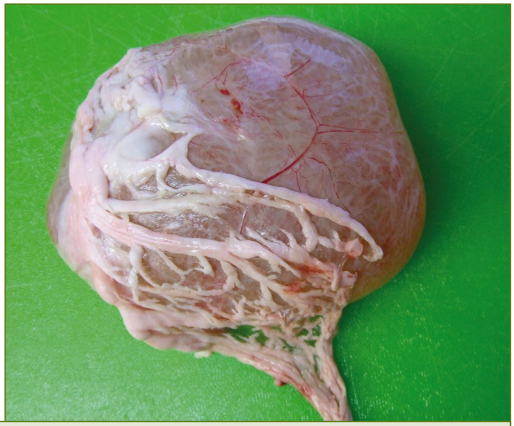
Life cycle and transmission: The definitive hosts of the parasite are carnivores such as wolf, dog, lynx and fox. The adult parasite, 75 to 500 cm long, lives in their intestines. The parasite's intermediate hosts are herbivores and wild boars, which get the parasite's eggs to their intestines through food. The larvae burrow through the intestinal wall and form cysts in the body of the intermediate host. Each



Cysticercosis in the liver of mouflon (Photo: Peter Paulsen).



A *Taenia hydatigena* cyst (*Cysticercus tenuicollis*) on the surface of a wild boar's liver (Photo: Jasna Prodanov-Radulovic and Radoslav Dosen).

Taenia hydatigena parasite forms liquid-filled cysts on the surfaces of the intermediate host's organs. The cyst contains one infectious larva. The larval form is called *Cysticercus tenuicollis*.

cyst contains one infectious larva. When the cyst-bearing animal is eaten by a carnivore, the parasite's life cycle is completed.

Symptoms and findings: The pearly grey, liquid-filled cysts of the *Taenia hydatigena* tapeworm, 1.5 to 10 cm in diameter, are most commonly found in the omentum, liver or peritoneum of cervids. Single, smaller cysts go easily unnoticed, since the parasitic cysts, as far as is known, do not cause symptoms to the intermediate host.

Control: In order to break the cycle, an infected animal's raw meat or organs should not be given to dogs or wild animals. Large adult parasites may cause symptoms in dogs. There is no need to interfere with the cycle of nature.

Risk of human infection and protective measures: *Taenia hydatigena* tapeworm is not contagious for humans.

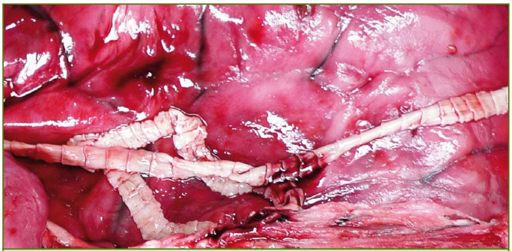
Is it safe to eat the meat? The meat of an infected animal is safe to eat. Altered organs are removed.

Cervid muscle cysticerci

Agent: The bear tapeworm (*Taenia arctos)* and the canine tapeworm (*Taenia krabbei)*.

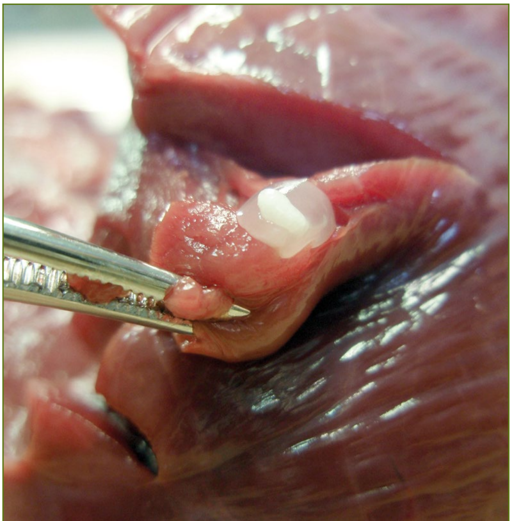
Prevalence: The parasites are prevalent in wild animals of the northern hemisphere. In Finland, the most common findings in cervids have been the cysts of *T. arctos* tapeworm.

Hosts, life cycle and transmission: The definitive hosts of *T. krabbei* tapeworm are carnivores, mainly canines. The definitive host of *T. arctos* parasite is the bear. Adult parasites that dwell in the intestines of carnivores produce eggs to the host's faeces. The eggs are passed in the faeces to soil, and from there



Adult *Taenia arctos* tapeworm lives in the intestines of the bear.

A heart of a moose with numerous cysts of *Taenia arctos* parasite.



The tapeworm cysts may be located deep inside the muscles and show only when the meat is cut.

to the herbivorous intermediate host via food. Inside the intermediate host, the parasitic larva burrows through the intestinal wall and travels to the muscles. In the muscles, the parasite forms cysts with one infectious larva inside each one. When an infected herbivore is caught and killed by a carnivore, the parasite's life cycle is completed.

Symptoms and findings:

- An infected herbivore is generally asymptomatic and in good condition. In the muscles, the parasite presents as rice-like cysts of 5 to 10 mm in size, containing wheyish liquid and one infectious larva. The cysts can be seen on the muscle surface, or they may be located deeper inside the muscles and show only when the meat is cut.
- Cysts can be found in deer species. So far, larval stage bear tapeworms have only been found in moose. The favourite locations of the larvae are the tongue and heart, but they can appear everywhere in the skeletal muscles. Minor infections often go unnoticed.

Control: The parasite's life cycle can be broken by handling cervid slaughterhouse waste in such a way that it will not end up as food for wild carnivores or dogs. The larvae are destroyed by cooking and freezing. It is neither possible nor necessary to interfere with the natural cycle of events.

Risk of human infection and protective measures: It has not been shown that either of these parasites are contagious for humans. The near relatives of the parasites, *T. solium* and *T. saginata*, neither of which are commonly found in Northern Europe, cycle between either pigs or cattle and human. Their prevention requires careful meat inspection and thorough cooking of the meat.

Is it safe to eat the meat? The meat can be eaten, but altered organs are removed. Severe infection causes the rejection of the meat as foodstuff for aesthetic reasons.

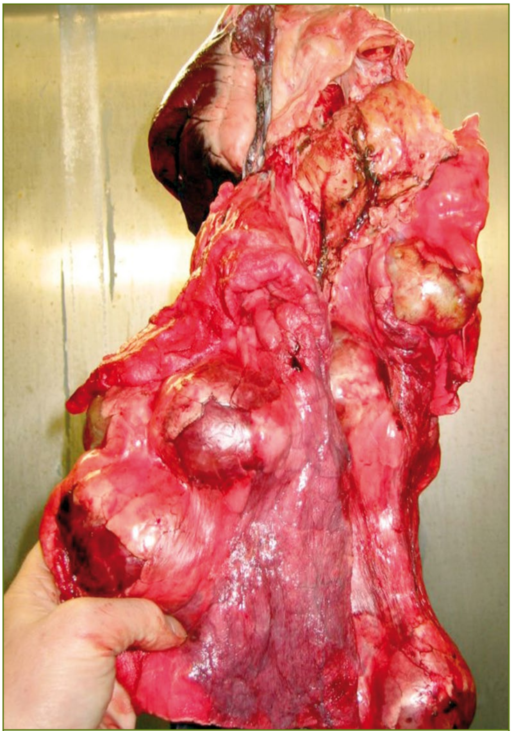
Echinococcosis

Agent: *Echinococcus granulosus* tapeworm, several genotypes.

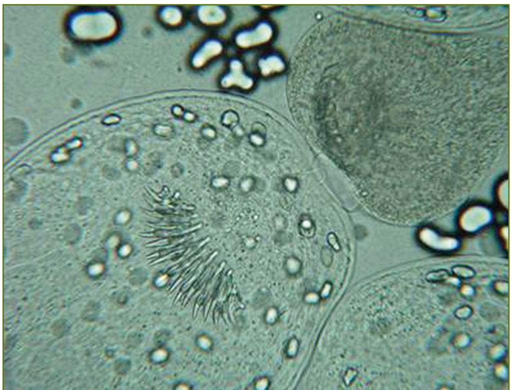
Prevalence: In the northern hemisphere, the parasite is found in cervids, mainly in moose and reindeer. The parasites of cervid strain are not found in other intermediate host species (excluding humans). In European wild boar, both sheep and pig genotypes have been reported. Other *E. granulosus* genotypes are found worldwide.

Life cycle and transmission:

- The definitive hosts of *E. granulosus* are canines, often wolves (*Canis lupus*), whose intestines are inhabited by adult parasites. Uncharacteristically for tapeworms, the adult tapeworm is very small, only 0.5 cm in length. The eggs produced by the parasite are very light and resilient. They are spread to the environment through the host animal's faeces, and further via food to the cervid that acts as an intermediate host.
- Inside the intermediate host, the parasite forms cysts that contain a large number of infectious larvae. When the animal and cysts are ingested by carnivores, the parasite's life cycle is completed.



Echinococcus forms cysts in the intermediate host's body, mostly in the lungs. Pictured here are the lungs of a reindeer.



Echinococcus cysts contain thousands of infectious larvae (Photo: Antti Oksanen).

Symptoms and findings:

- *E. granulosus* infection is asymptomatic in its definitive host, a canine. Typical cysts, called hydatid cysts, develop in the intermediate host. The cysts of the cervid genotypes are commonly found in the lungs. Their size varies, depending on the duration of the infection, from barely noticeable to cysts of 15 cm in diameter. The cysts are often of a pearly grey colour and contain clear liquid with thousands of small, infectious larval forms of the parasite. The number of cysts in the lungs may vary from a single one to over a hundred cysts.
- Severe infection and large cysts can fill most of the lungs, making breathing difficult for the animal and weakening its condition. Naturally, an animal suffering from this is more easily killed by carnivores. This assists in the completion of the parasite's life cycle.

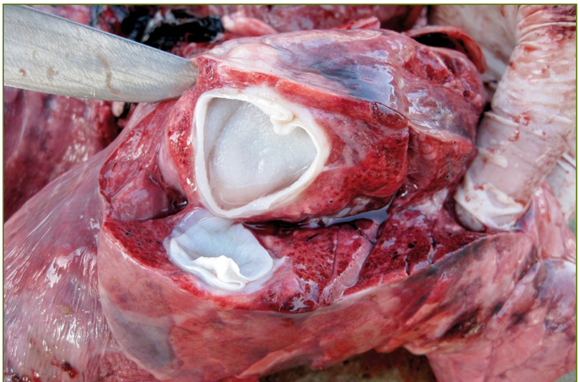
The life cycle of *Echinococcus granulosus* is completed when the herbivore intermediate host is killed by a carnivore and the carnivore is infected by the cysts in the intermediate host's body.

Control: The prevalence of *E. granulosus* is monitored in meat inspection and in various surveys by examining possible host animals, such as wolves. Since *E. granulosus* cysts can be tiny and difficult to notice, it is not advisable to leave organs of cervids to be eaten by predators; nor should they be given to dogs uncooked or unfrozen. It is not possible to interfere with the natural cycle of events.

Risk of human infection and protective measures:

- *E. granulosus* infection can be contracted by humans, who then act as intermediate hosts. In humans, the infection causes a so called hydatid disease (hydatidosis) when same kind of cysts are formed in the human body as in animals. The incubation period of the disease is long. In most cases, the disease is treated by surgical removal of the cysts.

Large echinococcus cysts can make the breathing of an animal so difficult that it is more easily killed and eaten by carnivores.



Wild boars can act as intermediate hosts for such echinococcus parasites that are more infectious to humans than cervid echinococcus (*Echinococcus canadensis*) (Photo: Jasna Prodanov-Radulovic and Radoslav Dosen).

- The risk for human infection of *E. granulosus* is regarded as minor and there is no need for restrictions for the use of wild berries or mushrooms. The greatest risks for infection are close contacts with infected dogs. Their fur can contain eggs of the parasite contracted from stools. Stools may also contaminate garden produce.
- Hunting dogs are dewormed with anthelminthic drugs that are effective against tapeworms (praziquantel or epsiprantel) before and after the hunting season. Special care should be taken when wolves or foxes are skinned.

Is it safe to eat the meat? The meat is safe to eat. *Echinococcus* infection cannot be contracted from eating meat.

Alveolar echinococcosis

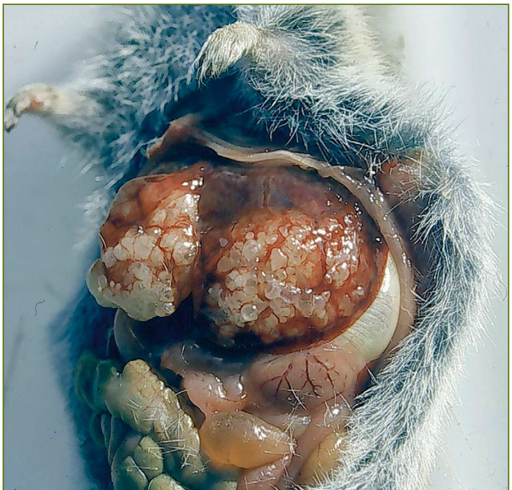
Agent: *Echinococcus multilocularis* tapeworm.

Prevalence: The parasite is commonly found in Central Europe and the Baltic countries. The *E. multilocularis* population has increased and it is suspected to be spreading still further north.

Hosts, life cycle and transmission:
- Foxes (*Vulpes vulpes*) (also arctic foxes, *Vulpes lagopus*) are the main definitive hosts of the parasite, but it is found also in dogs, (cats), raccoon dogs and wolves. The parasite produces infectious eggs to its host's faeces. The eggs passed in the environment are light and resilient.
- Intermediate hosts, voles, contract the infection from food contaminated by *E. multilocularis* eggs. Inside the intermediate host, the parasite forms cysts that contain infectious larvae. The parasite's life cycle is completed after a carnivore consumes the vole and gets infected.

Symptoms and findings: The definitive hosts of *E. multilocularis* do not suffer from symptoms. In the intermediate host, or vole, *E. multilocularis* forms a tumour-like mass of cysts by gemmation. The cysts contain numerous infectious larvae.

Control: The disease is controlled by surveys and follow-up programmes. The faeces or bowels of carnivores are examined for evidence of the parasite or its eggs, and voles are examined for cysts. Examinations are carried out especially in the risk areas for the disease spread. The prevention of the spread of the parasite includes the requirement of anthelmintic medication for imported dogs.



In its intermediate host, *Echinococcus multilocularis* forms a tumour-like mass of cysts by gemmation, usually in the liver (Photo: Heikki Henttonen). The cysts contain infectious larvae.

Risk of human infection and protective measures:

- In the endemic areas, *E. multilocularis* is a risk to human health. The infection causes, usually in the liver, a tumour-like mass of cysts that grows by gemmation. The disease is chronic and difficult to heal.
- Humans can be infected by direct contact with egg-bearing stools of carnivores such as dogs or foxes, or with vegetables, berries or water contaminated by stools. In endemic areas of the parasite, vegetable patches must be protected from wild animals and loose dogs, dogs must be dewormed, and close contacts with small carnivores and loose dogs must be avoided.
- In addition, vegetables that are inadequately washed, or irrigated with natural water, also form a risk for infection. Appropriate protection should be used when skinning risky animals.

Is it safe to eat the meat? *E. multilocularis* is not found in game animals that are hunted for human consumption, except in beavers. The parasite is contagious only through stools of wild carnivores or dogs.

Carnivores serve as definitive hosts of *Echinococcus multilocularis* and voles serve as intermediate hosts. Sometimes humans serve as intermediate hosts, if they have ingested food contaminated by faeces of infected carnivores.

2.4.4 Roundworms (Nematoda)

The nematodes, or roundworms, constitute the most common phylum of multicellular organisms in the world. There are numerous roundworms in almost everywhere in soil and waters, forming an important part of ecosystems. Not all roundworms are parasites.

Roundworms are tapered from both ends, and their body is covered by a strong layer called cuticula.

They do not have circulatory or respiratory organs, but their digestive and reproductive systems are well developed. Most species are dioecious (having separate sexes). Roundworms develop in five stages (L1-L5) from egg to adult.

Roundworms are slender parasites which have well developed digestive and sexual organs.

2.4.4.1 Meningeal worm

Agent: *Elaphostrongylus rangiferi* (reindeer), *E. cervi* (deer), *E. alces* (moose) roundworms.

Prevalence: *Elaphostrongylus* nematodes are common in cervids, especially in moose and reindeer in Scandinavia and Finland, but they also infect other cervid species and sheep and goats.

Life cycle and transmission:

- Cervids are the definitive hosts of *Elaphostrongylus* parasites. Adult parasites dwell on the muscle membranes. They produce eggs to the bloodstream, where they travel to the lungs and develop into larvae. When the host coughs up mucus, the larvae end up in the pharynx, and through the digestive tract in stools. On the ground the larvae burrow into snails or slugs, where they become infectious.
- When cervids become infected from food that contains snails or slugs, the parasite's life cycle is completed. The larvae burrow through the intestinal wall and travel to the central nervous system where they develop. The worm travels on to the membranes of muscles, where the final maturation of the parasite occurs (c. 112 days). Cross infections with domestic animals, for instance, are possible: the reindeer parasite can infect a sheep and cause severe central nervous symptoms.

Symptoms and findings:

- The parasite is common, but rather rarely it causes clinical disease in its primary hosts.
- Central nervous symptoms may occur during the migration and development of the larva in the central nervous system. Symptoms include dysfunction of consciousness, limping, different stage of paralysis of the hind legs, and blindness.
- In severe infection, lung damage may occur due to migrating larvae. Yellowish or greenish colour of muscle membranes, especially in the stomach area, are regarded as typical manifestation of

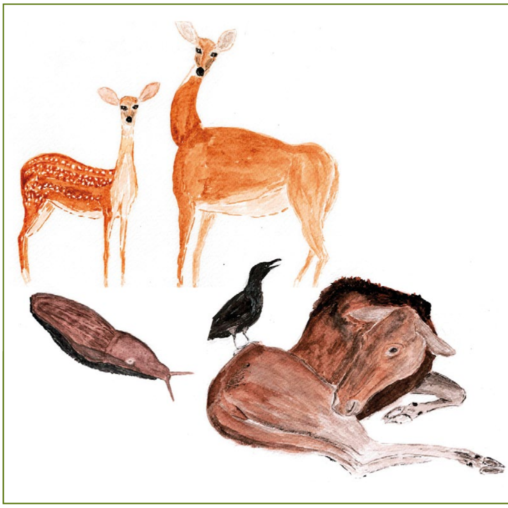
Cervids become infected via food that contains snails.

Elaphostrongylus roundworm produces eggs to the bloodstream. In the lungs, the eggs develop into larvae which are passed in stools to the ground and into snails.

In moose, the meningeal roundworm travels via spinal membranes epidurally and, depending on its location, may sometimes cause central nervous symptoms (Photo: Kjell Handeland).

Adult *Elaphostrongylus* roundworm in the muscle membrane of a reindeer. During the parasite's migration in the central nervous system symptoms such as paralysis of the hind legs may occur.

In Finland, the disease caused by *Elaphostrongylus* roundworm in reindeer is called 'liutsa' disease. The parasite causes similar symptoms in foreign hosts, goats or sheep.



Elaphostrongylus roundworm infection. Developing or adult roundworms can be seen in muscle membranes or the meninges, and in the spinal canal.

Control: Parasite control is not possible in wild animals. Production animals can be protected by keeping wild cervids and reindeer away from sheep pastures.

Risk of human infection and protective measures: *Elaphostrongylus* roundworm is not contagious for humans.

Is it safe to eat the meat? The meat of asymptomatic animals is safe to eat. If the animal shows central nervous symptoms, its meat must neither be used nor given to other animals before the cause is known.

Keep in mind: Deer meningeal worm (*Parelaphostrongylus tenuis*) has spread widely in the white-tailed deer population in North America. The life cycle of the parasite is similar to that of the parasites found in Europe. Adult parasites dwell in deer meninges. The infection is usually asymptomatic in white-tailed deer; limping occurs sometimes, central nervous symptoms very rarely. The parasite may also infect untypical hosts, such as moose, reindeer, caribou, wapiti, sheep and goat. In these animals the parasite causes severe symptoms, muscle cramps, circling and impaired vision. This often lethal disease is called moose disease. It has been suspected that *P. tenuis* parasite would be the cause of the decline of moose population in its prevalent areas in the USA and Canada. In this way, the parasite might help its primary host animal, the white-tailed deer, by decreasing other cervid populations that compete for the same pastures. The reindeer genus is also regarded as susceptible to the harmful effects of the parasite. The parasite has not been found in Finland, although the origin of Finnish white-tailed deer population is in the prevalent area of the parasite, in North America.

Parelaphostrongylus tenuis is an example of how a parasite can be fatal when contracted by foreign hosts. The parasite is usually harmless to deer, but causes a severe, often lethal disease in moose.

2.4.4.2 Gastrointestinal roundworms

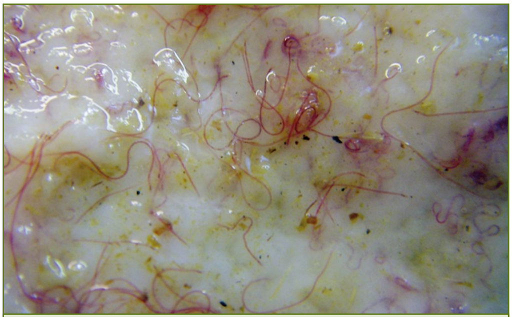
Agent: Roundworms of superfamilies Trichostrongyloidea, Trichuroidea, Strongyloidea, Ascaroidea.

Prevalence:

- Roundworms that parasitize in the gastrointestinal tract are found in all game animal species. Unlike in other animals, such as the bear or wild boar, large roundworms (Ascaroidea) are not found in ruminants in Fennoscandia, and probably not in wild ruminants in Europe.
- In general, parasites of the gastrointestinal tract do not cause problems under normal conditions, and their spread is self-limiting. However, these parasites are significant in dense animal populations and in farms, as well as when starvation occurs.
- In that case, diseases may be caused especially by abomasal roundworms (Trichostrongyloidea), whipworms (Trichuroidea) and, in monogastric animals, large roundworms (Ascaroidea). In situations like these, they can cause weakening of the animal and significant mortalities. Gastrointestinal parasites are sometimes connected to cervid and wild boar mortalities and changes in landfowl populations.

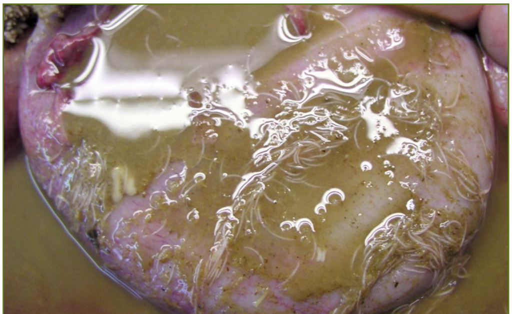
Life cycle and transmission:

- Generally, the life cycle of gastrointestinal parasites is direct. An adult parasite inhabiting the stomach or intestines of a host animal produces eggs that are passed to the environment in faeces. The eggs of some gastrointestinal parasites (Ascaroidea, Trichuroidea) are resilient to external conditions and can persist in soil even for years. Under favourable conditions with sufficient temperature and moisture, the eggs (Trichostrongyloidea, Strongyloidea) develop into infectious free-living larvae that are ingested by new host animals.
- The life cycle of the large roundworm (Ascaroidea) is more complex as it involves migrating from one organ to another inside the host animal. The host



A severe infection of abomasal roundworms (Trichuroidea) may include anaemia and abomasal disorders. Pictured here a severely parasitized abomasum of a moose.

Infection of abomasal roundworms and severe folding of the abomasum in a roe deer.



Whipworm (*Trichuris*) infection is common in dense cervid populations. Severe infection in the caecum leads to gastric disorders and the animal's starvation.

Infection of intestinal parasites is demonstrated by microscopic identification of eggs in the stool. Pictured here an egg of *Nematodirus* parasite (Photo: Terje Josefsen).

becomes infected with large roundworm by ingesting infective parasite eggs in its food. The eggs hatch into larvae in the intestines of the new host, and burrow through the intestinal wall into the bloodstream and travel to the lungs. They are coughed up to the throat and swallowed again to the intestines, where they mature to egg-producing adult parasites. Eggs are passed in faeces to soil.

Overdense animal population is often the reason for the high prevalence and abundance of faecally transmitted parasites, such as most gastrointestinal parasites and cervid lungworms.

Symptoms and findings:

- In dense populations, the increase of faecal contamination and infection pressure can be great, and severe parasitic infection can cause general symptoms. Animals with gastrointestinal parasites suffer from weight loss and wasting. In addition, animals with a parasitic infection can present a swollen abdomen, dry and dull hair, and diarrhoea.
- Anaemia is commonly found especially in infections caused by abomasal nematodes and whipworm. Roundworm infection may also include cough due to the parasite's presence in the lungs. Severe infection can cause intestinal congestion or peritoneal infection.
- Parasitic infection can be discovered in an autopsy by identification of adult parasites or their stages in the body. In live animals, eggs or larvae are demonstrated in the stool by microscopic or genetic examination.

Control: The spread of gastrointestinal parasites can be restrained by keeping game populations on a sustainable level, and by controlling the location of feeding grounds in order to prevent development of dense local populations. Attention must be paid to feeding ground hygiene: feed must not be contaminated by faeces. In farmed animals, regularly performed deworming is required.

Risk of human infection and protective measures: Animal gastrointestinal parasites are not usually contagious for humans. Intestinal roundworms of the genus Ascaroidea, which are parasites of carnivores and wild boars, can accidentally infect humans or other foreign host species and cause a disease called creeping eruption (larva migrans). The roundworm larvae penetrate the intestinal wall, as they do in a normal host, but they migrate often either to the central nervous system or to the eyes and cause visual or central nervous symptoms. In prevention, the best means are familiar to all: good hand hygiene after handling soil or unwashed vegetables, keeping wild animals and dogs away from vegetable patches and playgrounds, and taking care of the deworming of pets.

Giant thorny-headed worm of swine (*Macracanthorhynchus hirudinaceus*) that lives in the intestines of a wild boar may cause it gastrointestinal infection and wasting (Photo: Jasna Prodanov-Radulovic and Radoslav Dosen). The parasite uses beetle larvae as intermediate hosts, and pigs are infected when they ingest them. The parasite may sometimes also infect humans.

Is it safe to eat the meat? The meat is safe to eat. These parasites cannot be transmitted via meat.

Keep in mind: Many intestinal parasites, such as the intestinal roundworm *Ascaris*, are prevalent in humans. It is advisable to keep the possibility of infection in mind while travelling abroad.

2.4.4.3 Bear roundworm

Agent: *Baylisascaris transfuga* parasite, which is a large, 10 to 20 cm long roundworm.

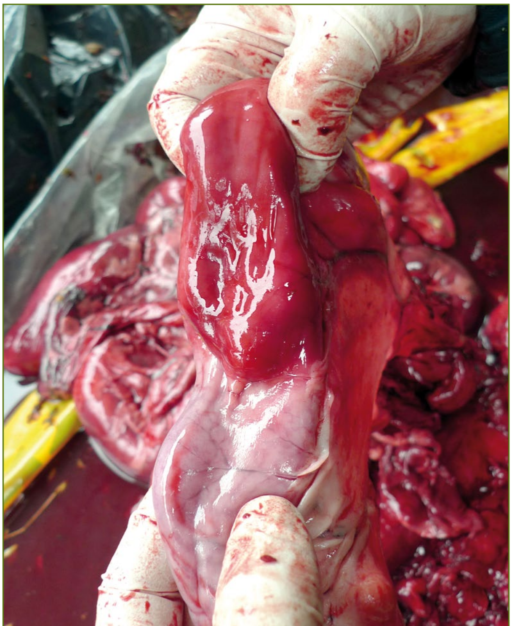
Prevalence: The parasite is globally prevalent in all bear species.

Life cycle and transmission:
- The life cycle of the parasite is direct. The adult parasite inhabits the intestines of bears and produces resilient eggs that are passed to the environment in faeces.
- New host animals are infected by ingesting food that contains eggs from faecal contamination. Inside the new host, the parasite penetrates the intestinal wall and travels in the bloodstream to the lungs, from where it is coughed up to the pharynx and returned to the intestines, where it matures into an adult.

Symptoms and findings: Severe roundworm infection has been connected to symptoms such as intestinal infection and obstruction, weight loss and slow growth of cubs. Large adult parasites can easily be observed inside the small intestine.

The bear roundworm is a relatively large parasite, common in areas of dense bear populations.

The nematode *Ascaridia compar*, is common parasite in older grouse species. The parasite's abundance has been connected to the grouse populations' declines. Here pictured *A. compar* parasites in the intestines of an adult capercaillie (*Tetrao urogallus*) (Photo: Saara Leivo).



Severe roundworm infection may cause the animal intestinal obstruction or intussusception and necrosis, such as in the bear pictured here.

Control: The spread of the infection can be controlled by preventing the development of dense bear populations through carcass-feeding, and by maintaining good feeding ground hygiene. Regular deworming of farmed animals is part of good farming practice and animal health care.

Risk of human infection and protective measures: Like several other roundworms such as dog and cat roundworms, the bear roundworm can occasionally infect humans via eggs in the soil. The larva that moves around the body may cause symptoms according to its route in the central nervous system (larva migrans disease). The most severe symptoms occur if the larva migrates to the eyes or to the central nervous system. Good hand, food and water hygiene are important measures for preventing the infection.

Is it safe to eat the meat? The meat can be eaten, but good hygiene practice must be followed while skinning the animal.

Keep in mind: *Baylisascaris procyonis* is a roundworm frequently found in intestines of raccoons. Also dogs can serve as hosts. These animals excrete the eggs of the parasite. When ingested by other mammals, also humans, eggs hatch and larvae penetrate the intestinal wall and migrate into various organs (visceral or ocular larva migrans), also in the brain. In humans, it is considered a rare zoonotic disease.

2.4.4.4 (Cervid) lungworms

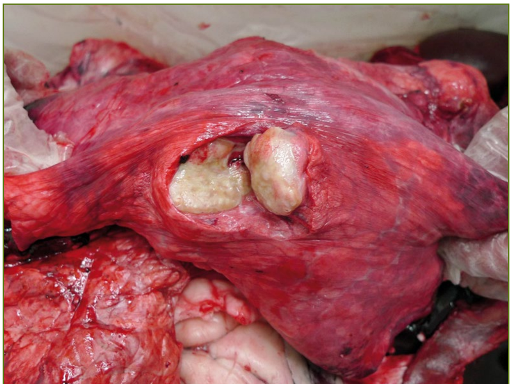
Agent: *Dictyocaulus eckerti*, *D. capreolus*, small lungworms; *Varestrongylus/Capreocaulus capreoli* roundworms. Sometimes also the bovine lungworm *D. viviparus* may infect cervids.

Prevalence: Lungworms are ubiquitous and common in all cervids.

Life cycle and transmission: Adult parasite dwells in the bronchial tubes of cervids, where it produces eggs. The eggs are coughed up to the throat and travel via the pharynx to the intestines. In the intestines, the eggs develop into larvae and are passed in faeces to the ground. New animals are infected after ingestion of food that contains larvae. Inside the new host, the larvae penetrate the intestinal wall and migrate via lymphatic vessels to the lungs, thus completing the parasitic life cycle. The reason for the high prevalence of lungworms may be the density of cervid population, which often is the natural explanation of the spread of a parasite transmitted from animal to animal. The *Varestrongylus* life cycle is similar to that of brainworms.

Adult lungworms live in the bronchial tubes of cervids. They produce eggs that are coughed up and swallowed to the gastrointestinal tract, from where they are passed in faeces to the ground (Photo: Antti Oksanen).

Wild boar lungworms (*Metastronglus* species) and alterations caused by them (Photo: Jasna Prodanov-Radulovic and Radoslav Dosen). The parasites are transmitted by earthworms. The parasite is widespread and may cause mortalities in dense populations.



The scars left by lungworms in the lungs are areas that contain greenish mass. Severe infection may weaken the condition of the animal.

Changes caused by lungworms in the lungs of red deer (Photo: Gottfried Grossbointner).

Symptoms and findings: Mild infections are asymptomatic. Severe infection causes cough and inflammation of the lungs, the symptoms of which may include deterioration of general condition, slow growth, weight loss and mortalities. Adult parasites can be seen in the bronchial tubes. The scars left by them are greenish areas of 0.5 to 2 cm in size in the lungs. The parasite can be diagnosed in live animals by identifying parasitic larvae in faeces in microscopic examinations.

Control: Infection pressure can be diminished by preventing the development of dense cervid populations and maintaining good game feeding ground hygiene.

Risk of human infection and protective measures: Cervid lungworms are not contagious for humans or dogs.

Is it safe to eat the meat? The meat is safe to eat.

2.4.4.5 Hare lungworms

Agent: Lungworms of the genus *Protostrongylus*.

Prevalence: Hare lungworms are ubiquitous parasites of lagomorphs. The lungworm is a common parasite in mountain hares and brown hares.

Life cycle and transmission:

- Adult parasites inhabit the bronchial tubes of hares and produce eggs. Larvae hatched from the eggs travel via pharynx to the gastrointestinal tract and are passed in faeces to the ground.
- The larvae burrow into slugs where they become infectious. Infection is transmitted to hares through food that contains molluscs. Worms penetrate through the intestines to the tissues of the new host, and travel to the lungs where they mature.

The life cycle of the hare lungworm is complex. Snails and slugs serve as intermediate hosts. They are infected via hare faeces.

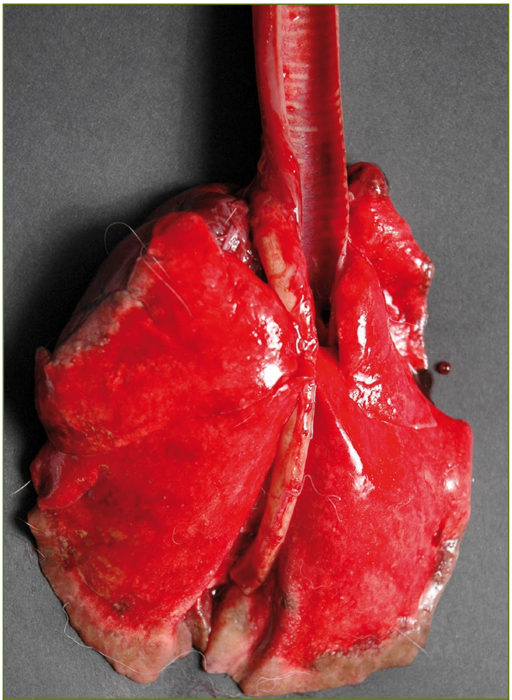
Symptoms and findings: Parasites cause inflammatory changes in the hare's lungs. They can be seen as dark and dense areas at the tips of the pulmonary lobes. These alterations are more rarely found in brown hares than in mountain hares. The inflammation often also includes fungal infection (*Pneumocystis*). Severe infection may weaken the condition of the hare, but apparently it is not often lethal. However, the infection may make the hare susceptible to other, more serious diseases.

Control: Dense hare populations and wet summers that favour molluscs contribute to the spreading of the disease.

Risk of human infection and protective measures: Cervid lungworms are not contagious for humans or dogs.

Is it safe to eat the meat? The hare meat is safe to eat.

Keep in mind: You should wear protective clothing when handling a hare that seems diseased or is found dead. The hares should be buried or sent to a laboratory where the cause of the disease can be diagnosed.



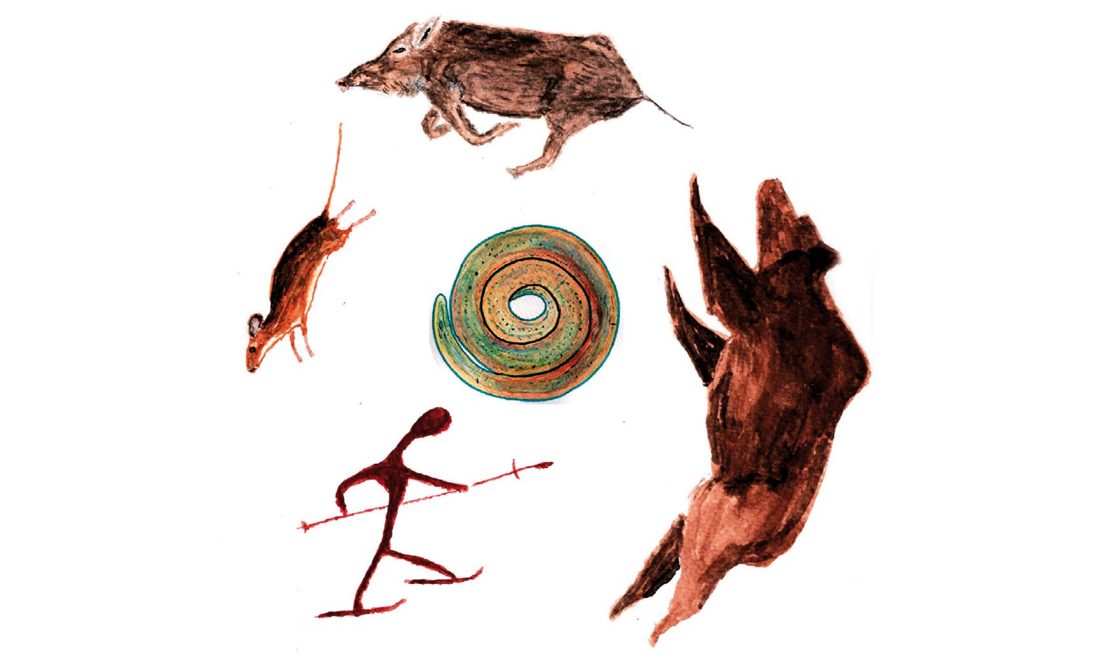
Alterations caused by lungworms are very common in the lungs of hares (Photo: Norwegian Veterinary Institute, Norway). The alterations are present as clearly defined dark areas at the tips of the pulmonary lobes.

2.4.4.6 Trichinella

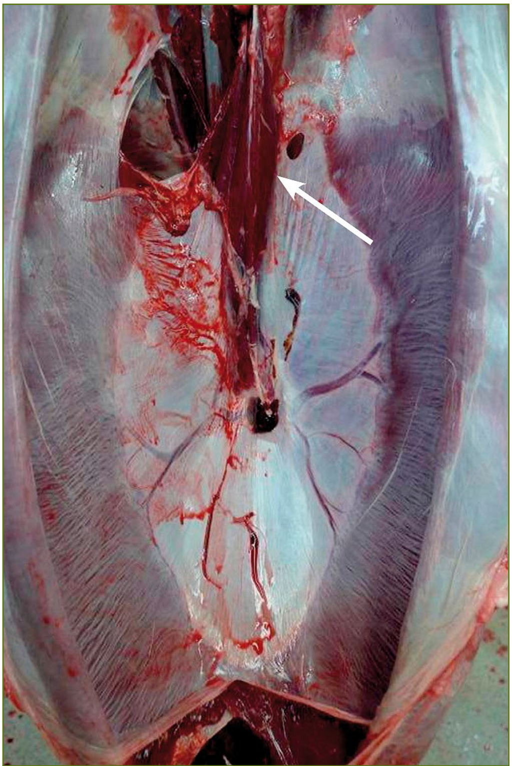
Agent: Roundworms (nematodes) of the genus *Trichinella (Trichinella spiralis*, *T. nativa*, *T. britovi*, *T. pseudospiralis)*. Adult worms are 1.2 to 2 cm long intestinal parasites.

Prevalence: Trichinella (sometimes called 'trichina'; although this term is ambiguous) roundworms are globally prevalent parasites of game animals such as wild boar and bear. The parasite is also common in carnivores such as fox, wolf, badger, raccoon dog and lynx. The parasite can also be found in seals, beavers and muskrats, and in small mammals such as rats that eat carcasses or animal waste.

Life cycle and transmission: Animals or humans catch the infection by eating meat that contains ca. 1 mm long *Trichinella* larvae. The ingested larvae hatch and develop to a sexually mature stage in the mucous membrane of the small intestine. Larvae produced by the female worm (500 to 1,500 larvae) penetrate the intestinal wall and migrate via lymph and blood vessels to the body. Specifically, the larvae find their way to muscle tissue into which they burrow. Once in muscle tissue, the larvae encyst and become infectious. Encysted larvae may stay infectious for long periods of time, for months or even years. Raccoon dogs and foxes are efficient spreaders of *Trichinella* parasites.



Trichinella is transmitted by ingestion of raw, larvae-infested meat. Transmission is linked to preying or scavenging.



The diaphragm pillar is the muscular middle section of the diaphragm.

Symptoms and findings: Symptoms such as inflammation of the muscles, reactions of the lymph nodes in infected areas and enteritis (inflammatory bowel disease) have been reported in wild animals. Severe infection may cause the animal similar symptoms to those of humans: muscular pain, fever and even mortalities. Adult parasites can be demonstrated from the intestines and larval forms in the muscles only by laboratory examinations.

Control: Thorough meat inspection of animal species susceptible to *Trichinella*, and burying uninspected carcases so that they will not be available to scavengers for feeding.

Risk of human infection and protective measures:

- *Trichinella* is infectious for humans. Infection is caught from raw or undercooked meat that contains *Trichinella* larvae, or from processed products, such as raw sausages, made from *Trichinella*-contaminated meat. Symptoms are dependent on the severity of the infection, i.e. how many larvae the ingested food contains.

- In humans, the first symptoms are diarrhoea and malaise, vomiting and stomach cramps, which are caused by the burrowing of larvae into the intestinal wall. After a period of 2 to 6 weeks from infection, the migration stage of the larvae causes fever, muscular pains and headaches and facial or under-eye swelling in humans.
- Protection from the disease requires thorough inspection of the susceptible game meat. In European Union, a risk-based plan has been established for pig and horse carcases intended for consumption. However, each possible wild host animal of *Trichinella*, such as wild boar, bear, badger, seal and lynx, must be inspected before their meat is released for consumption.
- Do not eat medium-rare meat of *Trichinella*-susceptible animals. The larvae are destroyed by cooking the meat thoroughly to the temperature of 70 °C. Freezing is not a safe way to destroy the larvae, as some species can survive freezing temperatures.

Trichinella cysts in the muscle of wild boar (Photo: Peter Paulsen).

Uncooked processed wild boar meat products are often the source of human infection.

Is it safe to eat the meat? Meat contaminated by the *Trichinella* parasite must not be eaten or given to dogs or other animals.

Keep in mind: When travelling abroad, you should remember that uncooked meat products made from uninspected wild boar meat or bear meat have been a common source of human *Trichinella* infection.

***Trichinella* sample**

The favourite locations of *Trichinella* larvae vary according to the host animal species. Due to this, the place from where *Trichinella* samples are collected is different in different animals. For examination, muscle samples are taken; amount and location are specified in legislation, e.g. 10 g muscle tissue minimum; foreleg, tongue or diaphragm muscular part in wild boar; diaphragm, masseter muscle or tongue in bear. After collection the samples are placed in clean containers and kept in cold storage until they are sent for testing. The samples should be packed in such a way that they remain chilled during transport. Each sample sent for testing must be accompanied by a submission form complete with details of the species, date and place of hunting, location of sample collection and the sender's contact information.
In the laboratory, *Trichinella* larvae are shown by digestion technique. Muscle tissue is broken down with chemicals from around the *Trichinella* larvae so that they can be seen with a microscope.

2.4.4.7 Insect vector-transmitted roundworms

Insect-transmitted roundworms (Filarioidea) are the most important group of roundworms that affect human and animal health all over the world. Their long and narrow, threadlike adult forms dwell in the tissues or body cavities of their host animals.

The parasites of Filarioidea superfamily are long, threadlike roundworms.

The group includes, among others, tropical human pathogens that cause diseases such as elephantiasis (*Brugia* species) and river blindness (*Onchocerca* species).

All parasites of this group are transmitted by haematophagous insects. Adult parasites produce tiny larvae, microfilariae, to their host animal's bloodstream or skin, from where they move to insects during blood meals. While inside the insect, the larvae go through two moults (L1-L3) and become infectious, and when the insect has its next blood meal, the larvae break out and infect the new host.

The significance of insect-transmitted roundworms has increased also in northern and central parts of Europe, and alterations caused by this group of parasites are commonly found in our game animals.

According to recent studies, global warming and the rising median temperatures of summers, i.e., conditions that further the development of larvae in vector arthropods (insects), are regarded as one cause for the emergence and reported mass appearances of these parasites. This trend may lead to the northward spread of new parasites that belong to this group. These parasites could have a significant impact on European game animal populations.

Infectious larvae of various unidentified roundworms have been found in almost all of our domestic haematophagous insect species.

Some of these insect-transmitted animal roundworms can be transmitted to humans via insects. They can cause some harm but they do not develop to the adult parasites in human beings. There is no evidence that insect-transmitted cervid roundworms prevalent in Europe could be transmitted to humans.

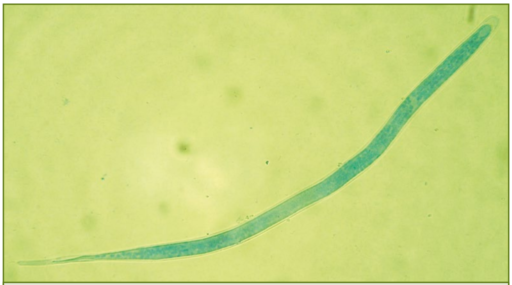
However, there has been evidence of human infection by many filarial parasites of animal origin. Most often, subcutaneous or connective-tissue cysts containing a parasite that has undergone some developmental stages have been reported. However, the parasites have not matured into adults in humans.

Peritoneal worm

Agent: *Setaria tundra* roundworm

Prevalence: *S. tundra* is a common cervid parasite in the northern hemisphere. In Finland, reported mass appearances in reindeer occurred in 1973 and from 2003 to 2005, and in moose in 1989. The outbreaks have included mortalities and weakened condition of animals.

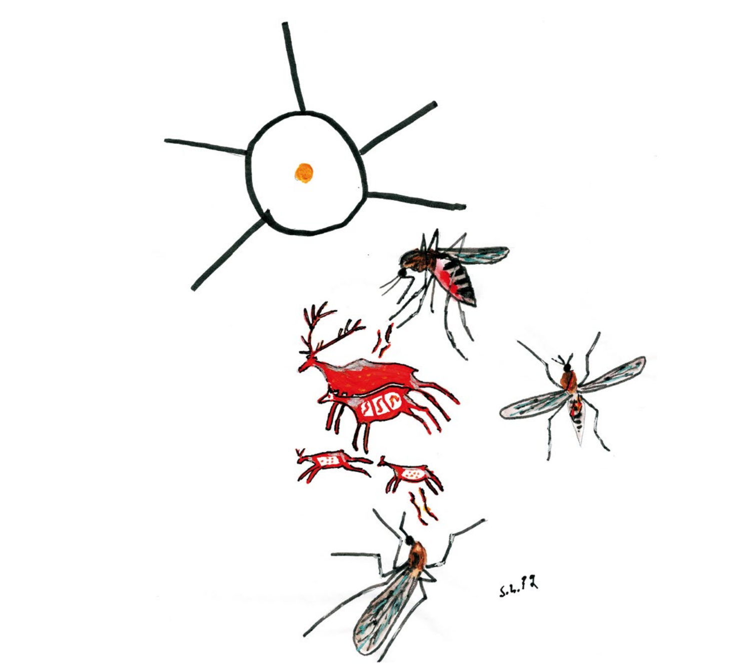
Life cycle and transmission: 2 to 9 cm long, adult *S. tundra* parasites dwell in a cervid's abdominal cavity and produce a great number of circa 0.25 mm long larvae (microfilariae) to its bloodstream. At best, there may be thousands of these larvae in 1 ml of blood during summer months. The larvae enter a mosquito when it takes a blood meal from an infected cervid. Inside the mosquito, the larvae go through two moults and develop within two weeks into infectious, 1 mm long larvae. Studies show that warm summers are favourable for the spread of the parasite. A relatively warm and long summer favours mosquitoes and expedites the parasite's life cycle and development inside mosquitoes.



The size of *Setaria* microfilaria in the host bloodstream is around 0.25 mm. During the summer months, there can be thousands of microfilariae in 1 ml of blood.

One mosquito may carry dozens of infectious 1 mm long larvae. When the mosquito has a blood meal, the larva penetrates into the new host through the bite hole and travels to its abdominal cavity, where it matures into an adult.

Severe infection may cause peritonitis and weakening of the host animal's condition. The surface of the liver is covered with a typical, granulomatous inflammatory reaction.



Adult *S. tundra* parasite resides in the abdominal cavity of cervids. It produces tiny larvae called microfilariae to the host animal's bloodstream. During blood meal, the larvae move to a mosquito where they develop to infectious stage. When the mosquito has its next blood meal, it transmits the infection to new animals. Warm weather is favourable for mosquitoes and, especially, the spread of the parasite.

Symptoms and findings: It appears that the *S. tundra* parasite originally adapted to parasitize in roe deer, in which the infection is asymptomatic. When infecting an alien host, the parasite causes pathological changes in species that are not adapted to it. This has occurred in moose, reindeer and wild forest reindeer. If parasites are found in the abdominal cavity, it is a clear sign of infection. The health of the animal is not affected by a few parasites in its abdominal cavity, but a severe infection causes disease and weakens the condition of the host animal, especially in case of young animals. Delayed development of winter coat, weight loss and bulging stomach are external signs of heavy infection. Adult parasites are found in the abdominal cavity and they cause a manifest (clinical) peritonitis. A typical sign of infection is the accumulation of granulomatous, greenish or grey inflammatory reactive

In 1989, *S. tundra* was the causative agent of severe outbreaks of peritonitis in moose in North Finland. This photo is from Alaska (Photo: Glenn Stout).

Dead and partly calcified *Setaria* worms on the liver of roe deer (Photo: Gottfried Grossbointner).

products on the surfaces of the abdomen and liver. The infection can also be diagnosed by examining the microfilariae contained in blood samples.

Control: Parasite control is not possible in the wild. Some 80% of breeding reindeer get antiparasitic treatment (ivermectin) every year in Finland. The medication is also effective for the *S. tundra* parasite, and it may decrease the parasite's opportunities to circulate in reindeer populations.

Risk of human infection and protective measures: There is no evidence that the *S. tundra* larva had infected people or that the larva could develop inside humans, although around 1% of the mosquitoes of the North Finland were parasite carriers during the *S. tundra* mass appearance in 2004. However, it is justified to wear protection against blood-feeding insects.

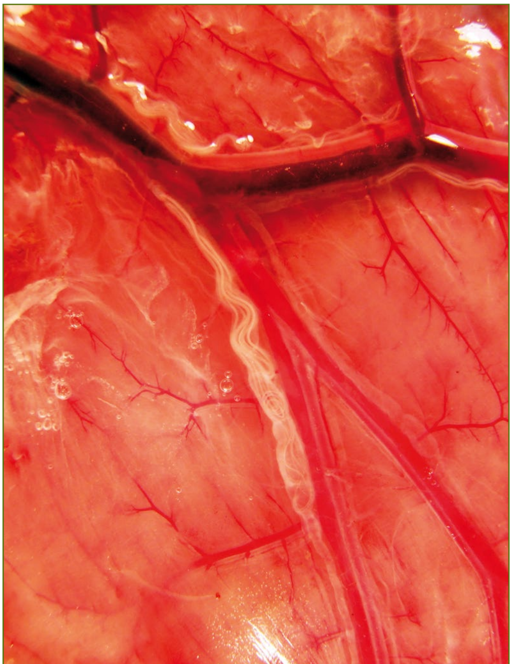
Is it safe to eat the meat? It is safe to eat the meat of an infected animal. Insect-transmitted roundworms cannot be transmitted by meat. Altered parts and areas are removed.

Cervid lymphatic worm

Agent: Roundworm called *Rumenfilaria andersoni* that inhabits the lymphatic system of cervids.

Prevalence: For the first time in Europe, adult specimens of a filarioid roundworm inhabiting the lymphatic vessels were observed in Finland in 2006. The parasite was first observed in reindeer and later also in other cervids. Earlier, the parasite has been found in moose in Canada. In Finland, the parasite proved extremely prevalent in 2003 and 2005, occurring at the same time as the mass appearance of the *S. tundra* parasite. Therefore, it is likely that warm summers are also favourable for the occurrence of *R. andersoni*.

Life cycle and transmission: The threadlike adult *R. andersoni* roundworm, usually 6 to 10, but sometimes even 20 cm long, dwells in the lymphatic vessels of cervids (moose, reindeer, wild forest reindeer, white-tailed deer). The parasite produces thousands of microfilariae into the host animal's bloodstream: the highest observed density is some 40,000 larvae in 1 ml of blood during summer months. The parasite is insect-transmitted, but so far the vector insect has not been identified.



Adult *Rumenfilaria* parasite dwells in the lymphatic system producing microfilariae to the host animal's bloodstream.

Symptoms and findings: The effects of the parasite on the health of cervids are unknown. The parasite causes visible changes in its target tissues on the lining of lymphatic vessels.

Control: It is not possible to control the prevalence of the parasite in the wild. Ivermectin, which is routinely used for reindeer antiparasitic treatment, is ineffective against the parasite although its microfilariae are sensitive.

In summer, there can be tens of thousands of *R. andersoni* microfilariae in 1 ml of a cervid's blood.

Risk of human infection and protective measures: There is no evidence of transmission of this parasite to humans via haematophagous vectors. However, it is justified to wear protection against haematophagous insects during their mass appearance.

Is it safe to eat the meat? The meat of an infected animal is safe to eat. Insect-transmitted roundworms cannot be contracted from ingested meat. Altered parts and areas are removed.

Legworm, jointworm

Agent: Several species of roundworms of the genus *Onchocerca*.

Parasites produce microfilariae to the surface of the skin, where they are readily available for black flies.

Prevalence: Prevalent in moose, reindeer, red deer and roe deer.

Life cycle and transmission: Adult, up to even 30 cm long, threadlike parasites dwell around joints and tendons and between muscular membranes. They produce larvae, microfilariae, to the skin where vectors, mainly black flies but also midges, get infected via blood meals. Inside the vector, the parasite goes through two moults and becomes infective. When the black fly has its next blood meal, the infection is transmitted to new host animals.

Symptoms and findings:

- Infections are extremely common in cervids. A mild infection does not cause noticeable symptoms. When the parasites are abundant, they cause visible chronic changes in the tissues they inhabit. Typical symptoms are grey or greenish nodules or granuloma on the surfaces of joints, tendons and membranes, and between muscular membranes in muscles. The changes between muscular membranes can only be seen when the meat is cut.

- In a severe infection, the entire hock area can be inflamed and bloody. It is possible that inflammatory changes, especially around the hock joint, can cause limping or stiff gait.
- In summer, skin alterations and ulcers around hocks are regarded as visible signs of infection in moose. The assumption is that these alterations are caused by parasitic larvae, microfilariae: a bloody area attracts vector insects, and the larvae are more easily available for them. This way their chances of being transmitted to new hosts are higher.

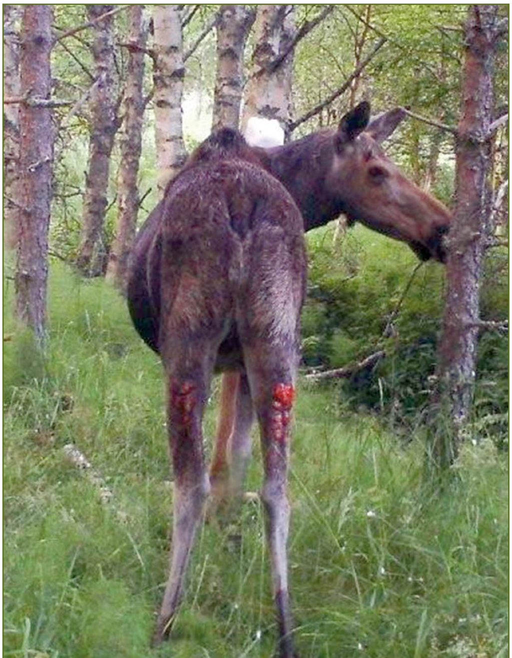
Control: It is not possible to control the prevalence of the parasite in the wild.

Risk of human infection and protective measures: There is no evidence of transmission of parasites of the genus *Onchocerca* of cervids to humans. Reports of zoonotic transmission of *Onchocerca* species of other animal species into humans and some form of subcutaneous or conjunctival development causing minor alterations have been published in the world. It is justified to wear protection against haematophagous insects during their mass appearance.

Is it safe to eat the meat? The meat is safe to eat. The parasite cannot be contracted from meat. Changed areas are removed.

Adult *Onchocerca* parasites dwell between muscular membranes and on the surfaces of joints and tendons. Severe infection causes visible pathological changes, such as in the pictured moose.

Onchocerca ('footworm') produces larvae to the host animal's skin. Black flies transmit the infection from one animal to another.



In summer, a legworm infection causes areas of skin to become raw. Vectors are attracted by the blood (Photo: Keijo Kiviaho).

Bear mediastinal worm

Agent: *Dirofilaria ursi* roundworm.

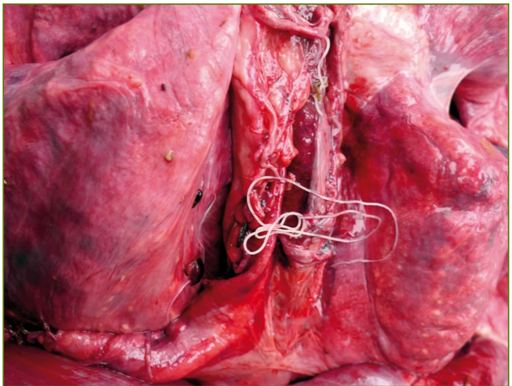
Prevalence: The mediastinal worm is a ubiquitous parasite of the bear. The parasite is prevalent in the dense bear populations in Southeast Finland.

Life cycle and transmission: Adult parasites, the almost white 5 to 20 cm long thread-like nematodes dwell around the large blood vessels near the bear's heart. The parasite produces larvae into the bear's bloodstream. It is transmitted from one bear to another by haematophagous black flies.

Symptoms and findings: The parasite is not known to cause symptoms in bears. Diagnosis can be made either by demonstrating the parasite larvae in the bloodstream by means of microscopic examinations or by identifying the parasites during autopsy.

Control: It is not possible to control the prevalence of the parasite in the wild.

The bear mediastinal worm produces microfilariae into a bear's bloodstream. The black fly transmits the infection from one animal to another.



The bear mediastinal worms dwell on the outer surfaces of large blood vessels near the heart.

Risk of human infection and protective measures:
In Europe, there is no evidence of transmission of the parasite into humans via black flies' bites containing parasitic larvae. However, it is justified to wear protection against haematophagous insects during their mass appearance.

Is it safe to eat the meat? The parasite has no effect on meat quality. It cannot be contracted from meat.

Keep in mind: Dog heartworm and subcutaneous worm.

The insect-transmitted roundworms *Dirofilaria immitis* and *D. repens* are common parasites of dogs in South Europe. The parasites produce larvae into a dog's bloodstream. Both parasites are transmitted by mosquitoes. Adult forms of the *D. immitis* parasite dwell in a dog's heart and large blood vessels. They cause the dog a severe chronic disease with circulatory disorders. Adult *D. repens* parasites dwell under a dog's skin. The symptoms are subcutaneous swelling, nodules and itching. There have been reports of some human infections of the parasite. A larva has developed under the infected human's skin or conjunctiva, and sometimes in the central nervous system. The parasites have undergone some developmental stages in humans, but they have not become sexually mature. Both parasites cause serious symptoms to dogs and they are also difficult to remove. Therefore, it is necessary to protect dogs from insects and possibly also use preventive medication in areas where these parasites are prevalent. The distribution and infection rates of these parasites may undergo significant shifts influenced by climate change.

2.4.5 Arthropod parasites (Arthropoda)

Arthropods are the most species-rich phylum of the animal kingdom. Only some of them are parasitic. Arthropods have a cuticular external skeleton and paired legs. Their chitin-rich exoskeleton functions as a supportive structure that protects the jointed, segmented body and serves as a place for muscle attachment. The heart is tubular and connected with the vascular system. A system of pipes forms the arthropod respiratory system, whereas the species that dwell in water have gills. Most arthropods rely on sexual reproduction. The parasitic species of the phylum are ectoparasites such as insects, fleas, lice, biting lice, and mites and ticks.

2.4.5.1 Insects (Insecta)

Warble fly

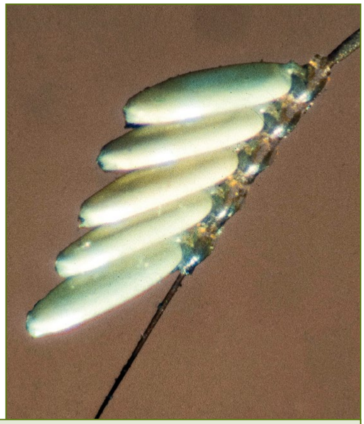
Agent: *Hypoderma* species, around 1.5 cm long, two-winged (dipteran) parasitic insects that are members of the bot fly family.

Prevalence: The warble fly *Hypoderma tarandi* is common in the reindeer (*Rangifer*) family throughout the northern hemisphere. Individual cases have also been reported in moose and red deer. *Hypoderma diana* is a parasite of the red deer.

Life cycle and transmission:

- The flying time of adult reindeer warble flies ranges from June to September, when they are active especially on sunny days. Warble flies prey by sight and they are extremely good flyers.
- The flies lay their eggs on the cervid's hair, and the hatched larvae bore through the animal's skin. After tunnelling through subcutaneous tissue and finding a good spot, the larvae carve a hole in the animal's skin in order to get air.
- The larvae overwinter under the skin and reach the length of 2 to 3 cm. In spring and early summer they drop to the ground and pupate. After around 40 days an adult warble fly emerges from the pupa.

Adult warble flies hunt for their prey actively on warm, sunny days (Photo: Arne C. Nilssen).

After finding a cervid, the warble fly (Photo: Arne C. Nilssen) lays its eggs and attaches them to the animal's hairs (Photo: Kjetil Åsbakk).

Symptoms and findings: The attacks of flying warble flies cause their target animals to panic and run in fear. A severe infection with dozens or hundreds of parasites dwelling under the animals' skin, which is common in reindeer, weakens the host animals' condition and causes hide damage due to puncture holes in the skin.

After hatching from the eggs, the larvae bore through the cervid's skin and move subcutaneously to reach the animal's dorsal region. Once there, they cut breathing holes through the host animal's skin, overwinter under the skin and develop into 2 to 3 cm long larvae. In spring, they drop to the ground and pupate.

Control: It is impossible to control the prevalence of the parasite in the wild. Around 80% of Finnish semi-domesticated reindeer are medicated (ivermectin) against warble flies every year.

Risk of human infection and protective measures: There are reported cases of warble fly larvae getting in the eye or under the skin of humans. The parasite has

Warble in roe deer, early stage (located under the skin, but outside the silverskin and muscle) (Photo: Peter Paulsen).

caused inflammatory changes and swelling. The cases are rare, but the possibility of infestation must be kept in mind if there are skin or eye symptoms and preliminary knowledge suggests the possibility of infection.

Is it safe to eat the meat? A reasonable number of warble flies in the animal does not affect the quality of the meat. During the hunting season in autumn, the developing warble fly larvae are small and difficult to notice under the skin. Infection cannot be contracted from meat.

Before they drop to the ground, the warble fly larvae can be clearly seen through the animal's spring coat. In around 40 days adult flies emerge from the pupas.

Deer bot fly

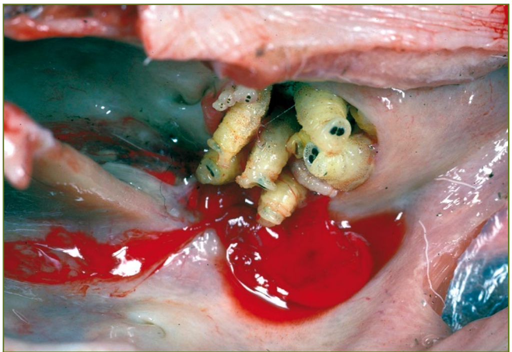
Agent: Parasites of reindeer (*Cephenemyia trompe*), western roe deer (*C. stimulator*), moose (*C. ulrichii*) and red deer (*C. auribarbis* and *Pharyngomyia picta*) They are members of the bot fly family and outwardly resemble the warble fly.

Prevalence: Deer bot flies, also known as throat or nose bots, are common parasites of cervids in the northern hemisphere. They commonly infest reindeer and moose. Cross infections in various cervid species have occasionally been reported.

The throat bot fly bears a close resemblance to the warble fly (Photo: Arne C. Nilssen). It is the more robust of the two.

The bot fly sprays her larvae to the nostrils of cervids from the distance of around 10 cm. The animals try to shield from their attacks by pressing their noses to the ground and pawing the ground.

In spring, when the host animal coughs, the larvae drop to the ground and pupate.



Masses of big bot fly larvae in the throat make breathing difficult and cause panic in animals (Photo: Arne C. Nilssen).

The inflammation in a human's eye was caused by a deer bot fly larva whose mother had chosen a wrong host animal.

Life cycle and transmission:

- Adult deer bot flies are active especially on the sunny days of mid- and late summer. When a fly finds a target animal, it shoots its larvae into the cervid's nostrils from a distance of around 10 cm. The larvae migrate to the animal's throat and spend the winter there.
- By spring, the larvae have grown to a size of 25 to 36 mm. Then they drop to the ground and pupate. After four or five weeks in the soil, adult flies emerge from the pupae.

Symptoms and findings:

- Preying throat bot flies cause flight reactions in cervids. The attacks of the flies may disrupt feeding and in this way weaken the condition of cervids. In springtime, the presence of a large number of larvae in the host animal's throat may cause coughing, hawking and pulmonary infections and even mortalities.
- Animals that are infested with these parasites have been known to panic, which is manifested by bolting, being exposed to traffic accidents, or even aggression as the animal is trying to get rid of the tormenting larvae in its throat. Throat bot flies are commonly found in moose that have been in involved in road accidents in spring.

Control: The spread of the parasite is impossible to control in the wild. Around 80% of Finnish semi-domesticated reindeer are medicated (ivermectin) against bot flies every year.

Risk of human infection and protective measures: Reports of individual cases of human bot fly infection have been made, also in Finland. As a result of an erroneous choice of host animal, some larvae have got into human eye and caused an infection. It is a minor risk, but a notable one also as far as dogs are concerned.

Is it safe to eat the meat? Deer bot fly larvae that develop during the hunting season in autumn are too small to be seen with the naked eye. They have no effect on meat quality. The infection cannot be contracted from meat.

Deer ked

Agent: A 3.5 to 5 mm long leathery ectoparasite called *Lipoptena cervi*, a species in the family of louse flies.

Prevalence: The deer ked is commonly found in cervids in Europe and North Asia. It has been introduced to North America. The parasite has emerged toward north and appeared in Finland 1960 from east and in Norway in 1983 from south. In Europe, the definitive hosts of the deer ked are red deer and other deer species, moose and western roe deer in Sweden, and moose in Finland.

Life cycle and transmission:

- Adult deer keds live under a cervid's fur coat. Males and females suck blood through holes that they have made through the skin. The depth of these 'blood wells' is around 1 mm.
- Deer keds mate in the host animal's fur. Female flies give birth to one larva at the time. The larvae pupate quickly, drop to the ground and find shelter under the snow and vegetation. A female deer ked can produce around 30 larvae. Adult flies hatch in late summer and early autumn, from August to October.
- The deer ked's ability to fly is limited. They are active when the temperature is higher than 5 to 6 °C and a possible host animal is in sight. Detection of a host animal is made easier by the large size and dark colour of the target animal, and possibly also by the carbon dioxide and heat it emits. As soon as the deer ked has settled in its host animal, it sheds its wings. This is a good way to distinguish the deer ked from the bird louse fly which will be winged.
- Adult deer keds endure freezing temperatures for short periods of time. As they are poor fliers, their dispersion is based on the movements of the host animals.

The difference between deer keds and bird louse flies is in the position of the wings and the colour of the wing veins. The wings of the deer ked are parallel and the wing veins are brown. The wings of the bird louse fly are in v-position and its wing veins are black.

The best identification mark of a deer ked is that it drops its wings after settling in a host animal. Pictured here a deer ked who has already sucked blood, resulting in the expanding of the abdominal cavity.

Symptoms and findings:

- A single moose can carry thousands of deer keds in its coat. The larger the animal, the more severe the infestation. In the autumn hunting season, the infestation is recent and moose do not present visible symptoms, although bites have already caused hide damage and scarring.

Female deer ked gives birth to one larva at the time. The larva pupates and drops to the ground. Adult fly hatches in the following summer. Pictured here: female, larva and pupa.

A severe and long-term deer ked infection causes skin alterations in moose. The alterations are visible in the hide after it has been worked.

The reddish brown staining of a moose bedding site reveals deer ked infection, and the splashes around it are signs of the animal's discomfort and shaking. The colour comes from deer ked faeces, or the moose's blood that has travelled through the flies' intestines.

- Infectious skin alterations have been reported in moose that were killed in collisions in spring or early summer. They had been suffering from deer ked infestation for several months.
- Another typical sign of moose suffering from deer ked infection is the strong reddish-brown staining of their snowy bedding sites and the surrounding areas. The stains come from the deer keds' faeces and the moose's skin excretions.
- In Sweden and Norway, hairless moose have been linked to deer ked infections.
- Reindeer and wild forest reindeer are aberrant hosts to the deer ked. Deer ked infestation causes them visible symptoms. Even a minor infestation results in itching and discomfort. Scratching and rubbing causes worn fur and hairless patches that increase loss of heat in cold weather. There have been reports of domestic animals such as horses, sheep and even pigs and dogs suffering from deer ked infestation. The deer ked can reproduce in reindeer and wild forest deer, but it seems that its reproductive efficiency is not as good in them as it is in moose or deer. This is likely due to their thick coat and underfur, which hinders the movement and feeding of the louse fly that is best adapted to dwelling in the more sparsely formed coat of moose.

Control:

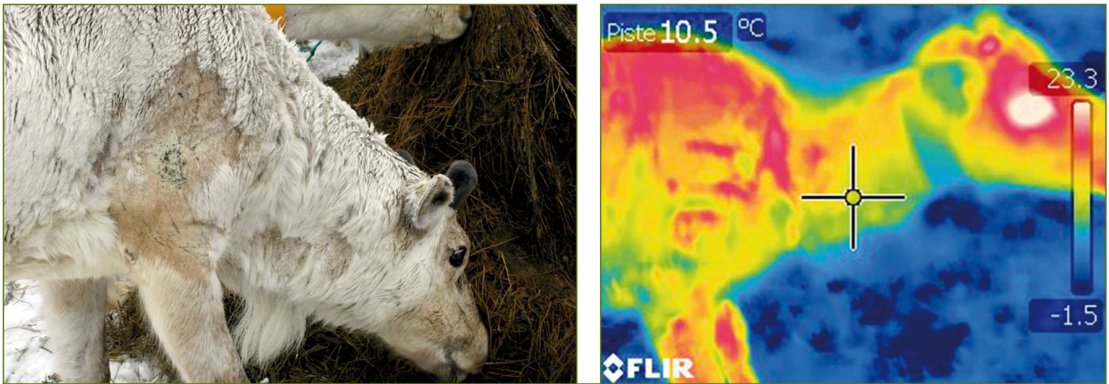
- As deer ked populations are strongly tied to cervid populations, their prevalence and dispersion can be controlled by regulating cervid density with hunting.
- In reindeer and farmed deer, deer ked infection can be treated with antiparasitic medicine that contains ivermectin. It is the same drug that is given to 80% of reindeer against bot fly infections in autumn. Deer keds can be removed from domestic animals with ectoparasite removal products.

Risk of human infection and protective measures:

- Some 30% of people exposed to deer ked bites develop a condition called deer ked dermatitis. The disease is a chronic condition in which itchy papules appear on the bite sites. The papules are susceptible to bacterial infections.

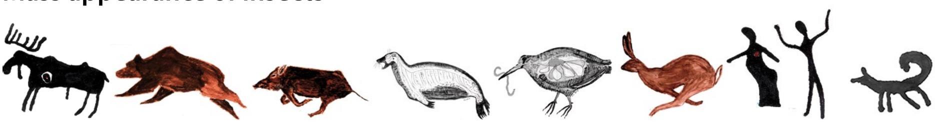
- The condition results from the victim's allergic sensitization to deer ked saliva, and the reactions of the immune system. Allergic people should avoid entering especially the winter habitats of moose during the periods when deer keds are active. The use of light-coloured protective clothing is advisable. Chemical deer ked repellents have not as yet proven effective.
- Deer ked can also be transmitted from animals to humans during handling of killed game.
- Deer keds have been shown to act as vectors for certain bacteria (*Bartonella*) that cause disease in humans. Definite evidence has not been shown. The efficiency of deer keds as vectors is diminished by the fact that the flies usually do not change hosts after they have shed their wings.

Is it safe to eat the meat? Deer keds have no effect on the quality of the host animal's meat, at least during the hunting season. The quality of reindeer meat may be deteriorated due to stress caused by the parasite. Allergic people should be careful in handling moose, as deer keds can be transmitted during skinning.



Deer ked infestation causes hair loss and loss of heat in reindeer and wild forest reindeer. In cold winters, it can be fatal to the animals.

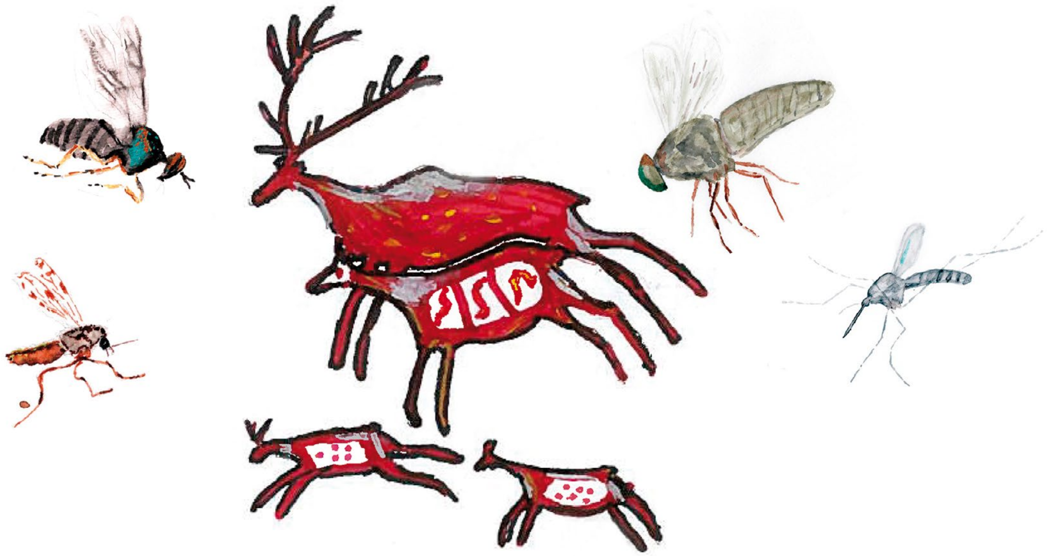
Mass appearance of insects



Haematophagous insects are the most significant and effective vectors of various pathogens from one individual to another, both in animals and in humans. A great number of insects, their recurrent blood meals in various animals, and their ability to fly or travel long distances by air currents are aspects of this phenomenon.

Agent: During the period of mass appearance, mosquitoes (Culicidae), black flies (Simuliidae), biting midges (Culicoidea), horse flies (Tabanidae), bot flies (Oestridae) and dump or horn flies (*Hydrotaea*) test the tolerance of both humans and animals in the wild.

Prevalence: The peak of mass appearance of blood-sucking insects is in warm summer months. Ordinarily, the infestation is at its worst in warm and moist summers.



'Räkkä' is the Finnish name for the simultaneous mass appearance of bothersome haematophagous and parasitic insects. The 'räkkä-time' is a nightmare for wild animals who are preyed upon by swarms and swarms of bloodthirsty mosquitoes, black flies, horse flies and bot flies.

Life cycle and transmission:

- Out of all 'räkkä' insects, only the females are haematophagous. The often short lives of the males are sustained on plant nectar.
- The female insect needs one or more blood meals in order for its eggs to develop. Many species, such as mosquitoes, lay eggs more than once during their lives, and they need a new blood meal before egg-laying. Their ability to transmit pathogens from one species to another is based on this behaviour.
- One larva hatches from each egg. The larvae develop into flying adult insects through a series of moults. Different species overwinter mainly as eggs on the ground or in water. Some species of mosquitoes hibernate as adults and appear already in the early spring.
- Many insect species need aquatic environment for their development. Various species can develop in ditches or pools, in stagnant or flowing waters. Both temperature and rainfall has a significant effect on the number of haematophagous insects in the wild.
- Haematophagous insects adapt well to cold weather, but cannot endure sudden changes in temperature. Some species, such as horse flies and bot flies, are most active when the sun is shining. If a cloud covers the sun, they disappear. Most mosquitoes prefer damp and cloudy weather. Signs of thunder increase their thirst for blood (*Aedes*), whereas other shyer species (*Culiseta*, *Anopheles*) launch an attack at their unsuspecting sleeping victims during the night.

Symptoms and findings:

- Mass appearance of insects causes many behavioural changes and protective reactions in animals. The behaviour has been passed on by or inherited from former generations.
- Animals may seek relief from swarming insects by moving to open, windy areas or snowy patches at fells. Against some insects, shadowy places provide best shelter, and some can be lost by shaking,

scratching, pawing the ground, dashing about violently, or by constant moving around. It has been suggested that a reindeer might be attacked by as many as 8,000 mosquitoes in one hour which cause circa 125 g blood loss. In addition to mosquitoes, animals are bothered by black, horse and bot flies.
- Mass appearance of insects and the energy cervids spend in attempts to avoid them can, in some cases, hinder their growth and weaken their condition, and cause blood loss especially in young animals.
- The endless swarms of blood-feeders harass also dogs and production animals. In unaccustomed animals they can cause shock and mortalities.

Control:
- Control of mass appearance of insects is not possible in the wild.
- Wild animals have adapted to the presence of insects. Insects are important for the pollination of plants and berries, and they hold a place in the food chain of many game animals, especially birds.
- Dogs and production animals must be protected with repellents, if they have to be outside during mass appearance of insects, and in areas of most infestation.

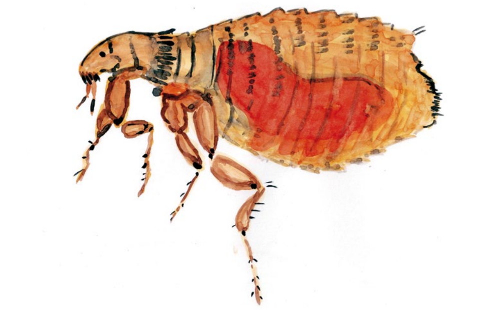
Risk of human infection and protective measures:
- Humans are also bothered by the attacks of haematophagous insects. Some people are sensitized and suffer from violent reactions against insect bites. Protection is necessary. It is especially important in tropical areas where insects are carriers of many pathogens and parasites.
- Haematophages also work as efficient and free collectors of blood samples in the wild. By studying them it is possible to gather information on many pathogens and their prevalence.

Insect harassment is the cause of many behavioural changes in animals. They escape from mosquitoes to open, windy places.

During mass appearance of insects, calves are still small and their immune response is underdeveloped. At the same time, the mothers shed their coats almost completely. This aids the spread of diseases and parasites via haematophagous insects.

Fleas (Siphonaptera)

Agent: Fleas are flat and agile insects with long legs well adapted for jumping. They are ectoparasites that live by haematophagy of the blood of their host animals.



A flea can jump at its prey from a distance of 60 cm.

Prevalence: It is not exactly known how prevalent fleas are in game animals. Flea species are not exclusive parasites of one animal species. Therefore, they can infest, at least for short periods, several species of animals. Fleas are especially common in birds and nesting mammals.

Life cycle and transmission:

- An adult flea lays eggs usually on the host animal itself. Before laying, it must feed on blood. The eggs fall to the ground and, under suitable conditions, hatch into larvae. The larvae feed on any available organic material and undergo three moults.
- After that the larvae pupate and develop into adults in a few weeks' time. When a suitable host animal comes near, signals such as vibration, heat and carbon dioxide alert the flea and it jumps on the host from a distance of even 60 cm. If there is enough nourishment and shelter, the life span of an adult flea can be very long.

Symptoms and findings: Finding fleas inside the fur is difficult, the fleas usually live as eggs, larvae or pupae in the animal's surroundings, and adult fleas can jump on the host animal only from time to time in order to feed. Repeated exposure to flea saliva may lead to the emergence of so called flea bite allergy.

Control: It is not possible to control fleas in the wild.

Risk of human infection and protective measures:

- Humans are susceptible to the infestation of fleas of animals such as dogs, cats, birds, squirrels or hedgehogs, but usually the infestation is short-lived. Fleas can act as vectors of various pathogens, bacteria, viruses and parasites. The gravest example is the bubonic plague, a bacterial infection caused by a bacterium called *Yersinia pestis*. This disease is known as the black death, an epidemic that killed hundreds of thousands of people in the Middle Ages. Outbreaks of the disease still occur in North America, among other places. The disease is transmitted by fleas from rodents to humans.
- Fleas can also act as vectors of the rat (*Hymenolepis nana* and *H. diminuta*) and dog tapeworms (*Dipylidium caninum*). If a dog is found to have fleas, in addition to long-lasting antiparasitic medication, attention should be paid to the cleaning and pest control of the host's environment. The greatest part of the flea population dwells as eggs or larvae in the environment, where they feed on impurities.

Lice and biting lice (Phthiraptera)

Agent: Sucking and biting lice are skin-dwelling parasitic insects. Visible symptoms caused by them are called pediculosis.

Prevalence: Lice and biting lice are common to almost all animal species. Most lice are found only on their specific hosts. No exact findings on their prevalence in game animals exist, but most commonly these parasites cause symptoms in cervids, wild boar and birds.

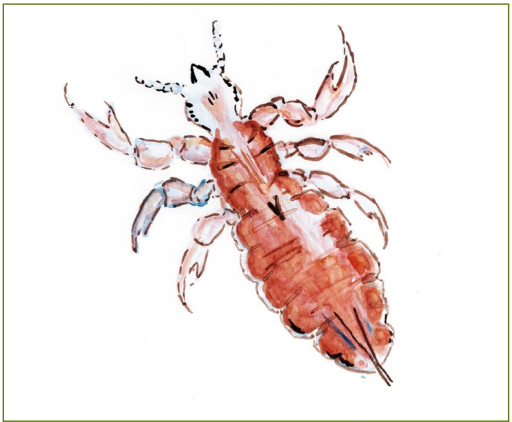
Life cycle and transmission:

- Lice and biting lice dwell on the surface of the skin, under the protection of fur or feathers. The lice suck blood from holes they have bored through the skin. The biting lice feed on the top layers and secretions of the skin. Both species reproduce by laying eggs called nits that they attach to the host animal's hairs.
- Transmission occurs directly from one animal to another, or from the ground. Dense populations and direct contacts between animals increase the transmission of these parasites.

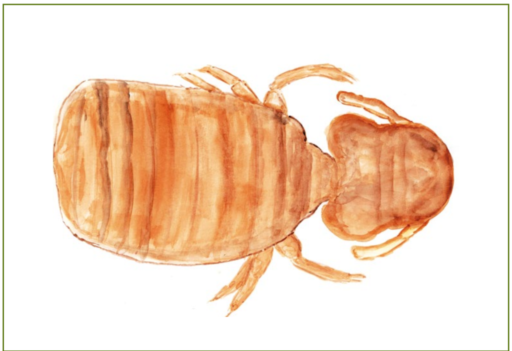
Symptoms and findings:

- Mild infections are usually asymptomatic and difficult to show, as animals have adapted to their own ectoparasites.
- Severe infection causes itching, scratching and hair loss as well as loss of energy. Secondary infections are also possible. The symptoms often occur in early spring.
- It is easy to tell the difference between lice and biting lice: lice have sharp heads that they need for blood-feeding, whereas the head of the biting louse is round and adapted to eating the top layer of the skin.

Control: Lice infestation can be controlled by avoiding dense regional populations of game animals and by following good feeding ground hygiene and practices. Contacts with production animals are not desirable due to cross infections.



The sucking louse has a sharp mouth that it uses for sucking blood from the skin.



The head of the biting louse is round. It feeds on top layers of the skin.

The almost hairless neck of a roe deer infested by biting lice.

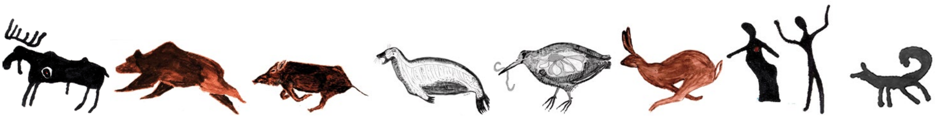
Risk of human infection and protective measures: The lice of animals can infest people for short periods of time, but they will not stay for long. Brief tasting and itchy spots have been reported.

Is it safe to eat the meat? Severe ectoparasitic infection can lower the quality of the meat.

Keep in mind: Hair loss syndrome (HLS), has been widespread in some deer populations in the USA since 1996. It has been suggested that HLS is caused by ectoparasites (lice, biting lice, *Demodex* mites) and the fact that these species are new parasites for deer, because they originated from production animals. The syndrome has caused population declines and mortalities, mainly due to heat loss in winter. In Sweden and Norway, moose suffering from hair loss have been found and the deer ked has been suggested as the cause. In Finland, hair loss has been found in western roe deer in context with severe biting louse infection, and in wild forest reindeer and reindeer in context with deer ked infestation.

2.4.5.2 Arachnids (Araneae)

Scabies



Agent: *Sarcoptes* mites.

Prevalence: Scabies is mainly found in carnivores and pigs. There have also been reports of the infestation in western roe deer and red deer. There are many scab mite subspecies and they have adapted to dwell in different animal species. Scabies is often found in foxes, raccoon dogs, wolves and lynx.

The scab mite has adapted to dwell in tunnels that it burrows inside the host's skin.

Life cycle and transmission:
- Scab mites tunnel inside the host's skin and form burrows where they reproduce. The parasite is easily transmitted by close direct contact between animals, but it can also be transmitted indirectly through the places where animals have been staying.
- The scab mite subspecies of different animals can also spread to other animal species or humans, if the contact is close and prolonged. In these cases, the infection is often brief and the symptoms disappear by themselves.

Symptoms and findings: Predisposing factors, such as starvation, set the scene for the disease. Severely ill animals are often abnormally tame. In the initial stage, the infection causes spots and intense itching and scratching. The symptoms typically begin from armpits and the tips of ears and later spread all through the body. The consequence is hair loss and thickening of the skin, ulceration and secondary infections. Secondary infections or the winter cold are often fatal to a severely infected animal.

Chorioptes mites live on the skin and cause intense itching.

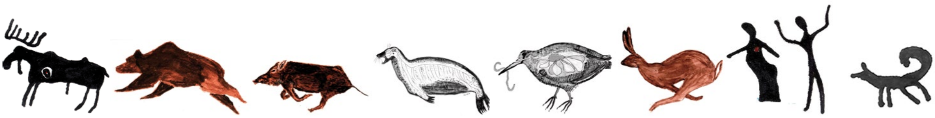
Control: The spread of scabies is reduced by keeping small carnivore populations at moderate level. In small carnivore and cave hunting, the risk of infection of hunting dogs must be kept in mind.

Risk of human infection and protective measures: Animal scab mites can be transmitted to humans. However, the infection is often short-lived. It is advisable to wear rubber gloves when handling small carnivores.

Is it safe to eat the meat? The meat of carnivores is rarely used as foodstuffs. The scabies infection cannot be contracted from meat.

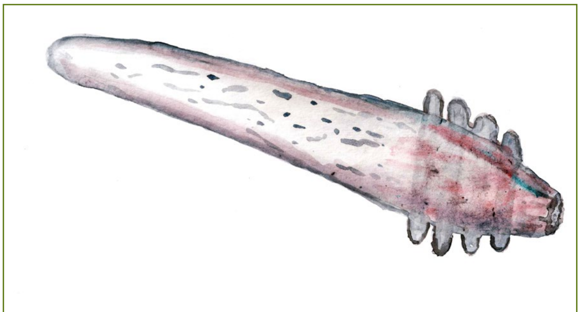
Keep in mind: Cervids also suffer from mites that dwell in the top layers of the skin (*Chorioptes*) or burrowed in hair follicles (*Demodex*). Severe infestations can cause skin alterations and hair loss.

Ticks



Agent: Castor bean tick, *Ixodes ricinus* and taiga tick, *Ixodes persulcatus.*

Prevalence: The range of castor bean tick (sheep tick) covers most of continental Europe and the British Isles and taiga ticks are distributed throughout Eastern Europe and Asia. Ticks can feed in almost all animal species from small rodents to birds.



The elongated body and short legs of the *Demodex* mite are adaptations for life in hair follicles.

The infected skin of a white-tailed deer infested by ticks.

Life cycle and transmission: The female tick produces thousands of eggs into its environment. The eggs hatch into larvae. The tick has a three-host and three-blood-meal life cycle, it develops from six-footed larva into eight-footed nymph and then into adult (see Section 2.2.12). The tick needs a blood meal from the host animal in order to develop to the next stage, and the female tick needs a third blood meal for the development of eggs. Depending on the stage of development, the tick feeds for several days, even a few weeks at the time. Between blood meals, the tick drops off and lives under the protection of the ground. It takes 2 to 4 years until the tick reaches the adult stage. The tick season lasts from April-May to October-November.

Symptoms and findings: It is not entirely known what effects or discomfort are caused to the host by tick infestation. Symptoms such as local skin irritation, skin inflammation and hair loss caused by severe tick infestation have been reported in deer.

Control: Tick control is not possible in the wild. It has been suggested that the dense deer population maintains a strong tick population. Protecting dogs from ticks and daily tick inspections are necessary in areas where ticks are prevalent.

Risk of human infection and protective measures: Tick bites can spread a large number of zoonotic diseases such as tick-borne encephalitis, borreliosis, babesiosis and Q fever. Vaccinations, wearing protective clothing and daily tick inspections are routine in areas where ticks are prevalent.

Is it safe to eat the meat? The feeding of ticks has no effect on meat quality.

Keep in mind: The brown dog tick (*Rhipicephalus sanguineus*) thrives in human dwellings and it is difficult to eradicate.

Reindeer tongue worm (*Linguatula arctica*)

Close relatives of the impressively large reindeer tongue worm are found in Asia and Africa (Photo: Arne C. Nilssen).

The tongue worm, mainly found in reindeer and wild reindeer calves, is a parasitic tongue-like worm of the Pentastomida order. The prevalent areas of other parasites of this order are far away in Asia and in southern Africa. Adult parasites dwell in the nasal cavity of reindeer. The name of this relatively large parasite comes from its tongue-like form. The parasite is common but rarely found, because nostrils are difficult to examine and it seems that the parasite does not cause any notable symptoms to its host animal. The parasite was first discovered in 1987. The life cycle of the parasite is direct: adult parasites produce millions of eggs on pastures. Calves are infected via food. The maturation and life cycle inside reindeer is not known. However, it has been suggested that maturation happens in the liver or another organ.

2.5 Poisonings and foreign substances


Human actions are most often the cause of environmental chemicalisation.

Foreign, toxic substances that spread to the environment usually originate in the activities of humans. Their possible harmful effects are first manifested in wild animals. Toxic substances are also generated in nature, for instance, produced by fungi and algae. Many chemical substances can be toxic if they get to the food of game animals or humans. The content of some chemical substances is so small that their harmful effects are only shown when they accumulate to the top of the food chain. In people and animals alike, foreign substances may cause acute intoxications or chronic long-term effects with indeterminate symptoms or genetic changes.

The foreign substance content of wild animal meat is an excellent indicator of the state of the environment. Poisonings or foreign substances are difficult to detect in animals, and laboratory tests are always required for their demonstration.

Observations made on the environment of game animals and identification of possible hazards such as old industrial areas, mining territory or the use of plant protection products (pesticides) is an important part of the prevention of possible health hazards caused by game meat.

For humans, the risk of getting toxic amounts of foreign substances from game meat is minor, as the amount of consumed game meat is small in proportion to total meat consumption. On the other hand, in some hunter families the main part of consumed meat can be game meat.

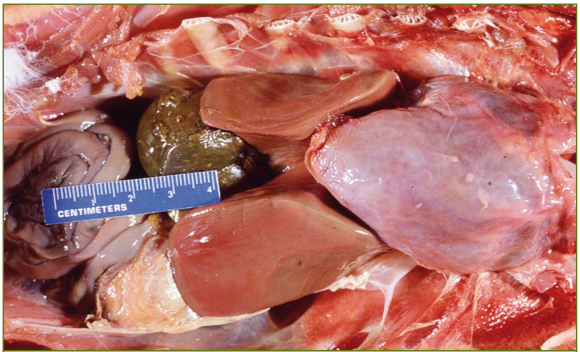
2.5.1 Heavy metals

Agent: Cadmium (Cd), lead (Pb) and mercury (Hg) are classified as environmental toxins. They may also cause health hazard for humans.

Occurrence and spread:

- Heavy metals accumulate to nature mainly from the emissions of industry and traffic. They concentrate in plants, herbivores and carnivores.
- One especially significant heavy metal is **lead**, which is found in game meat. It comes from environment and especially from lead bullets and pellets used by hunters. Lead has been shown to have harmful effects on waterbirds and birds of prey. Lead accumulates in waterbirds from shots and pellets that have sunk to the bottom of water. Birds of prey get lead into their systems either by eating lead-rich waterbirds or from the offal of animals killed with lead ammunition. There have been reports of mortalities caused by lead poisoning among endangered birds of prey species. Terrestrial mammals can get acute lead poisoning from licking a battery left to the ground, for instance.

If left to the ground, hunting by-products that are rich in lead can cause lead poisoning to birds of prey that feed on them.



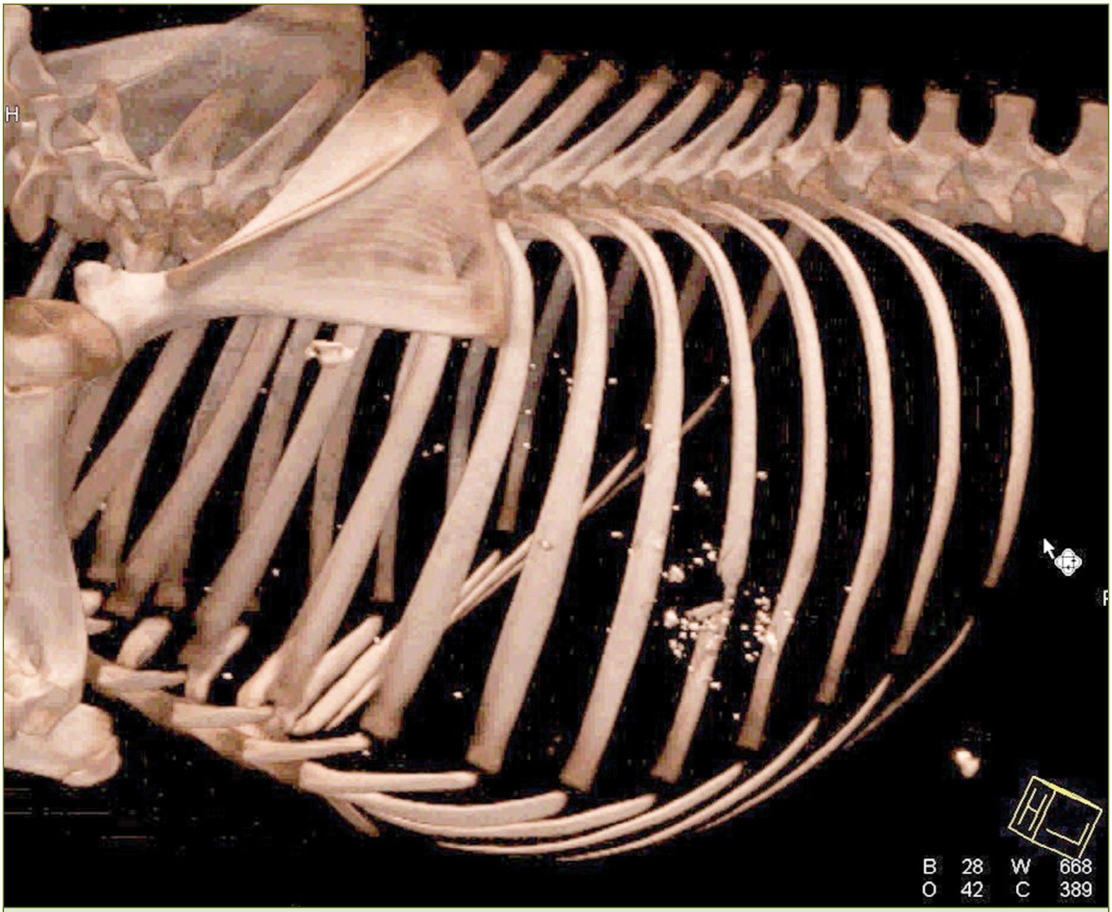
In birds with lead poisoning, typical findings are light tissue colour, loss of heart fat and enlarged gall bladder. Pictured here an eagle that died of lead poisoning (Photo: J. Christian Franson, National Wildlife Health Center, USA).

- There have been reported mass mortalities of birds caused by **cadmium**: cadmium has accumulated in plants and further, in toxic amounts, in birds that eat those plants.
- The occurrence of **mercury** is often connected to fish, but high concentrations can also be found in birds and mammals.

Symptoms and findings:
- Cadmium and lead are mainly stored in the liver and kidneys of game animals, causing deterioration and functional weakening in these organs.
- Among game animals, acute and lethal heavy metal poisoning is most often found in birds. Lead affects the central nervous system, whereas cadmium affects kidneys. Symptoms are often general, such as loss of appetite, starvation, weaning, central nervous symptoms, greenish diarrhoea and sometimes even the presence of pieces of lead in the digestive tract.
- In ruminants, banging the head against a tree is regarded as a typical symptom of acute lead poisoning. The effects of mercury demonstrate as reduced reproductive success.

Control: It is important to take measures against environmental pollution. In modern hunting, lead bullets and pellets should be replaced by non-toxic substances.

Risk of human infection and protective measures:
- As heavy metals mainly accumulate to the liver and kidneys of game animals, their use as nourishment should be restricted. In some regions, the heavy metal content of the organs of rabbits, hares and more than one year old cervids is so high that they must not be eaten.



If a lead bullet hits bone, it can be shattered and leave a considerable amount of residue to meat and organs (Photo: Sigbjørn Stokke). Bruised areas are carefully removed and the organs of the hit zone are not left in the wilderness.

- Special care must be taken when handling game killed with lead ammunition. All bruised areas must be removed in order to avoid bullet fragments or pellets remaining in the meat. Foreign substance content of game meat is monitored with national and international meat hygiene programmes.

Is it safe to eat the meat? Heavy metals accumulate in internal organs, which must not be given even to dogs. The meat itself is safe, if it does not contain residue of lead bullets or pellets.

Keep in mind:
- Studies in Europe and the U.S. reported outstandingly high lead contents in ground venison. The contents have exceeded manifold the action levels for lead content in meat.
- Evidently, current hunting and slaughtering hygiene is deficient. This impression is corroborated by the fact that elevated lead content has been shown in the blood of hunters. The probable cause of this contamination is game meat.
- Lead bullet breaks into fragments when it hits the animal and the fragments penetrate the tissues near the wound channel. The bullet is more likely to get fragmented if it hits big bones.

- It is important that the meat containing the wound channel and bruised areas resulting from the hit are removed as widely as is adequate.
- Bruised meat or organs within the hit zone must not be given to dogs.
- Before cooking, all pellets must also be removed from the meat of game killed with a shotgun.

2.5.2 Persistent organic pollutants (POP compounds)

Tree lichen and lichen are efficient in accumulating the pollutants from air and rainwater.

POPs are organic compounds that persist in the environment and accumulate in humans and animals in the food chain. The group includes some of the most harmful environmental toxins that may greatly harm the health of animals and humans. The effects many of these compounds and their interaction have on animal and human health are still unknown.

Agent: Chemical substances with high molecular weight that usually contain chlorine (Cl). POPs have low water solubility but high lipid solubility. This characteristic makes them able to accumulate in the fat tissues of living organisms. Some of the best known POP compounds are dioxins and dioxin-like PCB compounds (polychlorinated biphenyls). The group also includes chemicals formerly used as pesticides (such as DDT), PAH compounds (polycyclic aromatic hydrocarbons) that are created in incomplete burning processes, and BFR compounds (brominated flame retardants) used to increase the fire safety of plastics and textiles, and phthalates used to increase the plasticity of plastics.

Occurrence and spread:

- In practice, all POP compounds found in nature are produced by human industrial processes. They exist everywhere, also in areas where they have never been used.
- Although the use of many substances is banned today, they are still stored in the soil and will be released to the atmosphere for decades to come. POP compounds typically drift far from the source of their emission.
- Long-range transport poses a threat to the vulnerable ecosystems of the arctic areas. Substances are mainly transported by currents of air, but also by ocean currents. Toxins are vaporised in mild areas and, when carried by air currents to colder polar areas, condensation occurs and the compounds fall to the ground in rainwater.

- As POP compounds are liposoluble, they concentrate especially in animals that are at the top of the food chain. The threat of contamination is especially great in the arctic environment, threatening wildlife and humans alike. Reports have been made of high POP content in the fat and internal organs (especially the liver) of fish, and in sea (marine) mammals that feed on fish, and also in arctic terrestrial mammals.
- The susceptibility of the reindeer/deer family to the accumulation of these toxins is probably due to their lichen-rich diet. Lichen has the ability to gather toxins from air and rainwater.
- Typically, the POP content of young animals is higher than that of fully grown animals. Already in the uterus, a foetus is exposed to these substances via the placenta, and again after birth through the fatty milk of the mother.

Symptoms and findings: Laboratory tests are always required for the demonstration of POP compounds in foodstuffs. It has been shown that the effects of these substances on animals and humans include diminished immune resistance, foetal damage and deformity, weakened reproductive function and permanent changes in behaviour, learning ability and memory function.

Control: International measures must be taken in order to limit the amount of POP compounds and to diminish their harmful effects. Monitoring the POP content in the food chain and in foodstuffs is important.

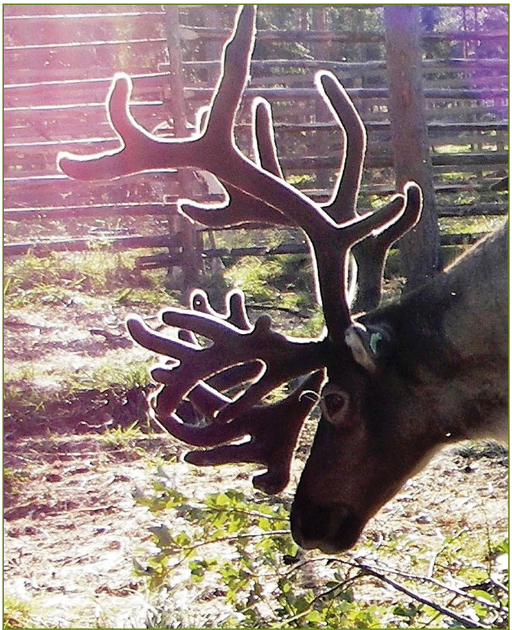
Risk of human infection and protective measures: The greatest risk of harmful effects caused by POP compounds is carried by the arctic indigenous peoples whose nourishment traditionally contains the fatty fish and meat of the region. In order to prevent the accumulation of these substances, it is important to follow the nourishment recommendations issued by the controlling authorities. It is especially important that these recommendations are followed by children, youngsters and women in fertile age.

2.5.3. Radioactivity

Agent: Radioactive substances are isotopes of chemical elements. They are unstable and produce harmful ionizing radiation when atoms decay. Radiation can break the molecular structure and genotype (DNA) of target tissue cells.

Occurrence:

- In the environment, the causes of radioactive radiation are, among others, radon that exists in the soil, background radiation of space, and nuclear power plant accidents. The most common radioactive substances that come from nuclear power plants are iodine-131, caesium-134 and caesium-137 isotopes, the half-lives of which are 8 days, 2 years and 30 years respectively.
- Due to nuclear weapon experiments, the level of radioactivity in Lapland was high both in nature and humans in the 1960s. Due to the Chernobyl nuclear accident of 1986, caesium was deposited in various parts of Europe.
- Radioactivity concentrates to the top of the food chain. It is greatest in fish of prey and predatory mammals. The radioactivity of natural products such as game, wild mushrooms and some berries is considerably higher than that of the corresponding production animals and plants.



Due to nuclear weapon experiments, high levels of radioactivity were detected in Lapland in the 1960s. The consequences of the Chernobyl nuclear accident were shown in wild forest reindeer, for instance.

- High radiation content is found in moose and European hare as well as in the animals of the reindeer/deer family, due to the ability of perennial food plants and some mushrooms to store radioactive isotopes (caesium). Compared to an average consumer, the radiation dose of people who eat plenty of natural products can be more than tenfold.

Symptoms and findings:
- Organisms may be impaired by radioactivity when they are near to a radiating source (e.g. X-radiation) or when radioactive isotopes enter the body through the food chain and continue to emit radiation. Radiation sickness is caused by brief but very strong radiation that causes extensive cellular damage in the body.
- Very little is known about the long-term effects of radiation on wildlife health. Mammals are more susceptible to radiation than arthropods. The effects of radiation focus on the genotype of cells. This may cause tumour-forming diseases and foetal deformity. Radioactivity persists in the body until the active substance leaves or is entirely disintegrated.

Risk of human infection and protective measures: Natural products, berries, mushrooms, fish and meat of game animals cause around 80% of the radiation dose that comes from nourishment. However, the proportion of radiation collected from foodstuffs is small, only around 1%, compared to the annual radiation dose. The dose does not rise significantly even if game meat has an important role in the diet. The radioactivity of the environment and domestic and imported foodstuffs is regularly monitored by controlling authorities.

2.5.4. Plant protection products (pesticides)

Plant protection products (pesticides) are chemical compounds that are used in agriculture and forestry for managing pest vermin and insects, plant diseases and sprouts, and for securing crops. Many plant protection products are chemicals that are harmful to the health of animals and people as well as to the environment.

The use of plant protection products contains one significant problem: the misplacement of chemicals. A large part (more than 90%) of plant protection chemicals ends up somewhere else than the intended target, i.e., in soil, air or water. Many of these products concentrate to the food chain and, over the years, accumulate in animals and people.

The effect of plant protection products on animal populations can also be indirect. For example, this happens when toxins destroy the nourishment of animal species, such as the insects and worms that birds eat.

After the use of plant protection products, it is important to take every precaution that no other animals than pests feed at the sprayed area during the regulated waiting period (Photo: Stig Hägglund).

In birds, some control substances have been reported to cause hormonal disorders, foetal developmental disorders and reduced reproductive success. The use of insecticides on cultivated land has been suspected as the cause of significant reduction of several bird species populations.

Control substances may also have an effect on biodiversity, for instance, by destroying environments and nest-protecting vegetation.

Animals are directly exposed to the hazardous effects of control substances when they feed on or spend time near fields that have been sprayed with pesticides. Most harmful to animals are common insecticides (organophosphates and carbamates). Although these substances do not accumulate to animals, they may cause intoxications.

The latest insecticides, synthetic pyrethroids, are low in toxicity to mammals and birds, but high in toxicity to fish if applied directly to water.

Humans are exposed to control substances through environment and nourishment. Control substances may be accumulated and stored into tissues throughout the human lifetime. Due to their underdeveloped immune system, children are especially susceptible to the harmful effects of control substances. Hazardous effects can vary from skin irritation to genetic alterations and tumours.

Hazards caused by control substances to animal and human health can be diminished with careful planning and consideration of toxin use. Great proficiency and expertise as well as consideration of animals and humans is required before these substances are used. It is important to follow safety instructions and choose a suitable growing time and weather when game animals do not enter the area.

2.5.5 Plant poisonings

The assumption is that game animals have behavioural patterns and physiological traits that enable them to avoid toxic plants. Their feeding behaviour is based on selection and tasting. Ruminants are also able to neutralize toxins through the activity of their rumen microorganisms and of the liver.

Due to overdense populations and starvation, this regulation system can falter and an animal has to eat whatever it can find. This may lead to poisoning. A reported example of this is acute common yew poisoning in moose.

Poisonings are difficult to verify. Verification requires both laboratory tests and good preliminary knowledge of the animal's feeding behaviour.

2.5.6 Poisonings caused by fungal toxins (mycotoxicoses)

The metabolic activity of some of the fungi living in soil, water, plants, feed or foodstuffs can produce toxins called mycotoxins into their environment. Toxins that are ingested with food can cause disease. Animals suffer from intoxication caused by, for instance, ergot fungus (*Claviceps purpurea*) and some *Fusarium* species.

Species of *Fusarium* fungi are common in the fields. Other common fungi that produce mycotoxins are, for instance, the fungi of *Aspergillus* and *Penicillium* genera that thrive in storage conditions. Mycotoxins produced by all these mould fungi have been found in cereals and feeds. Aflatoxins produced by some *Aspergillus* species are the most toxic of all mycotoxins. In particular, they are found in nuts, and in some amounts also in cereals.

Mycotoxins can get to animal food from grass or fodder made from grass, from silage and grain feed. There have been suspicions of mycotoxins appearing in undergrowth in mild autumns and during such winters when the ground was not frozen before snowfall. For instance, suspicions exist of mouldy lichen having an effect on disease outbreaks in reindeer, but, as it is very difficult to research this matter, no certain evidence has been presented.

Symptoms caused by mycotoxins in animals depend on the toxin and the ingested dosage. Symptoms vary from organ-destroying acute intoxications to chronic states of intoxication that may include allergic symptoms, reduced appetite, diarrhoea, weight loss and reproductive disturbances. Diagnosis is difficult to make as the mycotoxin content is very small and several toxins can be found in the same sample. Fungal intoxication has rarely been reported in game animals, perhaps due to difficulty of reaching a diagnosis.

In nature, the occurrence of mycotoxins cannot be controlled. However, the entrance of mycotoxins into the nourishment of game animals can be avoided with careful hygiene of game animal feeding grounds:

- Use only feed that would be acceptable for production animals.
- The grains must be dry, with water content less than 13%.
- Do not offer feed from the ground but from a feeding device that prevents the feed from getting wet.
- A good alternative is an automated feeding device dispensing feed in volumes that can be consumed quickly.
- The place of the feeder is changed often.
- Take care of the cleanliness of automatic feeders and the removal of old feed.

By following these rules, the risk of contagion of many other diseases or parasites through game feeding grounds can be diminished.

Ergotism

Agent: Ergot fungus (*Claviceps purpurea*) is a parasite of grasses. It is commonly found in grasses and cereals. The spores of ergot fungus are spread by insects from plant to plant. It has been estimated that warm summers favour the occurrence of ergot fungus.

Occurrence: Intoxications are commonly found in cervids. Ergot fungus was previously also common as a cause of human intoxications.

Symptoms and findings: Ergot kernels produce toxins called ergot alkaloids that cause vasoconstriction (narrowing of the walls of blood vessels). Vasoconstriction causes lack of oxygen in the distal structures of the body. Ultimately this can result in tissue death (gangrene) and the falling off of, for instance, an ear or the peripheral parts of limbs, such as hooves. Acute poisoning causes central nervous symptoms.

Ergot fungus is a parasite of grasses. The fungus forms easily identifiable dark kernels called ergots.

The toxin of ergot fungus narrows the blood vessels. This can lead to gangrene in the extremities, when, for instance, the tip of an ear or the hooves can fall off.

Control: Controlling the disease in the wild is not possible. Feed offered at feeding grounds must not include ergot kernels.

Risk of human infection and protective measures: Humans can be affected with ergotism through eating cereals or plants contaminated by ergot fungus.

Is it safe to eat the meat? When ergotism is discovered from gangrenous body parts, toxins have already evaporated from the animal. The meat of an animal showing central nervous symptoms must not be eaten before the cause of the symptoms has been determined.

The variety of cyanobacteria and the character of cyanobacterial poisoning makes them hard to diagnose. The significance of cyanobacteria to the health of wild animals is difficult to assess.

Keep in mind:

- Blue-green algae (Cyanobacteria) are prokaryotic, bacteria-resembling microalgae that are not considered actual algae. Like plants, they are able to produce oxygen through photosynthesis. Cyanobacteria include several species, about half of which produce hepatotoxins or neurotoxins. Intoxications that have been lethal to several individuals have been reported both in wild and production animals and dogs.
- Cyanobacterial poisoning can be acute or chronic. Chronic poisoning can be caused by long-term exposure to toxic cyanobacteria. Due to the variety of cyanobacteria and the characteristics of cyanobacterial poisoning, cases are difficult to diagnose and the significance of cyanobacteria to the health of wild animals is hard to assess.
- In dogs, the symptoms of cyanobacteria poisoning include nausea, vomiting and diarrhoea. At worst, the poisoning can cause the dog's death. The possibility of cyanobacteria poisoning has to be kept in mind when dogs are used for hunting during early autumn mild weather, and if fresh potable water is not available. Swimming can also expose dogs to cyanobacteria poisoning.

2.5.7 Poisonings caused by game feeding or nourishment

2.5.7.1 Nitrogenous compounds

Ammonia poisoning

Cause: If the feed offered to wild animals contains plenty of easily soluble non-protein nitrogen (NPN) compounds, ammonia can be formed in the rumen so fast that the rumen microorganisms cannot use it. The excess ammonia gets into the bloodstream, and the liver cannot break it down into urea. The consequence is ammonia poisoning.

Occurrence: There is no certain knowledge of the occurrence of the symptom at game feeding grounds, although diarrhoea is a common symptom in animals that are fed. The disease may also occur if animals graze in heavily nitrogen-fertilized cultivated land.

Symptoms and findings: Acute poisoning includes central nervous symptoms, anxiety, compulsive movements, convulsions and death. Chronic poisoning causes non-specific weakening of general condition and diarrhoea.

Control:

- NPN compounds are plentiful in young grass, root vegetables and poor-quality silage. Heavy fertilizing increases nitrate proportion. Caution must be taken in dosing these feeds. Over 1-year old or poor-quality feed must not be offered. Game feeding should be started carefully, in order that the digestive microbes in the rumen have enough time to adapt to new sources of nourishment.
- Feed should be offered in small volumes that can be eaten immediately. In addition, there should be several feeding grounds in order to prevent dominating animals from getting too large amounts of feed.

Nitrate and nitrite poisoning

Cause: Unfavourable weather and heavy use of nitrogenous fertilizers increase the amount of nitrate also in common grasses. Due to faulty fermentation, poor-quality silage can contain dangerous amounts of nitrate and nitrite. Contaminated water can also be the source of poisoning.

Occurrence: Nitrate is quickly reduced to toxic nitrite in the rumen.

Symptoms and findings: The symptoms of nitrite poisoning show in a few hours. The poisoning quickly causes decrease in blood pressure and the formation of methaemoglobin. Methaemoglobin cannot bind oxygen: the animal develops lack of oxygen and asphyxiates. The blood of an animal suffering from nitrite poisoning is dark and its capacity to coagulate is poor.

Control: In game feeding, the means of nitrate poisoning control are the same as in ammonia poisoning control.

2.5.7.2 Carbohydrate poisoning

Cause: In winter, the nourishment of cervids is usually high in fibre and low in low molecular (easily digestible) carbohydrates. When a diet like this suddenly changes to include mainly carbohydrates, the result can be intoxication. Intoxication can also occur when the offered feed contains too much cereal or other rapidly dissolving carbohydrates, such as root vegetables or fruit, i.e., the feed is too strong and includes insufficient quantity of roughage.

Occurrence: Occurs in cervids in context of game feeding.

Symptoms and findings:

- Large quantities of volatile fatty acids are quickly formed from easily soluble carbohydrates, and the rumen pH drops to values of 4-5. This results in the death of the rumen protozoa, and the function of the rumen stops. The body is quickly acidified. The acute form of this disorder and cervid mortalities pertaining to it have been discovered in context with game feeding.
- The chronic form, which seems more common in game feeding, causes the animal discomfort, weakened general condition, inflammation of the rumen and fore-stomachs and the absorption of toxic substances from the digestive tract. Nutrients are not absorbed from the rumen and the animal loses weight, even if it were eating a lot.

Control:

- Caution should be taken in offering high-carbohydrate feed to game animals. Game feeding must be started cautiously, in small volumes, so that the digestive microorganisms in the rumen have time to adapt to the higher carbohydrate content. Game feeding should be started already in the autumn, and it should contain small amounts of all feeds you intend to offer to the animals.
- High-carbohydrate feed should be offered in small volumes, for instance, from a feeder, so that the offered amount can be eaten immediately. There should be several feeding grounds in order to prevent dominating animals from getting too large amounts of feed.

Foods such as cereal and fruit are rich in fast absorbing carbohydrates (Photo: Pekka Helo). Too large or sudden quantities offered to cervids can result in severe digestive disorders.


(Photo: Hannu Hautala)

3. Identification of sick animals and diseases

The most demanding part of hunting hygiene is the assessment of the health of a killed animal and if it can be used as food. The purpose of the assessment is to ensure that only healthy game animals end up as human nourishment. Game animal meat must not pose a risk to humans or other animals.

The assessment of game animal health is based on medical history of the game and, after killing, observations made of the carcass and viscera.

Hunters are responsible for the quality and safety of the foodstuffs they offer or give to others. Therefore, it is important to master the basics of the assessment of meat usability.

3.1 Medical history and external symptoms

Year-round observation of game animals has always been part of traditional hunting, especially at hunt clubs. Observations of game animal populations, their movements and even abnormal behaviour of individual animals have been gathered during game management activities, with game cameras and at other times when familiar areas have been visited.

Many diseases cause external symptoms and abnormal behaviour in game animals. Knowledge and observations of game animal habitats help in the recognition of possible chemical and physical hazards that the animals might contain.

These observations form the medical history of the animals. Medical history is part of the food chain information concerning game meat. It plays an important part in the assessment of meat usability and the possible official meat inspection. In addition, an essential part of medical history is information on the circumstances of the hunt (drive or still hunt, etc.) and success of the kill shot.

Signs of a healthy game animal:

- the animal is alert, on its guard and conscious of its surroundings;
- eyes are bright and clean;
- ears are upright and moving;
- fur or feathers are shiny and clean;
- nostrils are clean;
- visible mucous membranes in the eyes, nostrils and vagina are pink;
- behaviour is active, the animal reacts constantly to insects, for instance;
- movements are normal; and
- stools are typical.

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A healthy animal is alert and reacts to its environment, for example, to insects. Its eyes and nostrils are bright and clean, ears are upright and moving, and it moves around normally (Photo: Ari-Matti Nikula).

3.1.1 Habitat and feeding traces

The habitat, movements and feeding traces of game animals provide information on possible environmental toxins or other foreign chemicals that may have entered their meat through feed. For instance, nearby industrial or mining areas may contain such chemicals.

If an animal lives for a long time in a small habitat poor in nutritious plants, this indicates that the animal is unwell, usually due to an accident that has made moving difficult. A worn out appearance of entire grazing areas or the use of unusual food plants are indicators of overdense populations. Feeding at the feeding grounds and pastures of domestic animals increases the possibility of cross infections between game and domestic animals. Unsuitable game feeding (including the disposal of catering waste) prepares the way to disease spread or even the appearance of new diseases via imported foodstuffs.

3.1.2 Tracks and bedding sites

The ability to read tracks is part of traditional huntsmanship. A wounded cervid spreads its hooves. Limping caused by accidents can be seen as various signs of dragging. Short steps can indicate that the animal has a systemic disease.

Animal bedding sites reveal a great deal, especially when the ground is covered with snow. Various discharges and secretions from, for instance, the skin, mouth, anus or vagina can be related to several infectious diseases, and bleeding is often related to injuries.

Skin secretions or suppurating discharge may point to, for instance, abscesses or ectoparasites such as deer keds.

A wounded or diseased moose spreads its hooves.

Bleeding is a sign of injury. Pictured here the bedding site of a moose wounded in the withers area maybe by shooting.

In birds, green, bile-like faeces is a visible sign of lead poisoning (Photo: Milton Friend, National Wildlife Health Center, USA).

Normal faecal pellets of moose. Unusual stools may indicate intestinal inflammation, unsuitable nourishment or poisonings/intoxications.

3.1.3 Faeces

Changes in the appearance or consistency of faeces, such as diarrhoea, can reveal poisonings, systemic diseases, intestinal inflammations or unsuitable nourishment, for instance, in context with game feeding.

The occurrence of blood in faeces is often a sign of a more severe condition.

3.1.4 Movement

During the hunt, it is usually possible to observe how animals move, and abnormalities are quickly detected.

Lack of typical movement, such as flight, for instance, can point to various diseases. Limping can indicate pain in the limbs or in the thoracic or abdominal cavity, or a central nervous disease. Circling often signals serious central nervous diseases or poisonings/intoxications.

Hanging ears and apathy are typical signs of disease.

Sick animal often lies with its head to its side. The old saying, 'snow does not melt on a sick animal', is correct.

3.1.5 Posture

Poor posture and hanging of the head or ears are usually indicators of serious diseases. Similarly, hunchback posture or sawbuck-like posture of the limbs are such signals.

During the hunt, there is rarely an opportunity to see a healthy animal resting. A sick animal often lies with its head to its side, stretches its neck, and there can be twitching of the eyes, grinding of teeth and changes in respiratory frequency. These are often signs of approaching death.

Ruffled and dirty feathers are typical signs of disease in birds (the bird has no longer been preening). Other signs are visible third eyelid and drooping.

Aggression can be caused by rut, starvation, defending of prey or wounding, but also by diseases such as rabies.

3.1.6 Behaviour

Game animals are normally shy and avoid contact with people. Apathy and loss of shyness are common and easily recognized signs of disease that can relate to many diseases.

Aggression of a game animal can relate to, for instance, it being wounded, in heat or defending its territory or prey, but it can also be a sign of disease, for instance, the dangerous rabies or deer bot fly infection.

Banging of the head can be an indication of chemical intoxication, such as lead poisoning, or central nervous disease.

Itching and scratching are indicators of ectoparasites or central nervous diseases. Frequent breathing is a sign of elevated body temperature, but it can also be an indicator of systemic or pulmonary diseases.

Skin scratching may be an indication of ectoparasites, but also of many other conditions.

Panting is a sign of elevated body temperature or, for instance, of pulmonary disease or anaemia.

3.1.7 Structure and discharges

Swelling of the joints, jaw, udder, abdomen or groin are easily recognizable pathological changes. Swelling changes may indicate several inflammatory or systemic diseases.

Discharges or protrusions from various bodily orifices are also easily detected. They can be caused by localized or systemic diseases.

3.1.8 Skin and fur coat

Various states of disease cause changes in the shine, vitality and renewal of an animal's fur or feathers.

Curled, dry hairs, often in conjunction with skin changes, indicate a weakened state of well-being.

Delayed change of winter (or adult) coat or underfur is an indicator of diseases or poor nutritional situation during the summer.

Ectoparasites and some viral diseases cause typical skin changes.

3.1.9 Antlers

Antlers are a good indicator of a cervid's health. They provide information on the animal's well-being during the development period of the antlers. Antler growth is affected by the animal's condition and state of nourishment, diseases and the mineral content of food (around 60% of an antler is mineral), and accidents to velvet antlers.

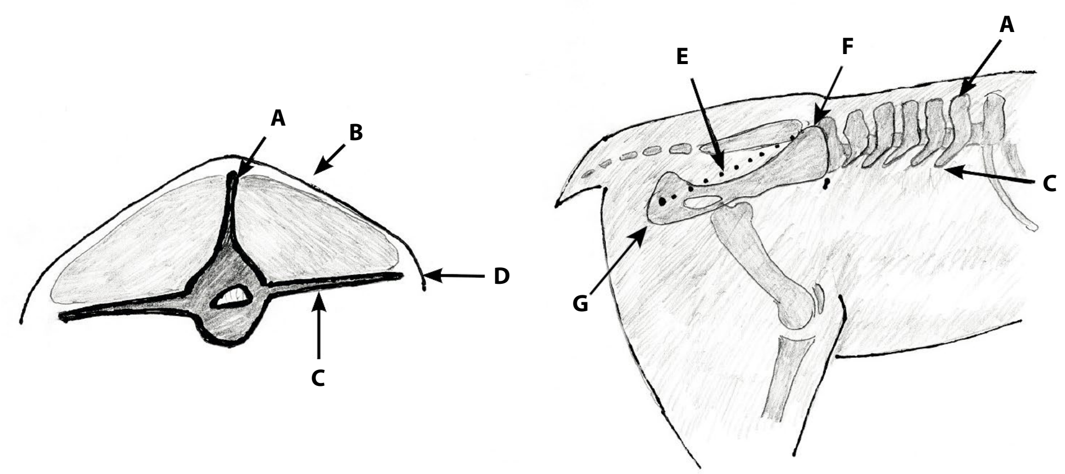
Delayed change of winter coat or underfur is an indicator of a weakened state of the animal caused by disease or starvation. Pictured here a reindeer fawn with underdeveloped antlers.

Accidents during the velvet stage or ergot poisoning, for instance, can be the cause of antler deformity.

3.1.10 Body condition and condition scoring

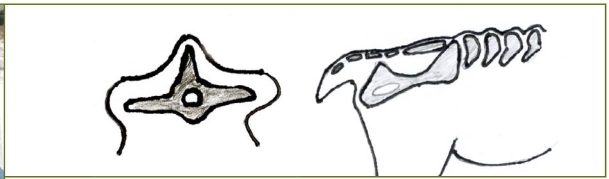
Body condition scoring is a simple way to assess the health and well-being of live as well as already killed game animals. The method is used to evaluate the thickness of subcutaneous fatty tissue and muscle mass. Suitable areas for assessment are the back (sirloin) and the pelvis area. The method can be used for the assessment of body condition of individual animals or animal populations.

The body condition and muscle mass assessment of birds is based on the thickness of pectoral muscles and sharpness of the sternum.



In body condition scoring, thickness of the back and pelvic area fatty tissue and muscle mass is assessed. (A = spinous process, B = back muscle area, C = transverse process, D = edge of transverse process, E = pelvic muscles area, F = point of hip (tuber coxae), G = point of buttock (tuber ischiadicum)).

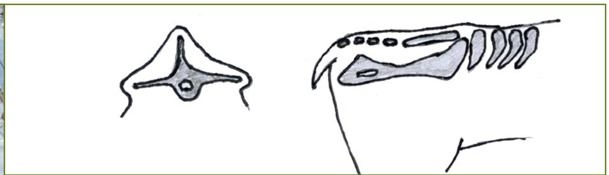
Starvation is a common cause of late winter moose mortalities during winters of thick snow cover.



Category 1 – extremely emaciated, starved:

- Spinous processes evident, gaps between vertebrae clearly felt.
- Gap between spinous and transverse processes sunken, muscle absent, skin seems to rest on bones.
- Edge of transverse processes sharp.
- Tuber coxae evident, deep gaps between tuber coxae and spinous processes.

Winter of thick snow cover has been strenuous to a moose cow who has reared a fawn (Photo: Teuvo Hietajärvi).



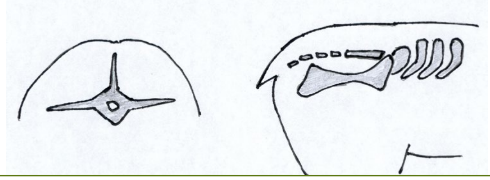
Category 2 – thin:

- Spinous processes and gaps between vertebrae still palpable.
- Evident gap between spinous and transverse processions.
- Edge of transverse procession evident.
- Gaps between tuber coxae and spinous processes indented.

Young moose cow in normal body condition.

Category 3 – normal:

- Spinous processes not palpable or can only be slightly felt, because of fat and muscle tissue cover.
- Gap between spinous and transverse processes is even or only mildly sunken.
- Edge of transverse processes is only a minor shelf.
- Gaps between tuber coxae and spinous processes even.



Category 4 – excellent:

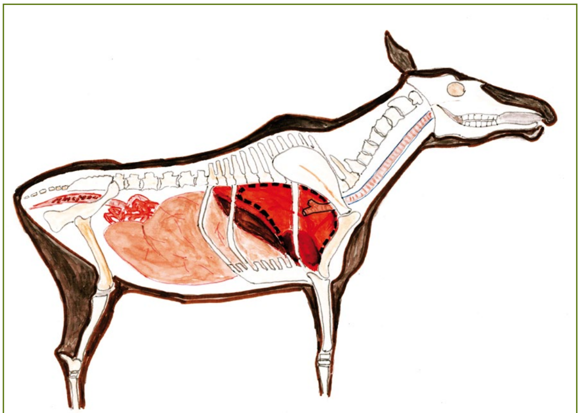
- Spinous processes palpable with difficulty under fatty tissue, backline smooth.
- Gaps between spinous and transverse processes convex, groove on backbone (spine) with banks on both sides formed by muscles.
- Transverse processes form a smooth edge.
- Gaps between tuber coxae and spinous processes rounded.

Young moose bull in excellent body condition.

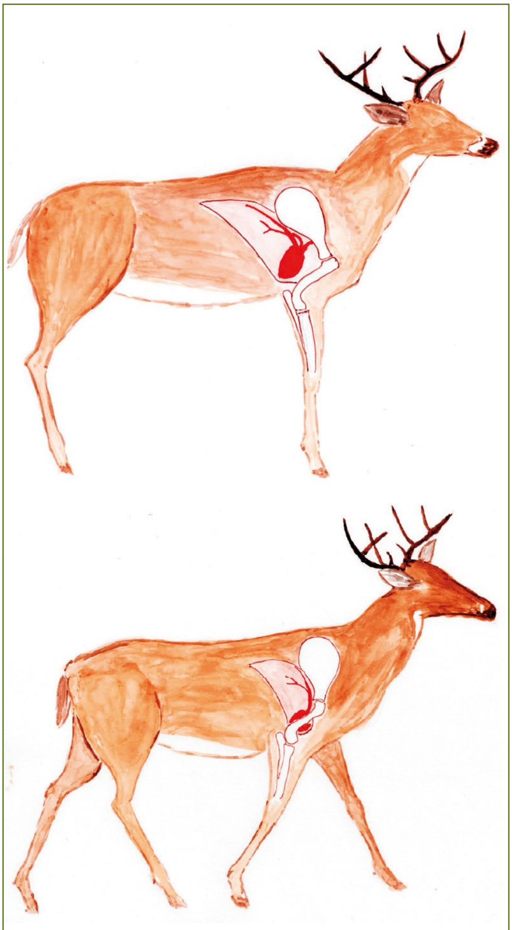
3.1.11 Information on shooting

The task/function of a good kill shot is to ensure the quick and painless loss of consciousness of the prey and, at the same time, spare the meat from contusions and contamination. The bullet's structure and kinetic energy has to guarantee sufficient kill effect without spoiling the meat too much. Death by firearm is most reliable when the hunter hits the heart, lungs or large blood vessels (aorta) and causes massive haemorrhaging.

In meat inspection, information on the success of the kill shot and shot placement is an important part of medical history.



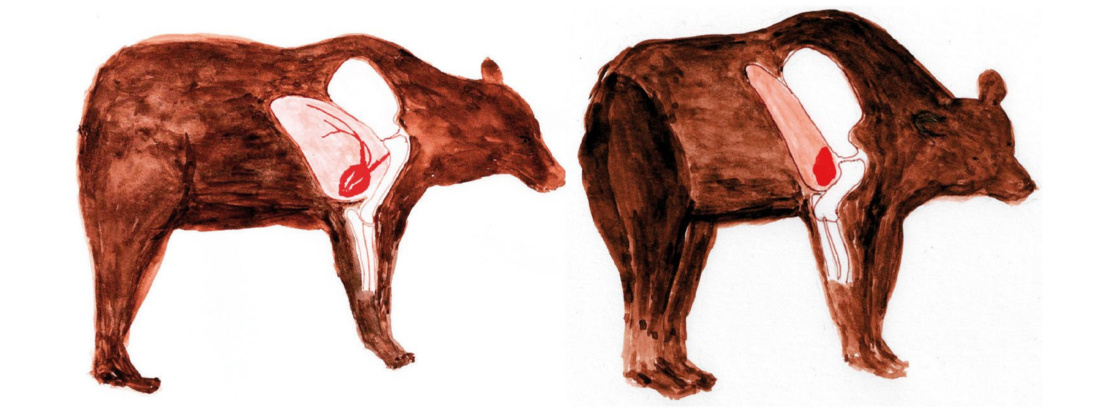
Death by rifle is most reliable when the shot hits the heart or large blood vessels in the lung area.



The effective hit area varies in sizes, according to the movement of the front leg and shoulder bone.

If the animal is wounded before the kill and runs for a long time, the pH of its meat will not drop, the carcass cannot be hung and the meat is dark and tasteless. If animals are excessively strained during hunting or if they are sick, the same phenomenon occurs.

A shot that hits the intestines causes the entrance of intestinal bacteria and bad odours to the body. In neither case, the meat cannot be hung to allow ageing/maturation.



Even a small change of angle sideways makes the efficient shot placement area smaller.

Good kill shot.

- Do not shoot at a running animal or at a (flock) herd.
- Well-expanding bullet leaves its energy into the moose. The hit of a quickly fragmenting bullet is hard, but its kill effect is low. Similarly, with a full jacket bullet, the energy does not stay in the animal.
- Too much power results in tissue explosion, bloodied areas and plenty of meat loss.
- Damage to the large blood vessels above the heart is the fastest way to kill. It causes a fast drop of blood pressure, and death follows in seconds.
- The first hit is the most important – injury causes the secretion of endorphins that constrict blood vessels, remove pain and prepare the body to function with minimum amount of oxygen. If the first hit does not kill quickly, the following hits are often less effective even if they were good.
- If the shoulder bone is hit, the bullet has to penetrate bone and muscle before the kill effect begins, and the bullet can be fragmented by bones and leave lead residue to the tissues.
- Trying to hit the spine or neck is risky: the zones are small and well below the fur and protected by thick muscles and vertebrae with transverse processes. Shots like this can only injure and cause suffering to the animal.
- Hitting the cavity is a legend: there is no empty space in the thoracic cavity – the movements of the lungs follow the contractions of the diaphragm constantly.

3.2 Changes caused by diseases in game animals and their assessment

After the kill shot, the inspection of the carcass and viscera and the assessment of health includes visual assessment and palpation, sometimes incisions of the carcass and viscera.

Avoid cutting changed tissues. In uncertain cases, specialists should be contacted.

If necessary, samples can be collected for additional and further laboratory tests. Additional tests performed in order to demonstrate meat quality or pathogens can be bacterial, viral, parasitic or foreign substance tests.

The sensory (organoleptic) quality of the meat is evaluated in a laboratory with a boiling test and the measuring of meat acidity (pH).

Official meat inspection, which includes stamping of the meat, can only be done by an authorised veterinarian. In approved game processing facilities, all carcasses are subjected to veterinary inspection. Meat inspection is performed in two phases: first on a live animal (*ante mortem*) and the inspection of the carcass afterwards (*post mortem*). In game processing facilities, the inspection on a live animal is replaced by the hunter's written notification of the possible changes noticed in the game animal or the pollution of its habitat.

Meat inspection is performed in special detail, if the inspected carcass is one of a diseased animal, or if the carcass or internal organs have been brought for inspection by a trained hunter.

Official meat inspection, which is documented by a health mark (stamping) on the carcass, is done by an inspecting veterinary surgeon.

3.2.1 Detailed assessment of the carcass and viscera

The inspection of the carcass and viscera must be performed as soon as possible after the removal of the intestines and the skin. Changes caused by diseases are best visible in fresh tissues. Freezing also prevents from making a competent assessment.

It is especially important to learn to detect changes caused by inflammation or degeneration in the vital organs, heart, lungs, liver, kidneys, spleen and lymph nodes. Experience trains the eye for detection of these changes.

Head:

- Examine surfaces, ear canals and nostrils, and eyes.
- Examine lymph nodes and salivary glands.
- Examine and palpate tongue.


Moose's healthy, bright eye.


Moose's eye blinded by cataract.


White-tailed deer's eye blinded by a punctured cornea.

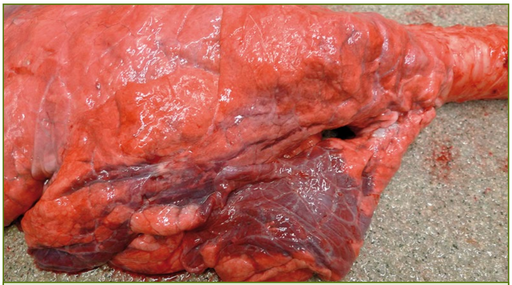

Acute eye inflammation can be an indicator of more severe systemic diseases.

Lungs:

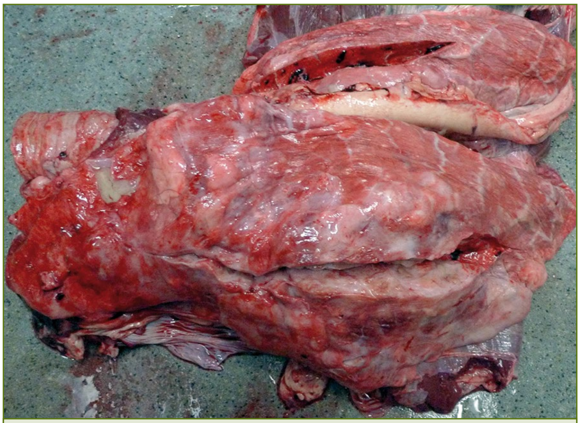
- Examine and palpate.
- Check the lymph nodes.
- If necessary, open the trachea and bronchial tubes.
- Examine the diaphragm.


Healthy reindeer organs.


Palpate the lungs. Echinococcal cysts or concretions are not always visible.



Inflammation of the lungs can present as a localized dense and dark area in the lungs.



Severe inflammation of the entire lungs (pneumonia). Be careful.

Moose's lungs with numerous lungworm scars. Common and harmless finding.

Heart:

- Examine after the removal of the pericardium.
- Cut to remove the blood, examine cardiac valves.

Examine the heart after the removal of the pericardium. If there are changes in the pericardium or cardiac valves, be careful.

Cutting the heart muscle can reveal a tapeworm larva.


The edge of a healthy liver is sharp.

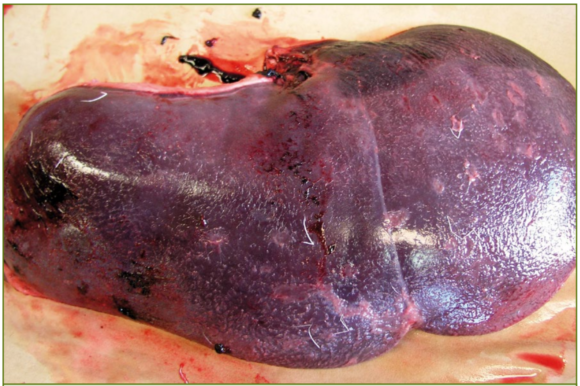
Liver:

- Examine the surfaces from both sides and check the colour of the liver.
- Open the bile ducts if liver flukes are suspected.
- Examine the lymph nodes.
- Check the sharpness of the edge of the liver.


Healthy moose liver.


The liver can be cut in order to discover liver flukes and to check the structure of the liver.


Moose's liver with an inflammatory reaction on the surface caused by parasites. If there are no other changes, there is no need to worry.


In case of severe generalized inflammation, the colour of the liver changes into reddish purple and the edges are rounded.

Spleen:

- Examine and palpate.

Shock spleen resulting from shooting is a common spleen change. The spleen (right) is enlarged and filled with blood. It can be the size of the liver (left). The phenomenon is not dangerous.

Moose's normal spleen.

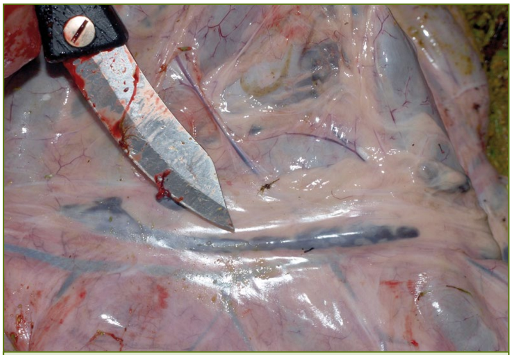
The spleen reacts in cases of severe generalized inflammation. Pictured here the enlarged and blood-filled spleen of a hare suffering from an inflammation caused by *Toxoplasma* protozoan.

Kidneys:

- After the renal capsule is removed, examine and split the kidneys.
- Examine the renal lymph nodes.

Take off the renal capsule and examine the kidneys. The capsule is easily removed from a healthy kidney.

Inflammation of the kidney. The capsule has partially grown into the kidney and does not come off easily. The colour of the kidney is also changed. Be careful.



Mesenteric lymph nodes are located in the mesentery. They react in context with intestinal infections. If you detect changes in them, be careful.

Digestive tract:

- Examine visually the rumen, reticulum, omasum and abomasum, or stomach, in case of non-ruminants.
- Examine the lymph nodes of the mesentery.
- Examine the omentum.

Uterus and testicles:

- Examine visually.

Carcass:

- Examine the muscles and their symmetry, the bones, joints, tendons and membranes and the fat layer.
- Note the condition, amount of blood and the success of bleeding as well as the colour of the carcass and membranes.
- Examine the condition of the serous membranes (in abdominal and thoracic cavities) and the cleanness of the carcass.

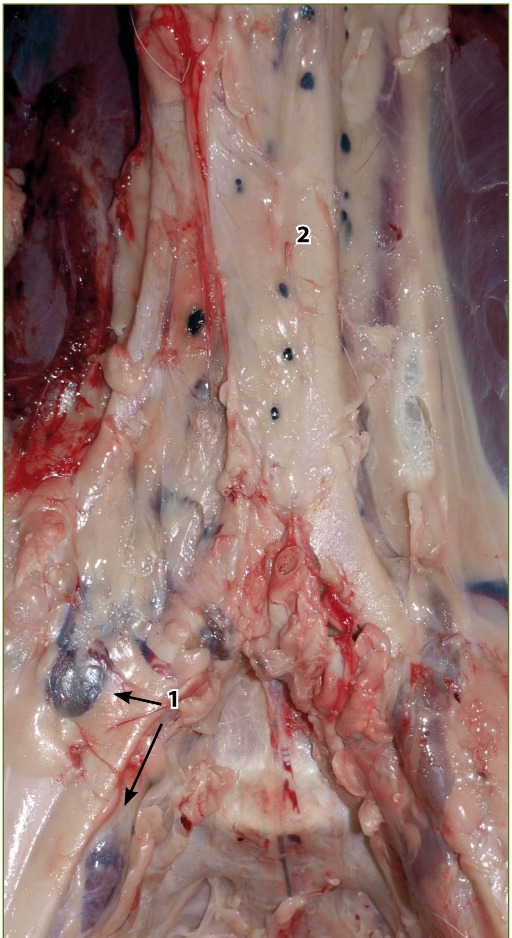
Healthy, muscular moose and starved moose. Starvation is always an alarming symptom.

Check the cleanness of peritoneal membranes. Increased amount of fluid in the abdominal cavity can be a symptom of peritonitis or malnutrition.

Lymph nodes:

- Examine and palpate.

Severely enlarged inguinal lymph node of moose. Be careful.



Normal inguinal lymph nodes of moose (1). The small dark red structures (2) are haemal lymph nodes, a normal finding.

3.2.2 Changes in game animals caused by diseases

3.2.2.1 Inflammation

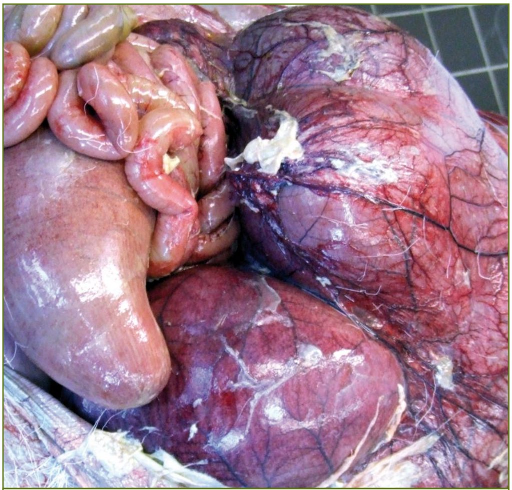
Inflammation is the way the body reacts to tissue damage, and its purpose is to improve the healing of damaged tissue. Inflammatory response occurs when tissues are damaged by pathogenic viral or bacterial infection, mechanical trauma, foreign body, allergens or chemical toxins, high temperatures, radioactive substances, or part of the radiation of the electromagnetic spectrum such as UV radiation.

From the viewpoint of meat usability assessment, it is important to differentiate whether the inflammation or disease is acute or chronic, and whether the pathological changes are localized or the disease is generalized, i.e., spread to other parts of the body.

The classic symptoms of inflammation are redness, swelling, heat, pain and loss of function. The symptoms are caused by vascular changes and the accumulation of tissue fluid and inflammatory cells into the inflamed site. Circulation is accelerated in the area. The capillary walls become more permeable and lymphatic cells, phagocytes and tissue fluids accumulate in the area.

Pus that contains inflammatory cells, pathogens and destroyed tissues accumulates in the inflamed site. Tissue damage is caused by pathogens and the defence reactions of the body.

In acute situations, inflammation has lasted only a few days at most. The pathogen or injury tries to beat or is beating the defence mechanisms of the body and causing damage to vital organs, i.e., the heart, liver, kidneys, spleen, lymphatic system and the general condition of the organism. Peracute state is a change that appears very quickly, and subacute state is classified as an intermediate form between acute and chronic state.

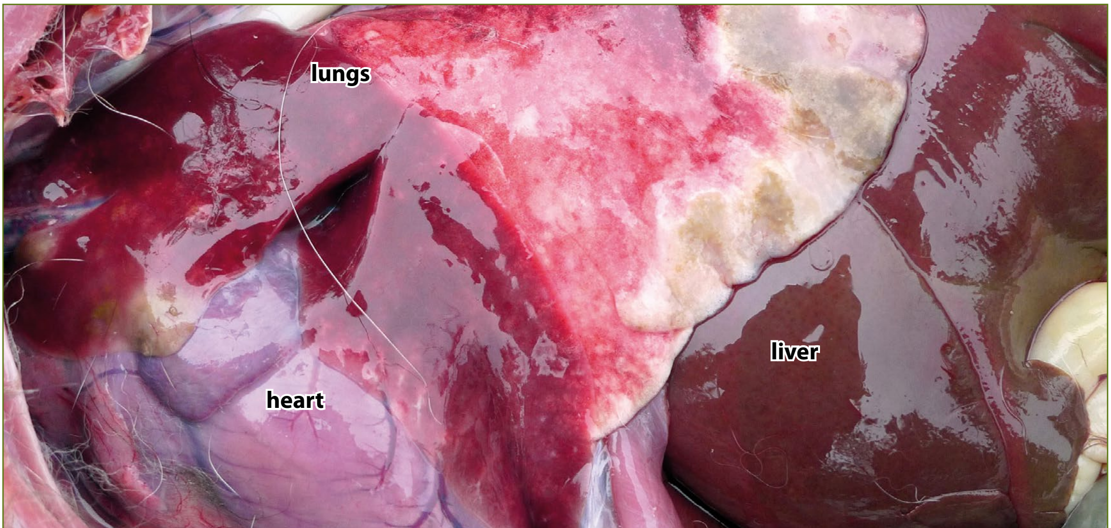


Circulation accelerates, blood vessels dilate and pus that contains inflammatory cells from the capillaries, destroyed tissues and pathogens accumulates in the inflamed site. Pictured here acute peritonitis in a Finnish wild forest reindeer.

Signs of an acute infection are, among others, congestion of blood and bloody lymph nodes. Be careful.

The signs of acute inflammation are:

- inflammatory changes;
- congestion of blood;
- enlarged and bloody lymph nodes;
- spotlike bleeding on mucous membranes and on the surfaces of serous membranes and organs; in the heart, liver and kidneys.



Hare that died of peracute pulmonary and generalized inflammation. Note the clearly defined inflammation of the frontal pulmonary lobes, and redness and spotlike bleeding in the liver. Brown changes at the tips of the pulmonary lobes are caused by hare lungworms.

Assessment of an acute inflammation is more rigorous than that of a chronic condition.

Chronic inflammation means a long-term inflammatory condition in which the body's defence mechanisms try to beat pathogens. The condition has been developing for some weeks, months or years.

Chronic inflammation involves tissue destruction and increase of connective and scar tissue. In a chronic state, inflammation and congestion of blood are replaced by adhesions, conjoining of tissues, connective tissue increase, scars, necrotic tissue or granulomas.

Assessment: Removal of chronically changed organs or carcass parts is often a sufficient measure. If changes are found in vital organs or the inflammation has spread, assessment is more rigorous.

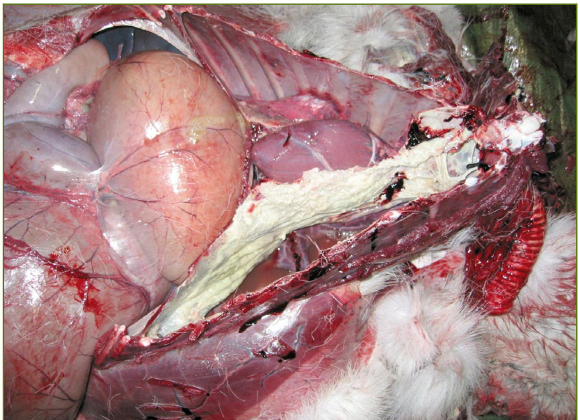
Inflammations are often named after their target organs as, for instance, dermatitis, pneumonia, pleuritis, pericarditis, arthritis, mastitis, etc.

If the immune defence system fails and pathogens or their toxins enter the body, an allergic reaction is too strong or external injury is severe, the result can be circulatory shock. In shock, blood pressure drops and not enough blood flows to tissues. Shock is often lethal to wild animals. Death is also often the consequence of tissue destruction or weakened function of the vital organs (heart, liver, kidneys or lungs) caused by chronic inflammation.

In chronic change, inflammatory reaction is often replaced by connective tissue. Pictured here a reindeer's healed peritonitis. Only conjoined tissues are left. Removal of the changed tissue is a sufficient measure.

Inflammations in viral infections

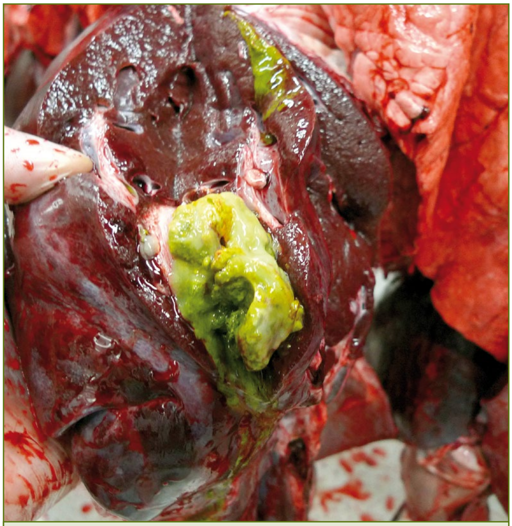
Inflammatory reaction in context with viral infections is usually a response to viral toxins and cell damage caused by viruses. In viral diseases, secondary infections caused by bacteria are common. Death can be caused by circulatory shock in conjunction with malfunction of one or several vital organs.



Finnish wild forest reindeer with chronic and fatal pleuritis.

Reindeer with chronic inflammation covering the whole peritoneal area. The cause is *Setaria tundra* parasite.

Localized inflammation of a joint. Inflammation of several joints can indicate severe generalized inflammation.



As a result of severe generalized bacterial infection, abscesses can be found in various organs. Pictured here inflammatory granuloma in the liver of a Finnish wild forest reindeer.

3.2.2.2 Localized and generalized alterations

Changes in the normal tissue structure can be caused by diseases, parasites, toxins and injuries. What is essential in the assessment of changes is the localized or generalized nature of the change, and the extent of the generalization in the tissues and the organism and their importance in relation with vital organs, especially the liver, kidneys, heart, spleen and lymphatic system.

In localized change, defence mechanisms have limited the damage to a certain area or organ. Localized change can be found in conjunction with generalized changes, such as jaundice caused by liver damage or general poisoning caused by inflammatory granuloma.

Assessment:

- In localized changes, the removal of the changed part is usually a sufficient measure. In generalized change, defence mechanisms have not been able to prevent the disease from spreading via the bloodstream or lymphatic system.
- The signs of a generalized disease are:
  - general inflammation of lymphatic nodes in the head, organs and body;
  - inflammation of joints;
  - changes in internal organs, especially in the liver, spleen, kidneys and heart;
  - inflammatory granulomas and pus in various parts of the body.
- Generalized changes are very severe and their assessment is more rigorous.

3.2.2.3 Fever

Fever means an abnormally high body temperature (>37-39 °C). Septic fever is caused by viruses, bacteria, bacterial toxins, protozoa or fungi. Aseptic fever is caused by, for instance, tissue necrosis, tumours, chemicals or state of shock.

Symptoms: Fevered animal is shaking and sweating. Its body is dehydrating, which makes the eyes sink in and causes the skin to lose its spring. Pulse is dense and breathing is rapid. The animal can be numb or apathetic. Fever includes loss of appetite and constipation, and sometimes also diarrhoea (septic fever) and smell of urine or phenol. Severe fever can end up in shock, convulsions and death.

Changes: Rigor mortis develops rapidly. Congestion of blood under the skin and in the carcass, bloodied and dark meat that rots quickly. Enlarged lymph nodes and non-specific swelling of the liver, kidneys and heart.

Assessment: The meat of an animal suffering from fever should not be used as food, especially if it shows signs of bacterial or viral infection or if chemical toxins are suspected.

Differential diagnosis: High temperature or physical strain in a hunting situation can cause hyperthermia, i.e., an increase in body temperature.

3.2.2.4 Blood poisoning (septicaemia)

Septicaemia is a life-threatening state which occurs in context with many infectious diseases, such as salmonellosis, leptospirosis, toxoplasmosis and anthrax. Septicaemia is caused by the presence of a pathogenic bacterium or the toxins it produces in the bloodstream.

Definitive diagnosis of septicaemia can only be reached in a laboratory by demonstrating the cause in the bloodstream. However, this is not always possible, but deductions are based on findings and observations.

Symptoms: The animal is lethargic and its breathing is difficult and rapid. Temperature can be elevated, normal or reduced. Typical symptoms include muscle tremor and redness of mucous membranes particularly in the conjunctiva, mouth and vagina.

Changes: Enlarged, watery or bloody lymph nodes. Degenerative changes in the liver, kidneys and heart. Congestion of blood and spotlike bleeding in the kidneys, on heart surface, in mucous and serous membranes and in connective tissues. Enlarged spleen and bloody meat. Bloody fluid in abdominal and thoracic cavities.

Assessment: The carcass and organs are discarded. The carcass is not taken to the slaughtering facility. It is buried or sent to a laboratory. Good hand hygiene!

Differential diagnosis: Symptoms and findings of various states of poisoning/toxication resemble each other and are not easy to distinguish.

Poisoning (toxaemia)

Poisonings/toxaemia are difficult to identify. The quality of changes and symptoms depends on the toxins that cause the poisoning/toxication. Poisoning/toxaemia occurs when a large amount of toxins (endo- or exotoxins) produced by a microorganism or the cells of the body are spread in the entire organism.

Toxications often cause acute changes in internal organs. Pictured here the bloodied and enlarged liver of a hare suffering from toxoplasmosis.

Toxaemia can occur when a large amount of bacteria or their toxins enters the bloodstream from, for instance, a purulent contusion.

Cyanosis (bluish discoloration) of the mucous membranes in the mouth and conjunctiva is associated with various states of generalized poisoning/toxaemia. Pictured here the eye of a reindeer infected with listeriosis, and the roof of the mouth of a reindeer infected with ORF virus.

The symptoms and detectable changes are similar to those of septicaemia.

Assessment: The carcass and viscera are discarded. The carcass is not taken to the slaughtering facility. It is buried or sent to a laboratory. Good hand hygiene is important!

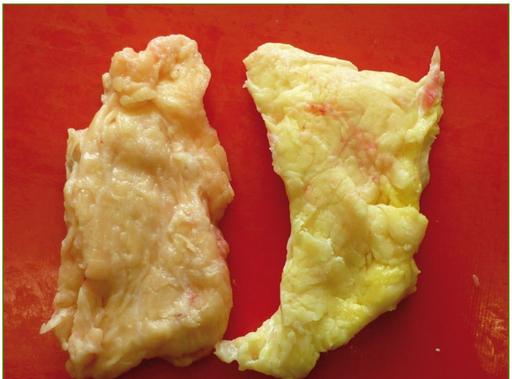
Bacteriological examination

Bacteriological laboratory examinations can be used for the assessment of meat usability. However, for practical reasons, this is often difficult in case of game animals. An examination can be done when the animal's health or medical history or meat inspection findings suggest a zoonotic disease or generalized bacterial infection. The examination is used to distinguish generalized infection from localized infection. There is usually no need to examine localized changes for bacteria. In case of suspect of generalized infection, several tissue samples have to be taken. Samples should have intact surfaces (i.e. capsule of inner organs intact and muscle covered by fasciae). In the laboratory, the surfaces of muscle samples and inner organs are sterilized and the interior of the samples is tested for viable bacteria.

3.2.2.5 Jaundice (icterus)

Jaundice is the accumulation of bile pigments (bilirubin) in the tissues. It is a sign of liver dysfunction or bile duct obstruction with bile pigments released into the bloodstream. Jaundice can also be caused by rapid destruction of blood cells, when a surplus of haemoglobin breakdown products spread in the bloodstream causing yellowness and bilirubin. A condition like this can be found in context with dysentery caused by the *Babesia* parasite.

Yellowness is commonly found in healthy cervids. Evidently, it comes from nourishment and no special measures need to be taken.



Fat tissue samples of deer, with feed-caused yellowness and the lemon-like colour of jaundice (Photo: Peter Paulsen).

Changes: Yellowness is found in the skin and internal organs, in the sclera of the eye, in tendons, cartilages and joint surfaces, for instance. Typically, jaundice is associated with a lemon-like yellow instead of the more orange tainted yellow colour due to feeding.

Assessment: Suspicious, strongly coloured carcasses are always discarded, as are carcasses that show signs of generalized disease. In mild cases, the colour may disappear during hanging. If there are no changes in vital organs and the discolouration is mild, caused by nourishment, for instance, the whole carcass can be used for human food.

Yellowness of carcass is often found in healthy cervids. Evidently, it comes from nourishment. If the vital organs are intact, there is no need to worry.

3.2.2.6 Bleeding (haematoma)

Bleeding or haematomas can be caused by injury, disease or blood poisoning (septicaemia). Haematoma is an aggregation of coagulated blood outside the blood vessels.

Bleeding or haematoma may follow, for instance, a collision, shooting or poor bleeding technique. Bleeding is increased by exertion and warm weather as well as a shot in the head, which causes rapid increase of blood pressure.

Haematomas can be found in many organs, in mucous and serous membranes or under the skin. They vary from small to even larger than one metre in size. Bleeding can vary from small, spotlike (1-2 mm) bleeding to extensive haemorrhages.

Assessment: Altered areas are removed. If there are signs of generalized disease, the carcass is discarded.

Most cases of bleeding found in game animals are linked to injuries from shots, and they are most commonly found under shoulder blades. Bloodied areas can extend widely between muscle membranes. They must be removed carefully in order to remove bullet metal (lead) residues.

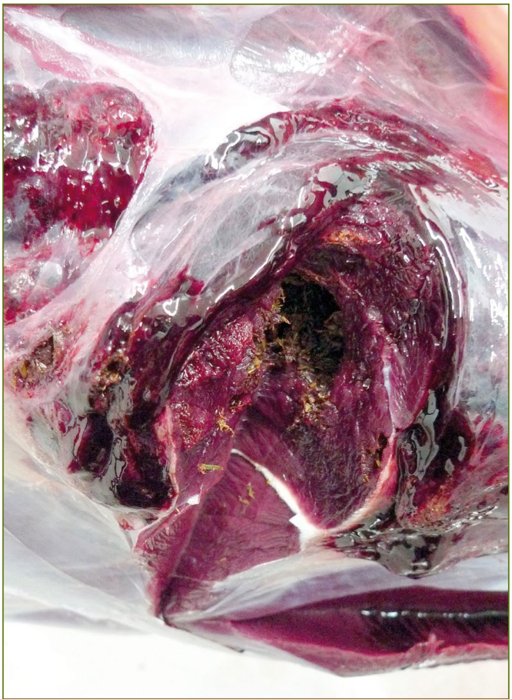
Shock spleen is a phenomenon in which the spleen is notably enlarged and can be almost the size of the liver. The phenomenon is common in hunted animals. It is caused by a circulatory disorder caused by shooting and the subsequent congestion of blood in the spleen. The phenomenon is not dangerous.

3.2.2.7 Contusions, bruises

Contusions are caused by traumas such as fractures, shooting or collisions. In a contusion, the target tissue has been injured and internal or external bleeding has occurred.

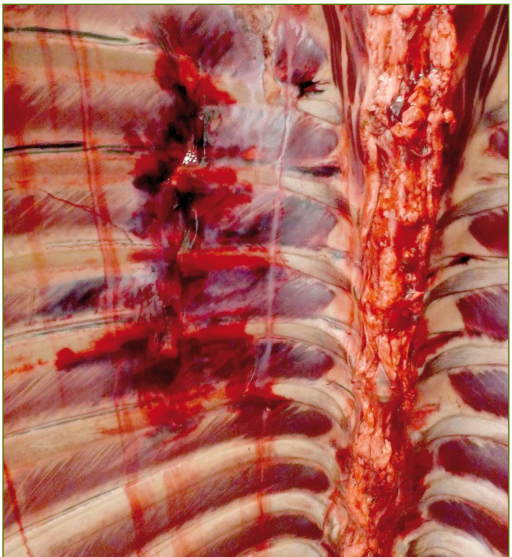
Assessment: Assessment depends on the size, type and age of the contusion. They are always suspicious. Fresh and localized contusions are removed. Contusions caused by shooting are removed in such a way that about 5 cm of healthy tissue is also removed. If the injury contains signs of infection, but changes do not extend above local lymph nodes, the changed parts are removed. If there are signs of generalized infection, the carcass is discarded.

Contusions caused by traffic accidents are always suspicious, for many reasons. The animal may have suffered from the injury for a long time and the deteriorating effect of stress hormones in the meat may have begun. Open contusions make it possible for bacteria to enter into the bloodstream. Also, impaired animals are more likely involved in accidents. Moose that have been involved in collisions must always be considered suspicious, and they should not be given to general consumption.

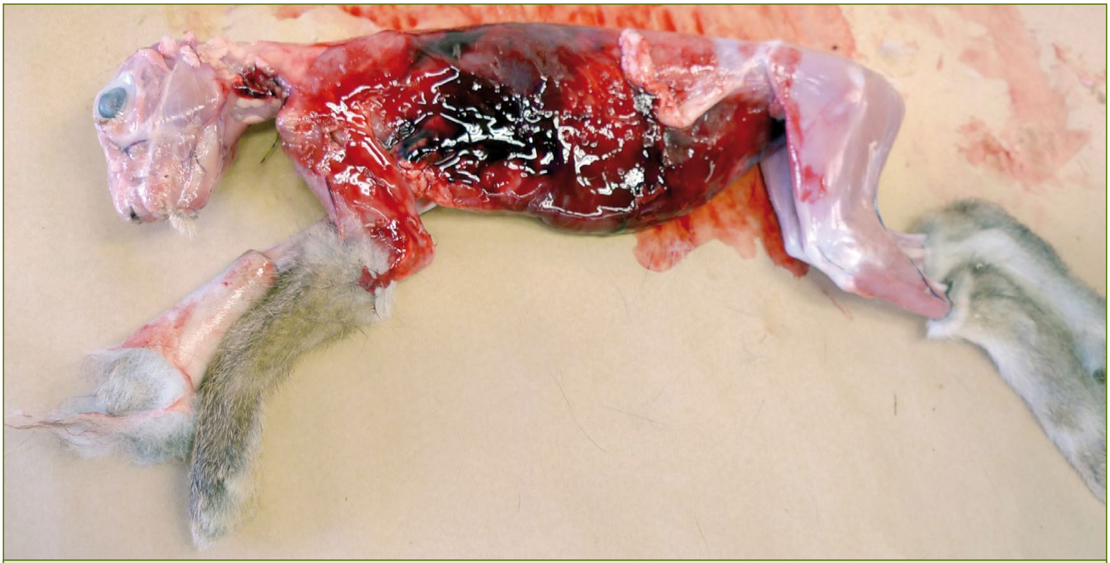


If intestinal content is present in bloodied areas caused by shots, the whole carcass is suspicious. Bacteria may have spread to the muscles via bloodstream. The carcass must not be stored for maturation. The recommended use is for heated products such as preserves or hot-smoking.

Old, purulent contusions are always suspicious.



Rib fractures are common findings in cervids that have been involved in traffic accidents (left), as are also old, healed fractures (right).



Cuts and contusions caused by predators are always suspicious. The meat must not be used as food.

3.2.2.8 Abscess

An abscess is an aggregation of pus surrounded by a connective tissue capsule. Abscesses are caused by the entrance of bacteria (*Actinomyces*, *Streptococcus*, *Staphylococcus* or *Fusobacterium*) into the body either through skin, mucous membranes or digestive tract. In ruminants, abscesses are often the result of damage to the rumen wall. Primary abscess is near the entrance of the infection, for instance, the digestive tract, respiratory organs, subcutaneous tissue or liver. Secondary abscess has spread via blood or lymphatic vessels to the body, such as to the brain or spinal cord, where it usually forms several small abscesses.

Assessment: In case of primary abscess, removal of the abscess and changed area is usually sufficient. The carcass is discarded, if spread infections have formed many abscesses around the body. Active, growing abscess is more severe than chronic, organized and calcified abscess, when only the removal of the abscess is sufficient. Do not cut or puncture abscesses during eviscerating and processing of wild game!

Secondary abscess has spread to various organs via bloodstream. Pictured here an abscess in the brain.

Wasting is related to many chronic diseases. The phenomenon is always alarming.

Tooth wear or damage is a common finding in wasted wild ruminants.

3.2.2.9 Wasting

Wasting is one of the most common reasons for the discarding of game animals as human food. Wasting is the loss of body fat and tissues caused by starvation. Wasting involves gradual decrease of organs and muscle tissue, and fluid retention (oedema).

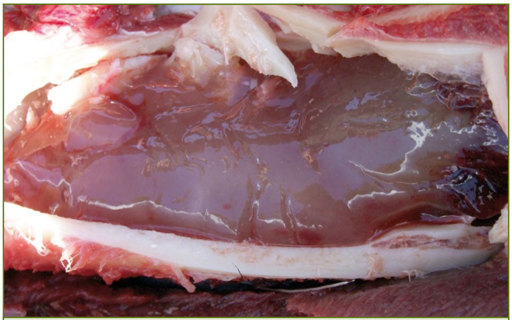
Wasting is associated with many chronic diseases, such as cervid wasting disease (CWD), tuberculosis, paratuberculosis, tumours, bad teeth, parasitic load (liver worms, brown stomach worms, whipworms) or lack of nourishment.

Changes: Wrinkled, thin skin, faded, dry hair, protruding bones. The animal's condition is Category 1. Body fat disappears and is replaced with gelatinous tissue. This is clearly seen in bone marrow and the heart as well as in kidney fat.

Wasting is associated with shrunken fat storages of the body. The fat of the coronary grooves has entirely disappeared from the heart of a wasted western roe deer. It has been replaced by gelatinous tissue.

Assessment: Cases of wasting are always suspicious. However, wasting (as a symptom of disease) must be distinguished from thinness, which is not a reason for discarding: bulls in rut and young animals as well as animals grazing in poor pastures can be thin. In such case, the colour and texture of their muscles and fat are normal. If wasting is caused by chronic disease, the carcass is always discarded.

Bone marrow float test is a simple way to find out the fat content of bone marrow. If a piece of bone marrow taken from a long bone does not float in water but sinks, all the fat has disappeared from it and the animal is wasted.

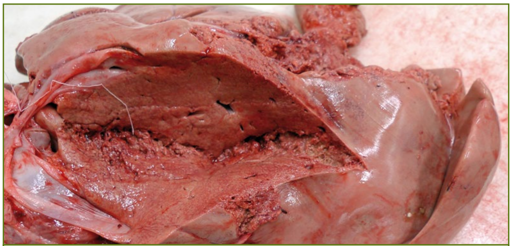


A sure sign of wasting is the total disappearance of fat from bone marrow, which has changed into translucent jelly.

3.2.2.10 Degeneration

Degeneration is the weakening of tissue function, chemical change in tissue, and the diminishing of the size of tissue. Degeneration can be the result of lack of oxygen, injury, immunological reaction, toxins and viral and bacterial infections. Tissue degeneration refers to the precipitation of cell proteins. This causes the cells to grow smaller. Degenerative changes are often found in the liver, kidneys, heart, glands and muscles.

Damaged organs are light, glossy and smaller than normal (they look as if they were boiled). Degeneration may include accumulation of fat into organs. This process is common in the liver, heart, kidneys and pancreas.



Degenerated organs are light and lacerable, as if they were boiled.

Fatty liver is enlarged and light-coloured or yellowish, and has rounded edges. Fatty liver can result from increased blood fat content. The fat can come from nourishment or the rapid release of body fat from storage to meet the needs of the body caused by, for instance, the rut or pregnancy or starvation. Then the condition is reversible. Fatty, light-coloured liver is commonly seen in bull moose in heat. In toxin-induced fatty liver, fat accumulates in liver cells and the condition is irreversible. Numerous chemicals, such as arsenic or phosphorus, can be the cause of this condition.

During the fierce rut in the autumn, the liver of bull moose is often fatty. Fat has been released rapidly from storages to meet the needs of the body, and it has accumulated in the liver. The phenomenon is harmless and reversible.

Assessment: Degenerated tissues are discarded. If generalized changes are found, the entire carcass is discarded.

Parasitic calcifications are common findings in the organs of game animals. Reindeer's liver with calcified liver damages caused by parasitic objects. The liver is somewhat degenerated, light-coloured and soft.

3.2.2.11 Calcifications

Calcifications are accumulations of calcium in dead or degenerated tissues. Calcification is a protective reaction of the body that can occur in any organ. Calcification caused by excess vitamin D is a well-known phenomenon.

Calcification is associated with many chronic diseases, such as tuberculosis. It is also a common change caused by parasites (insect-borne roundworms, *Besnoitia*, etc.). Calcifications are identified by a scratchy noise when tissue is cut.

Assessment: Changed parts are discarded, and if changes have been generalized, the entire carcass is discarded.

3.2.2.12 Swelling (oedema)

Swelling means accumulation of fluid in the interstitial tissues and body cavities. Swelling can be classified as inflammatory or non-inflammatory swelling.

When swelling is inflammatory and pathogen-induced, it contains yellowish or greenish, opaque or clear fluid (exudate) in the area of inflammation.

In non-inflammatory swelling, fluid (transudate) accumulates under the skin, in mucous membranes, lungs and the brain.

Generalized swelling is always an alarming finding. Subcutaneous tissue of a reindeer suffering from acute viral infection.

Localized swelling is caused by circulatory disturbance of the lymph or compression of veins (for instance, the swelling of legs after a long period of lying down). The cause of swelling can also be circulatory disturbance of the lymph due to tumours or parasites. Localized swelling can also be caused by inflammation or allergic reaction.

Generalized swelling is caused by heart defect or lack of proteins in the bloodstream. The causes can be severe malnutrition, parasites of the digestive tract, chronic liver disease or damage to the walls of the blood vessels due to inflammation or toxins.

If fluid accumulates in the abdominal cavity, the condition is called ascites, and if fluid accumulates in the thoracic cavity, the condition is called hydrothorax.

Changes: Swelling of the lower jaw, dewlap, legs, shoulders, thighs and abdominal cavity. The surface of oedematous tissue is cool and the tissue feels dense like dough. Watery and loose muscles that stay indented when pressed. Clear or yellowish fluid in abdominal and thoracic cavities and in subcutaneous tissue.

Assessment: Carcasses with generalized swelling are discarded. Swollen tissues or organs are considered suspect until the cause is determined. If the cause is tumour or inflammation, the entire carcass is discarded. In case of localized swelling, removal of the damaged area is a sufficient measure.

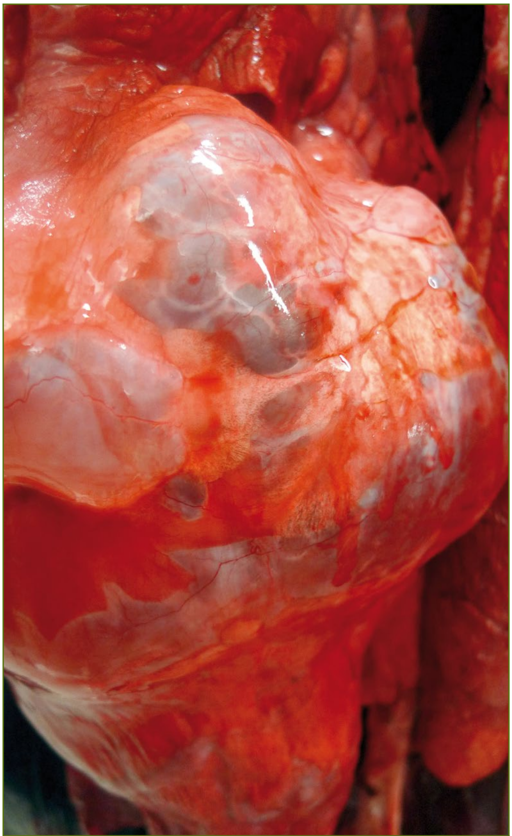
3.2.2.13 Pulmonary emphysema

Emphysema is caused by difficulty to exhale. The condition can be the consequence of shooting or caused by slaughtering. Other causes are diseases of the lungs, such as chronic inflammations of the lungs or bronchial tubes, or obstructions of air ducts by parasitic worms. Interstitial emphysema presents as extensive, air-filled, distended pulmonary lobes and areas.

Pulmonary emphysema (alveolar) presents as cyst-like air bubbles of a few centimetres in size inside dilated alveoli.

Changes: Light-coloured, yellowish and pearly lungs that feel scratchy when palpated.

Assessment: Changed lungs are discarded.



Pulmonary emphysema findings in game animals are often the result of shooting. Pictured here a pulmonary interstitial emphysema.

3.2.2.14 Cancers/tumours

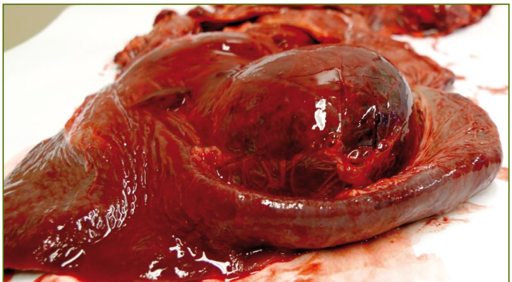
Various tumours are common findings in game animals. Tumour is an abnormal mass of tissue that grows uncontrollably. Cancer tumours impede the function of the organs in which they grow through pressure or tissue damage. Cancer cells replace the normal cells of the organ, but are not functionally corresponding.

Cancers are classified after the tissues where they originated, for instance, as muscle, skin, nerve and blood cancers.

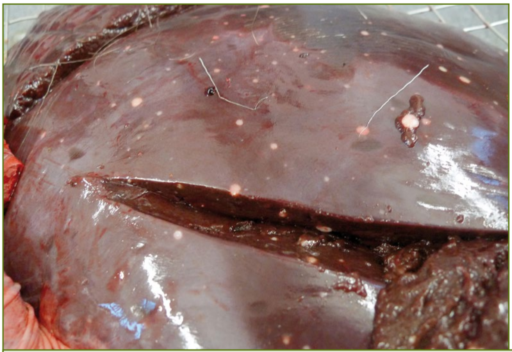
Cancer types are divided by their aggressiveness or ability to spread into slowly growing benign tumours and fast growing, tissue penetrating malignant tumours.

Malignant tumours spread either directly or through bloodstream or lymph circulation to other tissues.

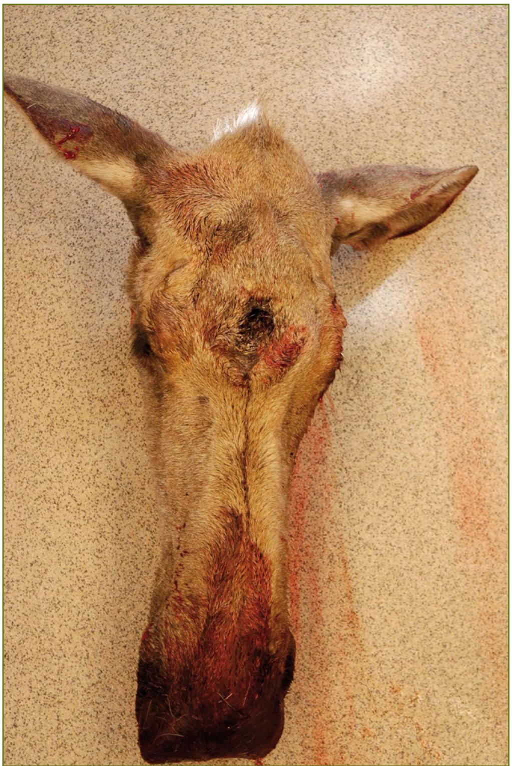
Carcinomas are tumours of the epithelial tissue and they spread via the lymphatic system. Sarcomas are tumours of the connective tissue and they spread



Various tumours are common findings in game animals. Pictured here a vascular tumour in reindeer’s spleen.




Carcass with metastatic cancer is discarded. Pictured here moose's muscle cell tumour that has generalized as small tumours in all organs, including the spleen and liver.



Moose cranium, with typical 'hole-in-the-head' disease due to an ethmoid tumor (Photo: SVA Uppsala, Sweden).

through the bloodstream. Distributed tumour cell masses are called metastases.

Assessment: Tumours are case-specific and always suspicious. In cases of metastasis, the carcass is discarded. Localized tumour can be removed and the rest of the carcass accepted.

Keep in mind: Ethmoid tumours have been found in Swedish moose and on rare occasions in roe deer in other deer species. Tumour causes moose 'hole-in-the-head' disease, which causes the formation of a hole in the bones of a moose's forehead. Tumour occasionally metastasizes. An infective agent, mainly virus, is suspected.

3.2.2.15 Dark, firm and dry meat (DFD meat)

After a successful kill shot, most of the animal's muscle glycogen breaks down into lactic acid. Lactic acid accumulation in the meat is responsible for increased muscle acidity, i.e. the pH decline from 7.2 to about 5.5. The rate of pH decline will differ between species and muscles, but an 'ultimate' pH should be reached 24 hours after death.

If the animal has been ill or stressed before slaughter, its muscle glycogen content is lower than that of a healthy or unstressed animal – the meat pH stays higher and the meat is dark, firm and dry (DFD meat).

The meat can become like this if the animal has fever, generalized infection or chronic disease. Prolonged hunt or running while wounded uses up the animal's glycogen storage and sets the scene for DFD meat.

The formation of DFD meat reduces considerably the value of the meat as food. The meat's pH affects its shelf-life (bacterial growth), water binding capacity, colour and flavour.

Assessment: If the condition is caused by chronic, generalized disease, the carcass should be discarded. Otherwise, DFD meat is no reason for discarding. DFD meat cannot be maturated, it has to be processed immediately after cooling and preferably used for heated products.

Meat pH can be measured when there is grounds to suspect that it has remained high. Meat pH is also always measured, if the boiling test is performed.

3.2.2.16 Immaturity

During the hunting season, still 'immature' muscle tissue can be found in young, late-born calves. The meat of an immature animal is light-coloured, soft and underdeveloped. The protein content is low, water content is high.

Assessment: The meat of immature animals is not hazardous to health.

3.2.2.17 Abnormal, foreign odours

Abnormal odours may occur in game animal carcasses. They are best observed in freshly skinned animals.

Foreign odours can be the result of nourishment or feeds, various diseases, especially digestive and urinary tract inflammations, and sexual smells of male animals. Starving causes ketosis and the smell of acetone. Intestinal hit or delayed evisceration (disembowelment) makes the meat smell of intestines.

Dark, firm and dry meat (DFD meat) cannot be maturated.

Assessment: Strong sexual odour may render the meat unfit for placing it on the market. However, it can be consumed.

Mild smells usually disappear during hanging in cool storage. Smoking also covers mild, harmless smells. In red deer, deep-freezing can reduce sexual odour.

Not all consumers are sensitive to such odours.

Clear odour of chemicals or foreign substances is cause for discarding. If necessary, more tests can be done, such as chemical tests.

Boiling test helps with the assessment of odours. Boiling test can be performed when there is a suspicion of foreign odour or colour in the meat. The sensory quality of meat is assessed with the boiling test. The laboratory assessment team comprises at least two experienced evaluators.

3.2.2.18 Plant poisonings

Diseases and findings caused by plant poisons vary greatly depending on the cause of the poisoning. Therefore, reaching a diagnosis is difficult. In cases of plant poisoning, various systems or their parts can be damaged. Symptoms may include diarrhoea, bloated stomach, sensitivity to light, liver degeneration and gangrene of the extremities.

Some examples of poisonous plants are the foxglove (*Digitalis purpurea*), European yew (*Taxus baccata*), rye ergot fungus (*Claviceps purpurea*), bog asphodel (*Narthecium ossifragum*) and English oak (*Quercus robur*).

The presumption is that wild animals use natural behavioural models as well as soil minerals and intestinal bacteria to neutralize plant poisons. In cervids, efficient liver function and microorganisms of the rumen can also neutralize poisons.

In case of overdense population or other food shortage, accidents can happen.

Assessment: Suspicious cases are discarded.

3.2.2.19 Chemical poisonings

Environmental toxins (DDT, PCB substances, dioxins, chlorophenols, heavy metals such as lead, cadmium or mercury, and radioactive substances) accumulate in the organism in the food chain and are hazardous even in small quantities. Some substances, such as copper, are necessary in small quantities but toxic in larger quantities.

Assessment: If the animal has signs of chemical toxins, the entire carcass and viscera are discarded.

Toxicity of a compound is described with LD_{50} value (lethal dose). It means the dose (calculated as milligrams of substance per kilogram of body mass) required to kill half the members of a tested population after a specified test duration, usually 24 hours. The lower the LD_{50} value is, the more toxic is the substance in question.

3.2.2.20 What to do if a diseased or abnormally behaving animal is found or shot?

Monitoring the health of game and other wild animals is an important part of monitoring the environment and environmental changes. Early detection of these changes gives us time to take the best possible measures of prevention and precaution.

Diseases can spread to new areas through people, animals, foodstuffs and belongings, and via traffic and insects. Human actions and changing climatic conditions may cause changes in the natural habitats of animal species, and worsen the nourishment supply and behavioural patterns of animals. These factors can reduce the tolerance of animals and expose them to pathogens.

Global warming makes way to the northbound invasion of diseases so far considered tropical. Several of these pathogens are borne by haematophagous insects. New diseases can first appear in game animals that may transmit infections to production animals. More often than not, the first victims of environmental pollution and chemicalization are wild animals.

In situations where a new pathogen is found in the immediate area, targeted follow-up is justified and gives best results. Follow-up can be done through samples collected from harvested, healthy animals, for instance by monitoring if there are antibodies to the disease in the animals' bloodstream or by demonstrating the pathogen itself from tissues.

Mass mortalities of game animals are alarming signals and require thorough investigation including sample collection and laboratory tests. One single case can also be significant, particularly if an apparently healthy and fit animal is found dead without an explanatory cause. The general rule is that single game animals found dead should be left to the wilderness, to be disposed of by nature. If dead game causes health hazard to humans, due to its location for instance, it can be buried.

If a diseased, injured or helpless animal is found in the wilderness, every reasonable effort must be made to help it. It is forbidden to capture wild animals, unless the situation calls for temporary medical or other care.

Mass mortalities of game animals are always alarming signals and require thorough investigation, including sampling of animals or their parts and laboratory tests.

According animal welfare legislation, if the state of the animal is such that keeping it alive would represent obvious cruelty to it, the animal must be killed or it must be seen to that it is killed. If an abnormally behaving animal is killed for purposes of further investigation, it must be killed, if possible, without injuring the head. Rabies can be contracted by all animals and it can only be tested from the brain.

3.3 Further investigations and sample collecting

The larger the group of game animals that catch a disease or die with similar symptoms, the more important it is to start further investigations. If a case involves suspicion of dangerous or infectious animal disease, the respective authorities must be contacted. Sample collection is then performed or guided by the authorities.

Animals killed by traffic are by no means to be used for food, but are often valuable for research, as diseases have been found to make animals susceptible to traffic accidents.

Diseased animals or changed tissues and organs found in the course of hunting can be sent in for further testing. Laboratories do the necessary bacteriological and viral tests and examinations of endo- and ectoparasites and toxins.

The basic rule for all samples sent for testing is that the sample has to be cooled near 0 °C to keep the tissues as suitable for testing as possible. The sample should not be frozen, although this has already happened to many animals found in the winter.

Samples are often transported by public transport. Special attention has to be paid to the packing of the samples, in order to minimize any harm to the environment. After cooling, the animal or animal parts are packed inside airy and dry material, such as newspaper. If the sample in question is an organ, it must first be packed in foil or baking parchment to prevent the newspaper from sticking to its surface.

After this the sample is transferred into a watertight plastic bag or sack. Lastly, the sample is placed in a box that can sustain the hardships of transport. The box can be made from polystyrene, cardboard or wood. In warm seasons, ice packs can be placed around the sample. Transport of large, whole animals must be arranged beforehand with the test laboratory. Courier or postal services usually have their own specifications for packing and labelling such biological samples.

The meat of a diseased animal or an animal suspected as such must not be given to dogs. Dogs must be kept away from diseased animal carcass.

The sample must always be accompanied with a referral. The referral contains important information including the sender's contact details, type of sample, date and place, possible observations on the animal's symptoms and information on other dead animals.

In case of a survey, the authorities conducting the survey issue guidelines on how samples are collected and delivered. Requests for individual or partial organ samples or blood samples can be issued.

Blood sample from a killed animal can be taken during bleeding or the final stage of slaughtering. After the blood coagulation factors run out, uncoagulated blood is left in the thoracic cavity or heart.

If you have killed a diseased animal:

- Do not take a clearly diseased animal to the slaughtering facility together with healthy animals.
- Use protective gloves and clothing.
- Do not cut or slash diseased parts or changes.
- Wash your hands and clothes with hot water and soap after handling.
- Wash and disinfect carefully all equipment used in slaughtering.
- Do not give the meat or organs of a diseased animal to dogs or other animals.
- If you suspect a dangerous animal disease or zoonosis, always contact an authorized veterinarian first.

From meat quality standpoint, it is most beneficial to choose a hunting method that is least strenuous to the prey animal. An elkhound that holds prey at bay is an excellent choice for hunting big game (Photo: Hannu Kesti).

4. Hunting hygiene

Various diseases, parasites and foreign substances have an effect on the hygienic, nutritional and gastronomic quality of game meat. The age of the game animal as well as its physiological condition, such as reproduction or gender, also affect meat quality. However, the greatest significance lies in the act of hunting itself and activities connected with it, i.e., hunting hygiene.

The purpose of hunting game for human consumption is to kill game animals for harvesting their meat. In fact, hunting is an act of animal slaughtering that differs from the controlled slaughtering of production animals in many ways.

Hunting is a seasonal activity that takes place in the wilderness, where the movements or nutrition of the animals are not restricted. Game animals are killed either with rifles or shotguns, and in some countries also with bows and arrows. The placement of kill shot varies greatly, or the animal may be hit by several shots. A bullet can carry various bacteria to the animal's bloodstream. Disembowelling often occurs at the hunting site where it can be difficult to follow hygienic practices. Carcass transport or chilling can be deficient or slow.

The concept of hunting hygiene includes the hunting method, shooting, disembowelling and transport of carcass, and the chilling and cutting of the meat. In the following sections, the focus will be put on two scenarios, i.e. (1) minimum processing of carcasses in the field (partial evisceration) and further processing in an appropriate establishment; and (2) full dressing in the field. Depending on region and animal species, scenarios may differ, but the operations remain the same as described in this section.

To know the physical, chemical and microbiological hazards is a prerequisite for following good hunting hygiene practice. The purpose of follow hygienic practice is to secure good game meat quality during the hunt, and to prevent the contamination of meat by possible pathogenic, food poisoning and spoilage microbiota or foreign substances that come from the animal's intestines or hide, the hunter's tools or hands, or from the soil or environment.

4.1 Hunting method

Strain caused to the animal by the hunting method has an effect on the quality of its meat. If an animal is strained by the method used for the chase, the quality of its meat is affected. After the hunt, the glycogen in the muscles of a healthy, not unreasonably stressed animal breaks down into lactic acid, and the acidity (pH) of its tissues drops down to around 6.0 to 5.5 during the following 24 hours.

Low pH is an important element that adds to the quality and safety of meat. It tenderizes and flavours the meat and causes it to keep better by preventing bacterial growth.

A strenuous hunt causes the secretion of stress hormones in the animal: the glycogen reserves of its muscles are used for energy and the blood glucose content rises. There is no pH drop in the meat of a strained animal, due to the fact that its muscles do not contain glycogen. This process results in dark, firm and dry meat (DFD meat). The water binding capacity of such meat is poor, it will not become tender and cannot endure hanging. High pH also favours bacterial growth and the meat is quickly spoiled. Thus, DFD meat should not be hung. It should be handled quickly, and it is best suited for

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The use of an elkhound that holds prey at bay makes it possible to stalk the prey before shooting and ensures a good game shot to a standing animal (Photo: Kimmo Kemppainen).

heated products. The occurrence of DFD meat can best be avoided by selecting a hunting method that is least stressful to the prey animal.

Still hunting or stalking does not strain the animal. It is not desirable to use quickly driving dogs in big game hunting. In moose and bear hunting elkhounds that hold the prey at bay should be preferred.

4.2 Game shot

The most important function of a successful game shot is to ensure a quick and painless loss of consciousness of the prey and, at the same time, spare as much meat as possible. The bullet's structure and kinetic energy has to ensure sufficient kill effect without spoiling the meat too much.

From the viewpoint of animal protection, a wounded animal is always a problem. If an animal has been wounded and it has been running before death, the pH of its meat will not drop and the meat will become flavourless DFD meat.

A shot in the intestines (soft shot) causes the entrance of intestinal bacteria and off odours to the body, which causes considerable decrease of the utility value and quality of the meat. In either case, the meat

Shooting on running animal causes often soft shots and problems for meat hygiene and the carcass cannot endure cold storage (Photo: Peter Paulsen).

cannot endure hanging, and it has to be processed immediately after chilling. The fastest and most reliable kill with a rifle is attained by hitting the heart, lungs or large blood vessels (aorta) and by the subsequent bleeding. Skeletal or spinal hits should not be sought for, as the possibility of wounding the animal is great. The training and maintenance of marksmanship is important for all hunters. Overlong shooting distances and shooting at running animals must be avoided.

When they hit large bones, lead bullets shatter and leave lead residue to the muscles of the hit zone. It is advisable to use slower and heavy, large calibre, lead-free bullets or pellets (this may be subject to national legislation).

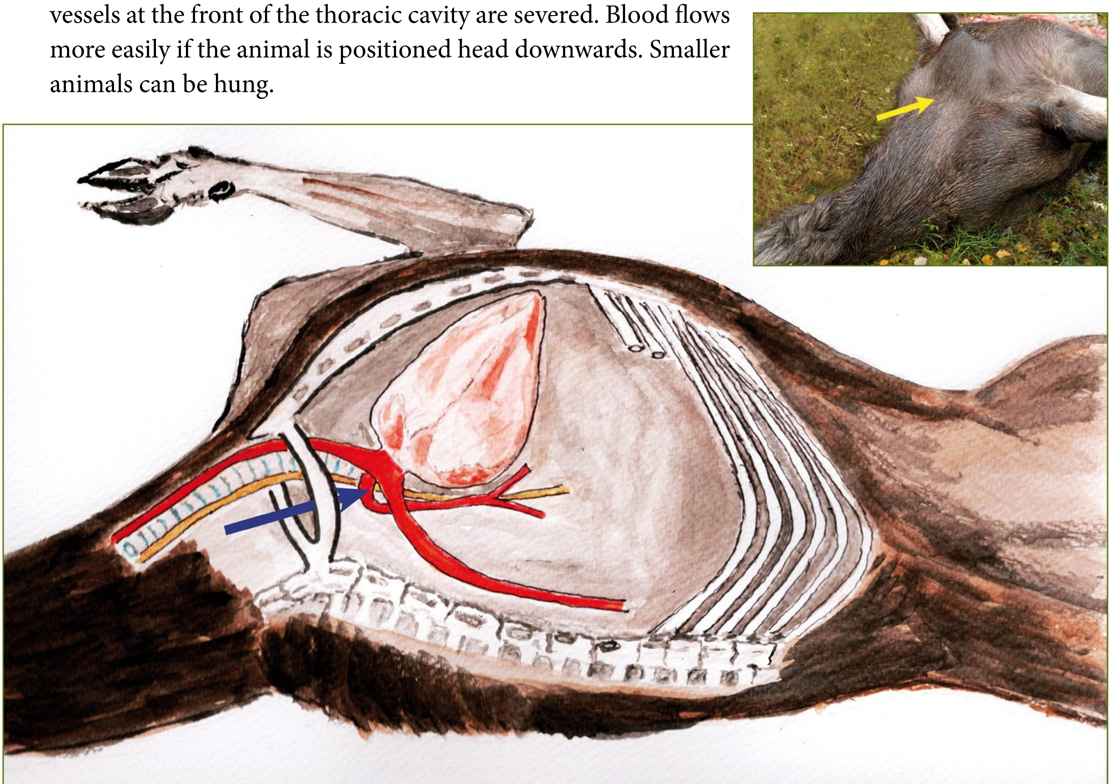
4.3 Bleeding

A good hit causes bleeding into the thoracic or abdominal cavity, and then bleeding is not necessary. Unnecessary cutting or bleeding of the carcass transfers bacteria from the hide to the chest area tissues and exposes tissues for dirt during transport.

If the bullet has hit the skeleton or skull, the animal must be bled. It is forbidden to bleed a conscious animal. In such a case, the animal must be killed with a shot to the head or neck.

Bleeding must be done during minutes after shooting, during the following 10 minutes at the latest. If bleeding is done later, it is of no use.

Before bleeding, make sure that your knife is clean and sterilized. An incision of about 10 centimetres is made along the ventral part of the neck. After that, the knife is cleaned and the large cardiac blood vessels at the front of the thoracic cavity are severed. Blood flows more easily if the animal is positioned head downwards. Smaller animals can be hung.



The bleeding site is in the middle of the thorax, between the first pair of ribs. After the incision, the large blood vessels that carry blood away from the heart are cut. Beware of puncturing the oesophagus.

4.4 Removal of the digestive tract

The digestive tract of a game animal should be removed as quickly as possible, not later than one hour after the animal has been killed. If the animal has been hit in the digestive tract, it has to be eviscerated immediately. The intestines contain the most microbes in an animal, and the number of microbes is almost as high as in the rumen.

Most zoonotic bacteria belong to intestinal bacteria. If they are found in the meat, it is usually a sign of faecal contamination during slaughtering or shooting.

In hunting conditions, the removal of the digestive tract is usually already done outdoors. The technique is slightly different from disembowelling done at slaughterhouses or game processing facilities.

The equipment as well as the hunter's hands and arms must be clean. If necessary, they are cleaned during the procedure. It is advisable to use disposable gloves and sleeve covers. During the procedure, knives must not be placed on the ground or on the animal's hide. The sheaths of knives are usually extremely filthy.

When an animal is disembowelled, peaceful and cautious moves are good. Every precaution must be taken to prevent the puncturing of the digestive tract. Other organs, such as the uterus or bladder, must not be cut either.

When big animals such as moose are slaughtered, an assistant is necessary. The animal is moved to a suitable place on the ground, as clean as possible, and turned on its back. The procedure starts with an incision immediately behind the tip of the sternum. Next, the knife penetrates through the skin and muscular membrane along the median line of the abdominal cavity, and lastly through the abdominal membrane all the way into the abdominal cavity.

Next, the skin and muscular membrane are cut open with a single incision that reaches down to the front of the pelvis. A round-tipped butcher's knife is a good tool for this purpose.

As the incision is made, the blade of the knife is protected with the fingers of the other hand, in order to prevent it from breaking the digestive tract. Beware of cutting the udder of a nursing female

At the beginning of disembowelling the animal is laid on its back. When a moose is disembowelled, assistance is necessary.

The abdominal wall is cut from below the sternum down to the pelvic cavity. Beware of puncturing the intestines.

A single incision opens both skin and abdominal wall. The other hand keeps the tip of the knife from cutting the intestines.

Skin stays attached to the abdominal wall, and no tissue is exposed to dirt.

in order to prevent milk from getting to the carcass surface. This technique exposes as little as possible of the abdominal wall that is vulnerable to dirt during transport.

After the abdominal cavity is opened, the animal is slightly tilted to its right side. This way the fore-stomachs (located on the left side) protect the intestines and the pressure they cause makes the removal of the digestive tract easier.

The assistant spreads the abdominal cavity opening, thus making it easier to see and work inside the abdominal cavity. The membranes that attach the digestive tract to the top of the abdominal cavity are carefully broken with fingers. The tough membranes of older animals can be carefully cut with a knife.

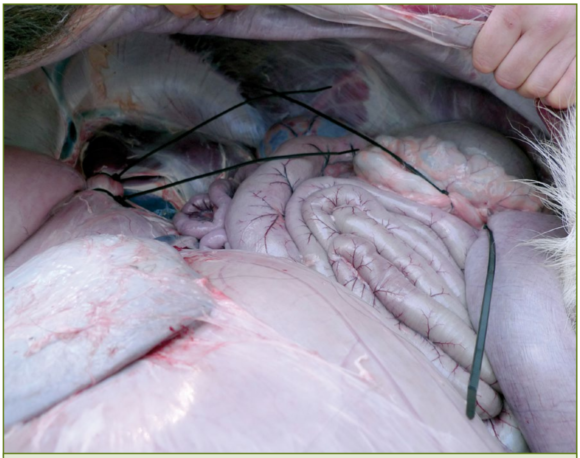
Next, the oesophagus passing through the diaphragm is tied with two ties around 10 cm apart. Cable ties are perfect for the job.

The rectum is also likewise tied, after it has been pumped empty of stool. The ties prevent the contents of the oesophagus and rectum from entering the abdominal cavity.

The oesophagus and rectum are cut between the ties and the digestive organs are rolled out. This technique allows the lungs, heart, liver and kidneys, excluding the spleen, to stay attached to the carcass. This lets them stay clean as they travel inside the carcass to the place of skinning, where they

The digestive tract is protected by the omentum, which is removed to make digestive organs better visible.

The digestive tract is attached to the roof of the abdominal cavity with membranes that are carefully broken with fingers. The use of knife should be avoided.



After the digestive tract is loosened, the oesophagus that emerges through the pillars of the diaphragm is tied. The rectum is also tied in two places, around 10 cm apart, and cut between the ties.

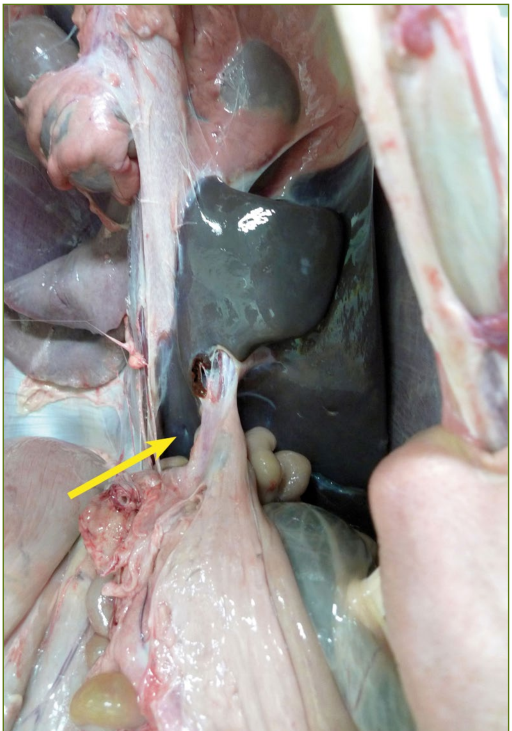
After this, the whole length of the digestive tract can be taken out. Organs stay inside the carcass.

are removed after skinning. Lastly, a hole is cut to the top of the diaphragm, in order to let the blood flow out from the thoracic cavity.

The digestive tract is inspected visually for pathological changes. If changes are found, the digestive organs must be buried or taken behind the slaughterhouse for a closer examination or to be properly destroyed. Blood collected in the thoracic cavity is removed via an incision through the diaphragm. The animal is tilted and blood and blood clots are scooped out of the abdominal cavity. If the animal's digestive tract has been punctured, the gut content can be mechanically removed from the abdominal cavity, for example, by using disposable gloves.

An animal must never be turned over to lie with its stomach to the ground. If so, soil bacteria will contaminate the carcass. Natural waters must not be used for cleaning.

If the animal can be transported to the place of skinning without delay, the removal of the digestive tract can be done there.



The connective tissue ligament between the liver and the intestines (ligamentum teres) is so tough that if you break it with fingers, you can easily end up breaking the intestine.

Intestines and organs can also be removed at the same time. In this method the food and wind pipes are loosened from the tissues of the neck and abdominal cavity and the gullet is tied with two ties and cut, and, similarly, the wind pipe. After the abdominal cavity is opened, the diaphragm and cardiac adhesions are loosened from the thoracic wall. After the digestive tract adhesions have been loosened, the digestive tract and organs are removed together. In

If the organs are removed from the thoracic cavity during disembowelling on the ground, the procedure starts with a skin incision on the left side of the neck. Through the opening, the trachea and the oesophagus next to it are exposed. The oesophagus is tied in two places and cut between the ties.

this method more tissues are exposed to contamination during transport. Clean bags are needed for the transport of organs to the slaughterhouse.

The worst alternative is the splitting of the thoracic cavity and pelvis outdoors. Contamination cannot be avoided, and the contaminated area is large.

The intestines of small ruminant species can be removed after skinning, if it is possible to take the animal to the slaughterhouse within one hour.

When the animal is hanging from its hind legs, the rectum is loosened from the pelvic cavity wall. The rectum can be bagged in a plastic bag secured around the rectum with a rubber band.

The oesophagus is loosened from the tissues surrounding the chest cavity. After this, the abdominal cavity is cut open along the middle line, downwards from above the front side of the pelvis. After the opening incision, the supporting membranes of the gastro-intestinal tract are loosened. Likewise, the oesophagus is loosened from the diaphragm. The weight of the gastro-intestinal tract causes it to fall out. The intestines must be supported to prevent breaking. Finally, the oesophagus is loosened from the diaphragm with fingers and the gastro-intestinal tract is removed. This method requires training.

The digestive tract of small cervids can be removed after skinning. The rectum is loosened from the pelvic cavity and the skin.

The abdomen is cut along the middle line from the pelvis down. The support membranes of the digestive tract are loosened with fingers and, if necessary, a knife.

Evisceration can be done hygienically in slaughterhouses also during dirty operations, before skinning (Photos: Peter Paulsen).

4.5 Transport of killed game to a game handling establishment

Killed game must be transported to the slaughterhouse as soon as possible after the kill. Hygienic transport is important in contamination prevention. Carcasses can be contaminated by soil, loose dust, other carcasses or transport equipment.

In many hunting conditions, transporting killed big game to a slaughterhouse can be a challenge.

Wild game is brought to the slaughterhouse unskinned. The carcasses must be transported as clean as possible, and if there are several carcasses, they must not be stacked.

Bear, wild boar and seal may have a very thick layer of fat that slows down the cooling process. In such cases, special attention must be paid on hygienic and fast transport. If the carcasses are kept in an intermediate storage unskinned, the facilities must be efficiently cooled.

In many hunting conditions, transporting shot big game to a slaughterhouse can be a challenge. What is most important is to keep the carcass from getting contaminated by the environment. Most often, downed game must be retrieved from the woods by various means of transport. The worst option is to drag an unprotected carcass over the ground, as then the soil contamination of the hide and carcass is extensive. During transport, the carcass must be protected from direct contact with the ground. It is good to use plastic dragging sleighs or plates that have been specially made for this purpose. There are many options available for ATVs or snowmobiles, such as wheeled trailers.

During highway transport, the carcasses are protected, for instance, with disposable tarpaulins or by using closed transport vehicles.

Transport vehicles must always be thoroughly cleaned from blood, debris and dirt.

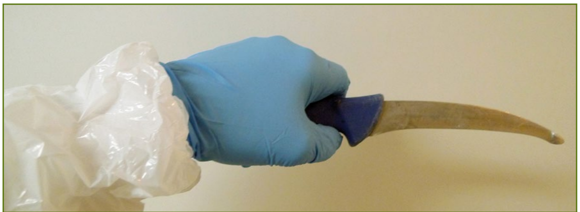
4.6 Skinning

Hide removal, or skinning, has to be done as soon as possible after the kill, especially if the weather is warm and the carcass cannot be efficiently cooled in, for instance, an appropriate temporary storehouse. Skinning is easier if the carcass is still warm.

As well as the removal of the gastro-intestinal tract, skinning is another important phase in securing hygienic meat quality. It can be done by using correct methods and appropriate, clean equipment. During skinning, the carcass may be contaminated with faecal, soil or skin bacteria due to contact with the animal's hide, the equipment used, or the skinner's hands. Therefore, attention must be paid to the cleanness of work clothes, knives and meat hooks.

An important rule of hygiene is that the outer surface of the hide or hands and equipment that have touched it must never be in contact with the freshly exposed muscle and fat surface of the carcass. Neither must the carcass be stained by blood. Hands and equipment are thoroughly washed with hot water before skinning, and always when they are dirty. Knives are cleaned and sterilized in at least 82 °C water or steam.

People who work in slaughterhouses wear clean protective clothing.



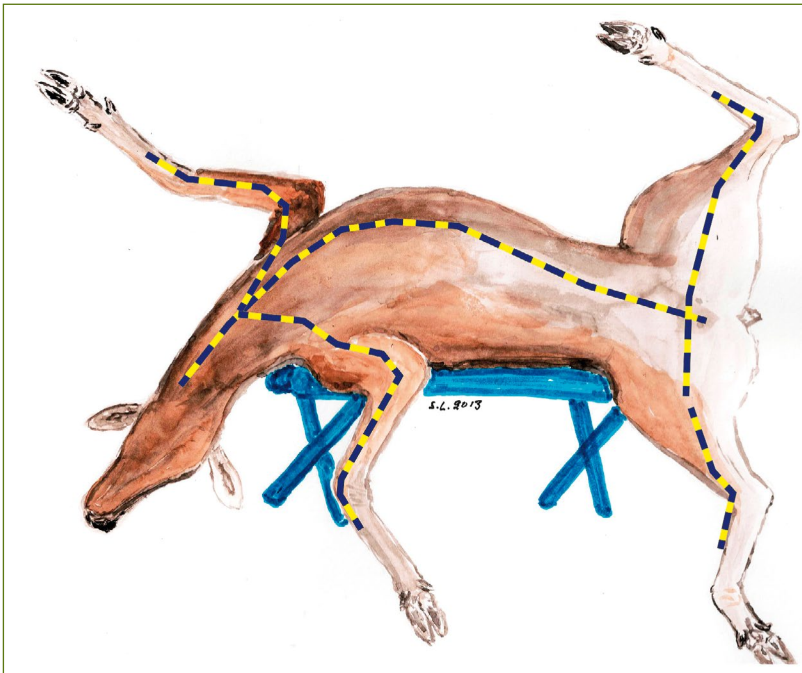
Hygienic hide cutting is possible with a ball head knife.

An important rule of thumb is that the outside of the hide, or hands and equipment that have touched it, must never touch the muscle surfaces and the linings of the thoracic and abdominal cavities of the carcass.

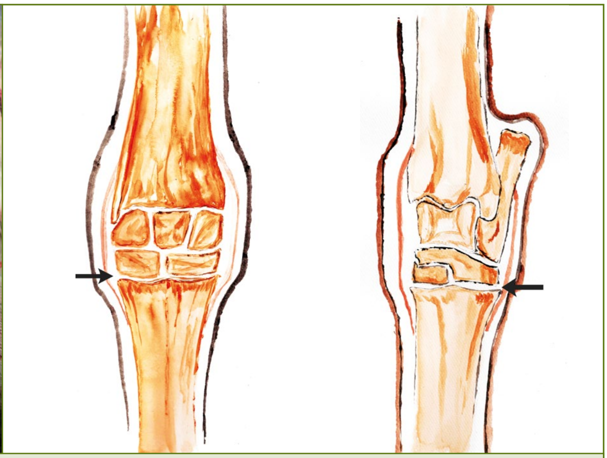
Both in cutting and skinning, the direction of the cut must be away from the carcass.

The animal is placed on its back on the skinning stand. The skinning of big animals starts with the cutting of the hide, and then the skin is slit along specific lines. When the hide is cut, the knife must always cut from inside out, to prevent the contaminants on the skin and in the hairs from getting into the carcass. The method also reduces hair breakage and keeps loose hairs from getting on skinned surface. This is best done with a round-tipped knife.

The cutting of the hide begins by slitting the skin along the middle line downwards from neck to anus. If the bowels are already removed the skin is already cut in the ventral median line in the abdominal area. Then the legs are opened by incisions that reach the middle incision.



The skinning of cervids is begun by splitting the skin from neck to anus. Next the skin on the legs is cut along the lines marked in the picture.



Skinning is started from the legs, from the middle of the leg bones by exposing the hock and anterior knee joints. The legs are cut from the interface of leg bones and joints.

After cutting, the legs are skinned starting from the middle of the front and hind legs. When the legs are skinned to above the front knee and hock joints, the legs are cut from the interface of the leg bones and joints. Alternatively only the hind legs are cut, if the aim is to hoist the carcass up by the hind legs (big animals) or, conversely, only the front legs. The lower legs still left are cut at the end of the skinning, when the carcass is already hanging down.

Skinning is continued vertically downwards to the middle area of the abdominal and thoracic cavities. This area is easier to skin when the carcass is placed in a horizontal position. The rump is skinned until above the anus and tail and the tail is cut.

The stretch between the Achilles tendon and shinbone is punctured in order to attach the carcass hook.

This area is easier to skin when the carcass is placed in a horizontal position.

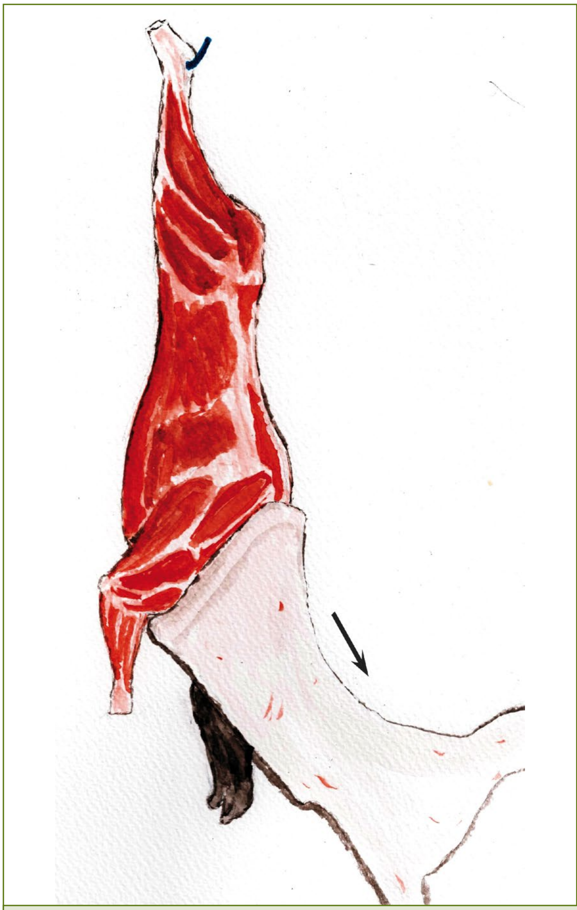
The rectum is removed before the animal is hoisted up. The rectum is detached with a knife from the pelvic cavity wall and the tissues surrounding the anus, and removed through the abdominal cavity. The penis is cut from the base. The urinary bladder and sexual organs are removed at the same time. Care must be taken that the contents of the rectum or urinary bladder do not get to the abdominal cavity.

After detaching the anus, the knife that was used and the operator's hands must be carefully cleaned and sterilized before the work is continued.

The mammary glands must be carefully removed in such a way that the milk that may be secreted from them cannot contaminate the skinned surface of the carcass.

Carcass hooks or chains are attached to the hock joints, and skinning is continued downwards.

In the beginning of hoisting the carcass, the rectum, urinary bladder, sexual organs and mammary glands are removed.



As the carcass is being hoisted, as much of the hide as possible is loosened, for instance, by pulling. The use of knife is avoided.

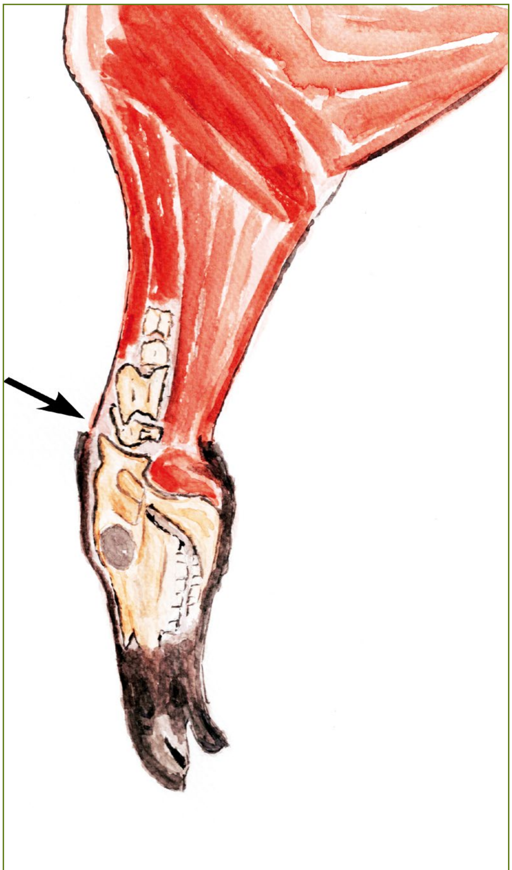
Skinning blunder: the knife was directed at the meat and the protective muscle membranes have been broken. The meat to be ground has already become dirty.

The use of the knife must always be avoided if it is possible to detach the skin by pulling or by using a skinning axe.

The skinning knife must be directed away from the carcass and along the skin, at the same time seeing to it that the muscle membranes or skin is not punctured. Pulling the hide simultaneously downwards makes skinning easier.

At all times while working, the operators must beware of touching the skinned carcass surface with their hands, equipment or clothes.

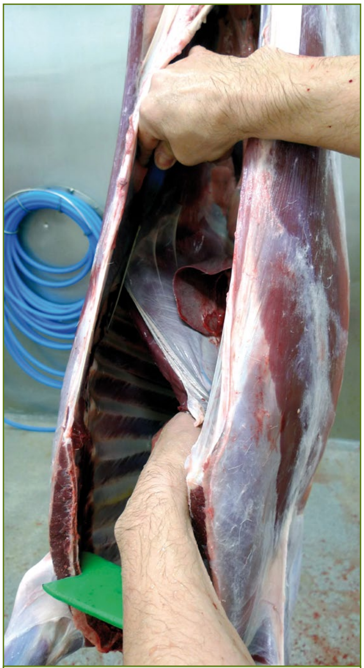
The head can be detached before skinning or at the end. It is most easily done when the animal is hanging. When the skinning has progressed to the front of the ears, the flayed hide is cut so that the ears are attached to it. The head is detached by cutting through the ligaments between the skull and the first vertebra (atlas), the spinal cord and the larynx tissues.



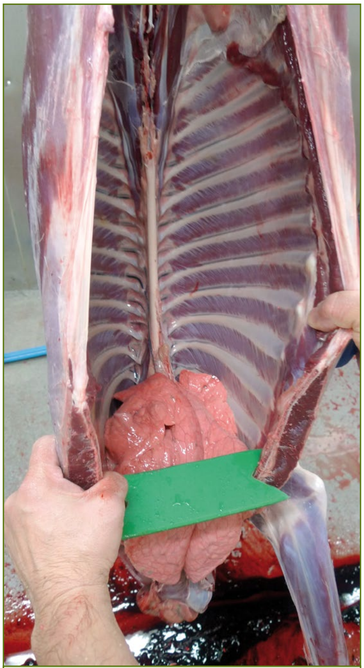
When the head has been skinned up to the front side of the ears, it is detached from between the skull and the atlas vertebra.

Basic principles and techniques for hygienic skinning of wild boar (Photos: courtesy Zentralstelle Österreichischer Landesjagdverbände).

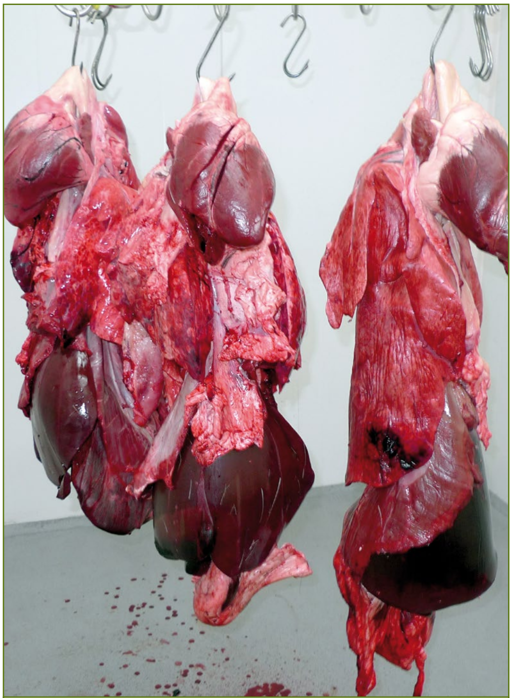
The breastbone is cut with a saw.



The diaphragm and kidneys are detached from the abdominal wall.



The organs fall out under their own weight, carefully assisted by a knife.



Organs are hung from their own rack. Organs must not touch the carcass.

After skinning, the thoracic organs (oesophagus, windpipe, kidneys and spleen) are removed as one big bundle. The soft tissues on the breastbone are cut with a clean knife down to the sternum and the chest is split by sawing through the breastbone down to the abdominal cavity.

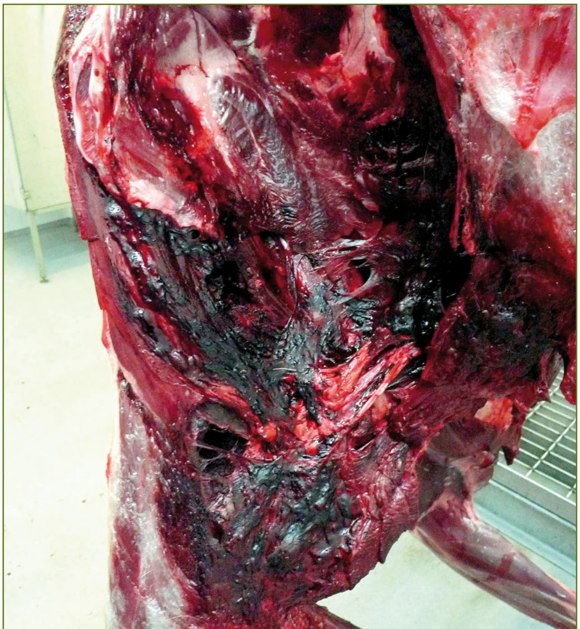
The kidneys are loosened from the abdominal roof, the diaphragm is cut loose following the rib cage, and the attachments of the pericardium are cut. The bundle of organs falls out almost under its own weight, and it is assisted, if necessary, by pulling and also by splitting neck muscles, whereupon the oesophagus and windpipe come loose. The heart is opened in order to remove blood from the ventricles. After this, the organ bundle is hung on the rack and taken to the cooler.

The carcass is dressed by cutting off visible dirt with a knife and pulling out loose hairs. The equipment must be clean and sterilized. The operators must beware of touching the carcass with their hands. The possible remaining sexual organs or their parts are removed.

The carcass is dressed by removing visible splashes of dirt and loose hairs with a knife.

If necessary, the abdominal and thoracic cavities and the organs can be cleaned with water. However, water must never be used on the skinned carcass surface.

If the skinned surface is washed with water, it causes dirt and bacteria to spread. The carcass becomes slimy and is quickly spoiled, as pictured here.



Areas bloodied from shooting are removed last. A shoulder shot had caused an extensive bloodied area and splintering of bone. The whole front quarter is removed. Due to lead residue, bloodied areas must not be given to dogs.

Shoulders can be opened in order to remove bloodied areas (left). However, they must not be opened all through. A pocket remains between the shoulder and front carcass with favourable conditions for bacterial growth (right).

Water must never be used for cleaning skinned carcass surface. Skinned surface must never be wiped with paper towels, cloth or other porous material. If necessary, the inside of thoracic and abdominal cavities can be cleaned with sprayed water, if they have been dirtied by the contents of the gastro-intestinal tract. Subsequent cooling must ensure the evaporation of excess moisture from the carcass.

Lastly, bloodied areas of the carcass resulting from shooting are carefully removed. The removal area must extend several centimetres deep into undamaged tissue, so that the possible lead or other foreign substance residue caused by the bullet are removed.

At this stage, samples for laboratory tests are taken from species prone to *Trichinella* (see Section 2.2.4.6).

There are other useful methods for the transport, skinning and removal of the alimentary tract from game animals. The main thing in all of them is that the carcass or organs will not be contaminated by the animal's skin or gut content or by the soil or the operator's hands.

4.7. Refrigeration

After slaughtering, the carcass and organs are chilled. Despite good hygiene, bacteria always enter the carcass during slaughtering. They can worsen the microbiological quality of the meat.

Coldness hinders the growth of food-spoiling or pathogenic bacteria in the meat. In situations where meat must be temporarily stored, special attention must be paid on efficient refrigeration.

The optimal storage temperature of carcasses is 0-2 °C. The cooler must have a functioning air conditioning system.

The carcass and organs must be chilled in such a way that the maximum temperature of meat in big animals is under 7 °C and in small game animals under 4 °C. The closer the temperature is to 0 °C, the worse are the conditions for bacterial growth. The objective of retarding bacterial growth is that the optimal carcass storing temperature 0-2 °C could be reached during around 12 hours from the beginning of chilling.

On the other hand, too rapid chilling must be avoided, because it can cause a phenomenon called cold shortening in meat.

Pieces of paper or other porous material must not be placed on the carcass surface. Carcasses must never touch each other. Organs must be kept airily in their own racks and in such a way that it is known from which animal they have been taken.

If an official meat inspection is going to be done to the carcasses, inspected carcasses must be separated from uninspected ones.

Cold shortening of meat occurs if the carcass cools down too rapidly after slaughtering. The phenomenon is quite familiar in context with moose hunting in north. If meat reaches temperatures

If the hunt is conducted in very low temperatures and a suitable storing space is not available for the carcass, it is better to delay skinning the carcass to prevent cold shortening.

In warm weather, delay in the chilling of the carcass can lead to warm shortening of meat (Photo: Hannu Kesti). Then the meat becomes extremely tough.

of 10 °C or lower before the pH drop of muscle tissues (result of glycogen breakdown) has reached the value 6, this causes irreversible contraction of the muscle tissue which makes the meat extremely tough. This can easily happen when hunting is done in very low temperatures, or if automatically refrigerated or, alternatively, heated facilities are not available. Then it is more beneficial to delay the skinning of the animal and thus prevent the rapid chilling of the carcass.

A reverse situation may occur when hunting in warm weather or if the carcass is left unskinned for too long a time and the beginning of chilling is delayed. This phenomenon is called warm shortening of meat. Also in that case the meat is extremely tough.

4.8 Cold storage and hanging for maturing

After death, muscle is biologically active: enzyme activity continues, muscles use oxygen and produce carbon dioxide for as long as 48 hours. During cold storage chemical and enzymatic changes occur in the muscles. They cause the formation of substances of colour and flavour in the meat, and the meat is tenderized and matured into actual meat.

In addition to cold storage period, other factors have an effect in the tenderizing of meat. These are the species, age and sex of the animal, and its fat content. Young animals' intra-muscular connective tissues disintegrate faster than those of old animals, and those of females faster than those of males. Ruminants require the most hanging time, wild boars less, and birds even less time still.

Muscle tissue is soft and elastic immediately after the animal's death. Its vital functions continue, fuelled by energy that comes from the breakdown of glycogen stored in the cells.

When the energy stores have been used up, *rigor mortis* occurs: in healthy animals within 24 hours, depending on the temperature. Lactic acid produced by the metabolism lowers tissue acidity from the pH value of about 7.2 down to 5.5. The decline of acidity activates the enzymes of the tissue to break down muscle proteins. This, together with other biochemical changes, causes the tenderization of meat and the improvement of its colour formation, water retaining capacity and shelf-life. The phenomenon is called ageing.

The meat of game animals can be stored and hung in the temperature of 0-3 °C (relative humidity 90 to 95%), depending on the species, for 3 to 14 (even 20) days, provided that hunting hygiene has been good.

The ageing time for venison can be about 14 days. If it is an old male moose, three weeks may be not too much. For smaller cervids 10 (15) days is sufficient for ageing, and wild boar can well stand 10 days of ageing. Organs can be stored at most for 5 days.

The meat of an animal that was hit in the intestines or experienced strain during the hunt (DFD meat) cannot endure cold storage. It is advisable to process such meat immediately after the carcass has been thoroughly chilled. The meat should be frozen or heat treated (e.g. warm-smoked), or processed into cooked sausages or preserves.

Vacuum-packing is a useful and compact way for ageing and cold storing game meat, especially big game meat. Carcass is cut into pieces after about 24 hours from slaughter, when *rigor mortis* has disappeared. At that point muscles can easily be separated from each other.

Thin meats and other raw materials for ground venison are ground and frozen, thick meats are vacuum-packed into portions of desired size. After this, each hunter may do as he pleases and mature his share of the meat near the temperature of 0 °C for as long as he thinks is safe. This method keeps the meat juicy with minimal weight loss, as the package stops evaporation of water.

Vacuum-packing is a useful and compact way to age meat. That way meat is also protected from drying even during long-term ageing (Photo: Peter Paulsen).

It is common in Central Europe to hang unskinned game in such a way that only the alimentary tract, organs and legs from the hocks and front knees down have been removed.

This is not a question of benefits derived from ageing meat. The custom is based on regulations for logistics and meat hygiene covering hunts and post-hunt handling of prey.

Game is chilled and temporarily stored unskinned in regional cold storages and transported once a week, for instance, to actual game processing facilities, where skinning is done and meat inspection is held. The hide protects the carcass from getting soiled during transport. Organs have been inspected already prior by a trained hunter. They are not sent in with the carcasses. Hanging times do not differ from the corresponding times of skinned animals.

In Central Europe it is common to store unskinned carcasses in temporary storages before they are transported to a game slaughtering facility (Photo: Jasna Prodanov-Radulovic and Radoslav Dosen).

It is possible that this method protects meat from cold shortening, which can occur if the carcass temperature has dropped too rapidly, for instance, due to efficient cooling equipment or cold weather.

4.9 Field dressing

In some areas the situation is sometimes such that carcasses of big game animals cannot be transported to slaughtering facilities either due to long distances, difficult terrain or, e.g. land use restrictions.

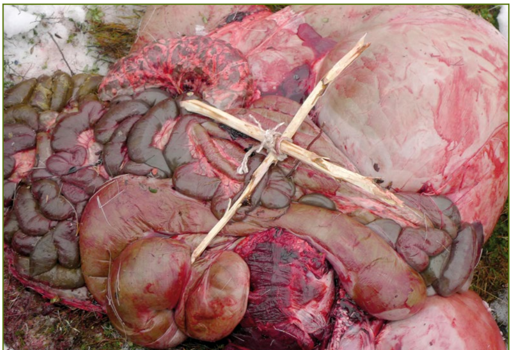
Even in such cases, with proper slaughtering methods, cleanness and caution, it is possible to retrieve first-class meat to be used at a hunter's own kitchen. Out in the woods, the animal can be skinned either in a horizontal position using its own skin as a cover or in a vertical position with the animal lifted hanging with a hoist or a so called tripod lever.

In difficult terrain, when it is not possible to transport the carcass as a whole, traditional methods can be used in slaughtering. Skinning is done by utilizing the clean inside of the hide. Skinning begins with slitting the skin and working on the first side. After the carcass is turned, the second side is skinned. After skinning, the carcass is dressed by cutting and the pieces are placed in clean plastic bags for carrying.

With a tripod, skinning can be done easily in a hanging position (Photo: Hannu Kesti).

As skinning progresses, the carcass is lifted by moving one leg of the tripod at a time. A single man can lift the moose and the work is getting on nicely. Dressing is done in the following order: shoulders, flanks, chuck, rump and roasts (Photos: Hannu Kesti).

4.10 Slaughterhouse hygiene



Traditional rebel for scavengers. A cross made from peeled twigs keeps scavengers away.

In this chapter, the facility where a hunter finishes the slaughter (skinning) of game, possible removal of organs, and dressing and chilling of the carcass will be referred to as 'slaughterhouse'.

The requirements set on slaughterhouses vary according to which purpose the game meat is produced for. Other criteria are dependent on the extent of operations (i.e. on the amount of game handled and the degree of processing). Maintaining a small-scale slaughterhouse that receives only a few moose or wild boar per autumn is very much easier than the upkeep of a facility that handles dozens or hundreds of game animals. Therefore, the requirements for space are also less strict. A small-scale slaughterhouse can also be a facility reserved by hunters for game slaughter, where only the hunters' own prey is slaughtered for their private consumption.

If the purpose is to sell small quantities of game meat directly to consumers (i.e. official meat inspection not mandatory), the slaughterhouse must meet certain legislative prerequisites as far as, among others, compulsory notification, hygiene of facilities and operations, chilling and self-monitoring are concerned.

Many new-built slaughterhouses have been designed primarily for game handling, and it is possible to maintain excellent hygiene in them. A slaughtering facility can also be a modest space where game is slaughtered only for the hunter's domestic use.

If game meat is to undergo official meat inspection, the slaughter facility and its operations must be officially approved before the facility is opened for use. The requirements are stated in the presently effective food hygiene legislation.

To ensure the safety of hunters and the good quality of raw materials harvested from game, the following general operational and structural procedures apply to all slaughterhouses. It is important to proportion the facilities to the extent of operations and to the assessment of risks that arise from these operations.

Slaughterhouse hygiene comprises the following factors: clean clothes, good personal hygiene, functional and clean work and storage areas, equipment and surface hygiene, self-monitoring, and the hygiene competence of hunters.

4.10.1 Dress code

Clothes and footwear used in slaughterhouses are to be clean. They are not to bring dirt from the outside to the slaughtering facility. Before work is begun, hunting clothes and shoes are changed into suitable protective clothing that is not worn outside the slaughtering facility. Protective aprons and disposable sleeves, gloves and headgear come with the territory. Helmets should be worn if you work with large animals. If you need to have a mobile phone, put it in a clean plastic bag.

4.10.2 Personal hygiene

Every person handling unprotected foodstuffs, such as wild game meat, is to maintain a high degree of personal hygiene.

It is important to wash hands with soap and warm water before beginning work, and always when they get dirty. Hands must be washed especially before and after going to the toilet, and before and after using a mobile phone. There must always be hot water, liquid soap and disposable hand towels available. Hand- or arm-operated water taps may be sources of dirt. Therefore, special attention must be paid to their cleaning. Photocell controlled taps are best suited.

Rings or piercing jewellery must not be used when handling meat. Naturally, smoking is not allowed in a slaughtering facility. People who have an infectious disease or who have recently suffered from intestinal symptoms are not allowed to take part in game animal handling. If a hunter has purulent wounds, they must be covered well.

Simple, good and easy-to-clean protective clothing comprises a water resistant apron that covers arms, disposable gloves and rubber boots as well as a helmet.

4.10.3 The hygiene of work and storage areas

In slaughterhouse work, the separation of dirty and clean operations is an important principle. The dividing line ('clean line') between clean and dirty (areas) operations, lies in skinning. After skinning the carcass surface is susceptible to contamination and absorption of dirt.

During skinning working utensils (instruments, tools), hands and working clothes are exposed to bacteria that come from the hide or possibly from the intestines. Clean carcass surface must be protected from these bacteria. It must be seen to that contamination does not occur at the dividing line between dirty and clean operations or areas.

This can be done by providing a separate area for skinning, from where the carcass is transferred to the clean area and operations are continued with clean working utensils and equipment. Hanging carcasses from a roof rail is the only means of how this can be done if the game animals are large. This practice is called spatial separation of operations.

A well-functioning place for hand washing and washing and sterilizing knives is a prerequisite of hygienic operations. Disposable hand towels must be provided.

The 'clean line' is set at skinning. The 'clean line' can be spatial, when hanging carcasses are transferred to the clean area, or temporal, when operations are continued with clean equipment.

A well-lit slaughterhouse with easily cleanable surfaces. The wire rack for the viscera is not as easy to clean as this hooked rack.

Clean and dirty operations can also be separated in time. This means that operations are not continued after skinning until the working utensils and equipment as well as the working area have been cleaned. Dirty and clean operations are not conducted simultaneously in the same area. This is a good practice for small slaughterhouses where only a few animals are slaughtered at the time. Slaughterhouse facilities can also be used for meat cutting and packing, provided that all the operations are separated in time from each other.

Adequately efficient lighting in all slaughterhouse areas is required for hygienic operations.

The refrigerating area must be sufficiently effective in relation to the quantity of carcasses. Special attention must be paid to good ventilation. Pests such as birds, mice or insects must be prevented from entering the slaughterhouse. This requires solid structures and protective screens. Pests may be carriers of microbes that cause several diseases. Pesticides used for pest control must not be kept in work or carcass areas.

Waste management must be functional. A designated area or container must be reserved for animal by-products in order to separate waste from the carcass parts that are intended for consumers. If animal by-products are not regularly taken away, the storage area must be refrigerated.

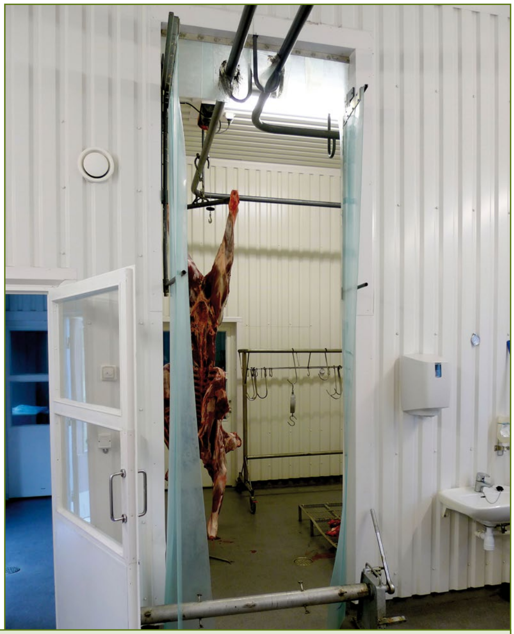
Hides are not handled or kept in the skinning or carcass storing areas.

Insects must be prevented from entering the slaughterhouse. Carrion fly eggs in wild boar hind leg/opened pelvis (Photo: Peter Paulsen).

Animal by-products must be appropriately collected, stored and disposed. Pictured here a good, solid way for both collection and short-time storage of waste (Photo: Peter Paulsen).

4.10.4 Equipment and surface hygiene

All slaughterhouse surfaces and floors must be made of easily cleanable, waterproof materials. Porous materials such as wood or plywood cannot be cleaned easily: they soak in dirt and moisture and are, therefore, excellent places for the proliferation of microbes. Special attention must be paid to seams, for instance, between floor and walls, and electrical or drainage entries.



All slaughterhouse surfaces must be easily cleanable. There are several options for materials that are chosen depending on how much the facilities are used. Coated metal is good material for slaughterhouses; corrugated metal causes problems at seams between floors and walls. Stainless steel is suitable for heavy industrial use. The floors are made of coated concrete. Stainless steel is the correct material for carcass and viscera hooks.

The utensils used for slaughtering must be easy to clean and disinfect and they must be stored appropriately (Photo: courtesy LEVO company, Lower Austria).

Thorough cleaning after the workday keeps the slaughterhouse clean and in good condition. Smooth coated metal is a good choice for wall material, and the floor join is easy to seal and keep clean.

Hot steam is excellent for destruction of bacteria.

Slaughterhouse surfaces and structures must be free of rust or flaking paint, as they can contaminate meat. The slaughterhouse must be cleaned whenever necessary, and at least once a day after work is finished, to keep dirt from sticking. Dirt is breeding ground for bacteria. Bacteria form thin layers of growth on all dirty surfaces. It is difficult to get rid of such growth layers. Cleaning is done in the following order: mechanical dirt removal, wash with detergent, rinsing with potable water, air-drying; disinfection of facilities with suitable, approved chemical. The best alternative to chemical disinfectants is hot steam. Due to splash hazard, water must not be sprayed near unprotected carcasses.

The utensils used for slaughtering must be easy to clean and disinfect. Stainless steel is the correct material for carcass hooks and organ racks. Hot and cold potable water must be available. Objects such as knives and hooks that come into contact with the carcass must be cleaned and disinfected with water heated up to at least 82 °C. Utensils and equipment must be cleaned if they get dirty, and at the end of each workday. No meat-handling equipment, such as boxes, must be kept directly in contact with the floor. Naturally, they must never be stacked within each other, not even after cleaning.

Meat boxes must not be stacked after cleaning. When meat is divided into shares, the use of disposable box liners is an excellent meat-protecting alternative.

Special attention must be paid on the cleanliness of cleaning equipment. Both clean and dirty operations have their own designated cleaning equipment that are kept apart, preferably in a hanging position. It is also important to remember that often touched objects and equipment, such as light switches, door handles and taps, are carefully cleaned.

4.10.5 Slaughterhouse design

The starting point of slaughterhouse design is in defining how much the facilities will be used in the future. It is not worthwhile for small hunting parties to take on too large facilities that are only used for a few days in a year but must be maintained all year round.

Design starts from finding out if it is possible to use already existing local slaughterhouses, or if it is possible or practical to use the services of approved game handling establishments.

Collaboration may provide hunting clubs and parties many advantages, especially where distances are not too great. A distance of a few dozen more kilometres will not reduce the quality of meat, especially if the destination has better facilities for following hygienic practices and efficient refrigeration. On the other hand, it must be remembered that the larger the facility and number of users, the bigger the risks. In such cases, the requirements set for the construction and practices of the facilities are more strict.

The foundation for layout design is the route of the game through the facility, and the operational areas along it. It is important to note the possibility of separating dirty and clean operations.

4.10.5.1 Preliminary refrigerated storage

Game arrives to the slaughterhouse, so to say, with fur coat on. In larger units throughput can be several carcasses per day. In such cases it could be advisable to consider constructing a refrigerated storage room as the first department of the slaughterhouse. This could also be called preliminary refrigerated storage space where the chilling of the carcass begins, even if it could not be immediately skinned. Preliminary refrigerated storage gives operators some leeway and, if necessary, skinning can wait (until the following day). However, in such case the carcass must be eviscerated.

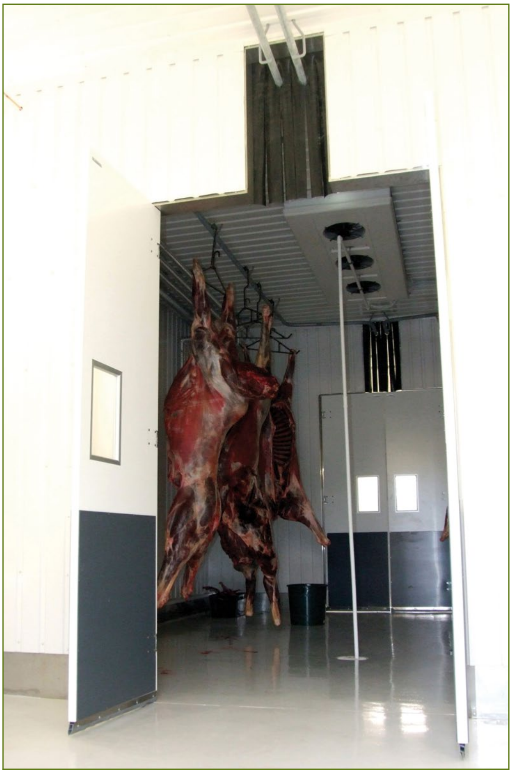
In the preliminary refrigerated storage, carcasses hang from roof rails that continue as an unbroken line throughout the slaughterhouse.

Surfaces must be easily cleanable. The floor is easy to keep clean if the area is equipped with floor drains and water taps.

The starting point of slaughterhouse design is the route of the carcass through the operational areas. Pictured here a simple and functional linear solution. Situated first is the preliminary refrigerated area for carcasses, then the skinning area and last the refrigeration area and cold storage. The door at the back opens to meat cutting area.

4.10.5.2 Skinning and slaughtering area

In most slaughterhouses, skinning and slaughtering are done in the same area. A useful way to do this is doing the operations at different times, i.e., the utensils and



An excellent, airy refrigeration area for carcasses. Condensation from refrigeration machines is collected hygienically into the drain to prevent it from dripping on the carcasses. Note the moisture protection at the bottom of doors.

Special attention must be paid to the seals of joins and entries. They must be easy to keep clean.

equipment are cleaned and sterilized after skinning, and the possible removal of organs and dressing of carcasses are done after that. In order to make this possible, it is important to place water taps and sterilizing places near the operational area.

In more industrial slaughtering, operations are separated when carcasses move ahead on the rails and different operators work at different stages. Slaughter by-products, such as contaminated hides, must be easily disposed. The waste area or a wheeled plastic container must be situated nearby.

4.10.5.3 Refrigerating and carcass storage area

Finished carcasses are moved to refrigerated carcass storage. The storage must be sufficiently spacious to keep the carcasses from touching each other. The facility layout must be designed in such a way that condensation caused by refrigeration will not drip on the carcasses, and that the area is adequately ventilated. Carcass storage area can be smaller if the carcasses are cut rapidly and matured in vacuum packages in the cold-storage room.

Organ racks or hooks are also situated in refrigerated storage. They must be designed in such a way that the viscera can be identifiable as belonging to a given animal. When a carcass arrives at the slaughterhouse, the organs may remain attached to it in order to keep them clean. If the viscera have been removed in the field, they are usually already soiled and placed in plastic bags. In cases like these the viscera must be kept from contaminating clean organs and carcasses.

4.10.5.4 Meat cutting area

In low throughput slaughterhouses, the slaughtering area can be used for cutting the meat into shares.

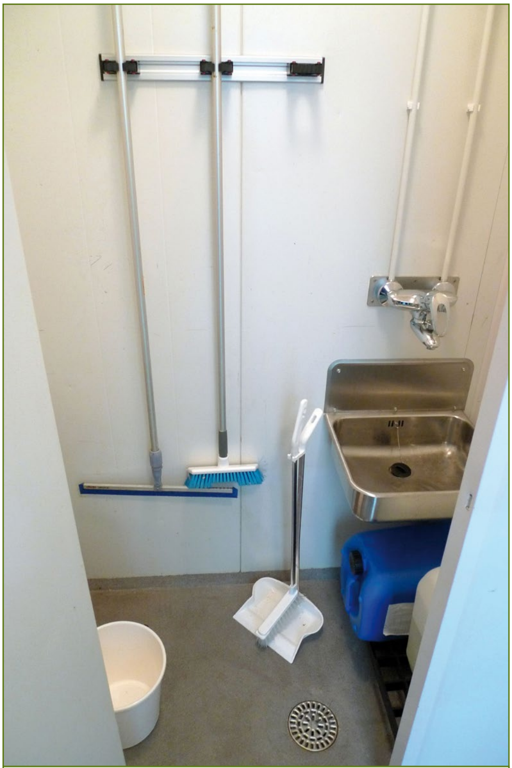
These operations must be done at different times. Slaughtering cannot be underway at the same time, and the facilities must have been thoroughly washed and disinfected beforehand. If this operation includes, for instance, mincing, slicing or vacuum packing of meat, it is best to have a separate meat handling room. Otherwise, the necessary machinery and surfaces are difficult to keep clean during slaughtering and washing.

Packing materials are kept in a specially designed cabinet where they are sheltered from splashes and dirt.

4.10.5.5 Cleaning equipment

Cleaning equipment and detergents are kept in separate cupboards or cabinets. There must be at least two sets of cleaning equipment, one set for the dirty and one for the clean area. They are stored separately. If there is a separate meat handling room, it must also contain a set of cleaning equipment.

Industrial plastic cutting boards are suitable surface material for meat cutting tables.



Cleaning equipment and detergents are kept in a separate cleaning cupboard. The equipment is airily stored in racks.

4.10.5.6 Changing rooms

Changing rooms are facilities where it is possible for workers to take care of their personal hygiene and where their working clothes are kept. They also function as rest rooms for relaxation and rest during work day, and often also as a place where documents are stored. The size and quality of changing rooms vary considerably, in accordance with how much the slaughterhouse is in use, both in terms of quantity and nature of operations. At minimum, such changing rooms must be provided where workers can change and keep their working clothes and wash their hands.

Changing rooms must be located in such a way that routes to various slaughterhouse areas cross as little as possible. In larger units, there are separate routes leading to dirty and clean areas.

4.10.5.7 Surfaces and equipment

A general requirement for all areas is that they are easy to keep clean. There are many suitable solutions. Coated, smooth sheet metal is inexpensive and good solution for walls. Stainless steel is durable and suitable for large units.

The floor must endure heavy use. For floor material, coated concrete is an economical and hygienically acceptable solution. It is wise to be prepared to re-do the coating (after some years of use). Attention must be paid to the join between the floor and walls. It must be easy to keep clean.

Coated concrete is the correct material for the floors. The design of the join of the floor and wall must be waterproof. It must be easy to keep clean.

Surfaces that are in direct contact with meat must be made of stainless steel.

Floor drains are designed so that they are easy to clean.

The material of doors and window frames can be painted wood, at least in small facilities. The surface must be kept in good condition. The effects of moisture are quick to emerge and paint must not be allowed to flake. It would be better if the frames were made of metal, which is more expensive material. Carcass routes must be taken into account in door design. Sliding doors are often functional solutions. Flap doors that carcasses hit while passing through are not recommended.

All surfaces and equipment (meat hooks, organ racks, meat handling tables, etc.) that come to direct contact with meat must be made of stainless steel. Plastic cutting boards are provided for meat cutting.

Professional working utensils (knives, saws) are provided, and their washing and storage areas are designed.

4.10.5.8 Water taps and floor drains

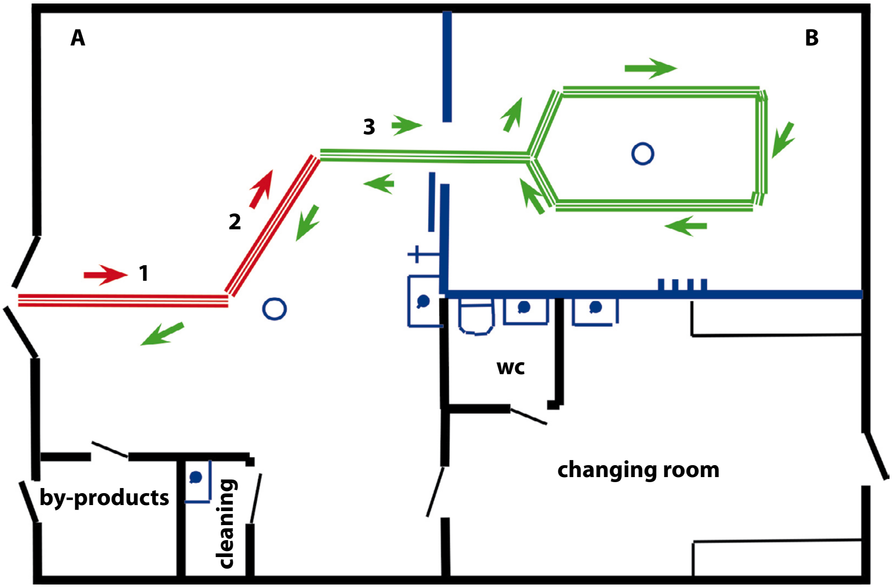
The operations and cleaning of a slaughterhouse require substantial water use and plumbing. Dirt and blood are mechanically removed into floor drains with running water and floor wipers. All meat handling facilities must be equipped with floor drains that are easy to clean.

Basins for washing hands and utensils are placed at every working area so that they are easily available for use. Water taps are especially important at skinning and meat cutting areas, i.e., in places where unprotected meat is handled. In larger units, hot water sterilizers for utensils are placed next to washbasins. In smaller units sterilizing can be arranged in other ways, for instance, by using a hot water pot. However, this is not a very practical or risk-free practice.

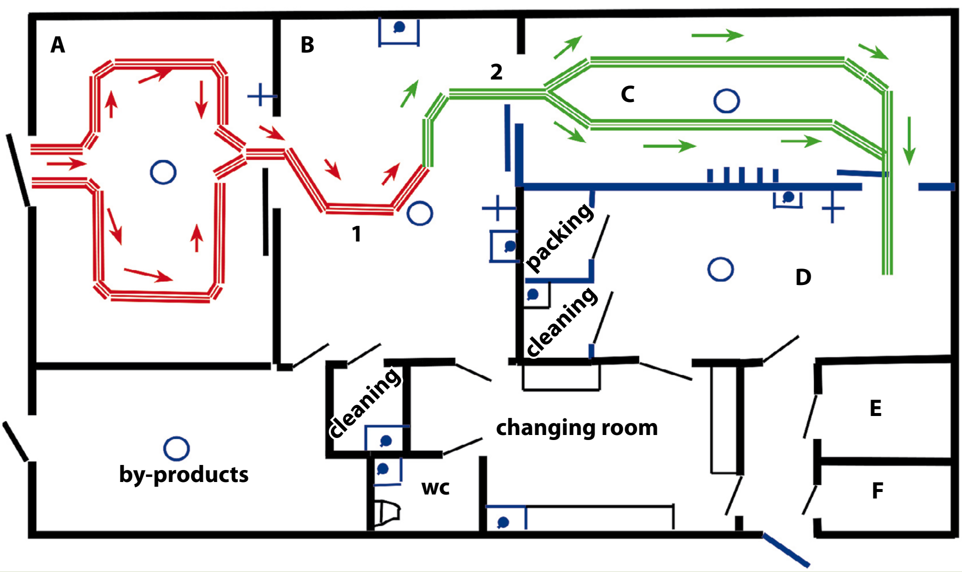
4.10.6 Slaughterhouse self-monitoring

The practices and operations at a slaughterhouse are the most important factors for securing hygienic end results. Even in good facilities it is possible to achieve bad results. On the other hand, meticulously conducted operations and proper self-monitoring can compensate for deficient facilities.

The self-monitoring plan of a slaughterhouse is a food safety procedure. Hunters can ensure hygienic meat quality by following the plan. The removal of intestinal tract and skinning are critical stages for meat contamination during slaughtering. A third critical stage is the refrigeration of carcasses.



The principle of a simple slaughterhouse. Dirty side operations are in the red carcass rail area, clean side in the green area. An animal arrives at slaughter area (A), is placed on skinning rack and marked, cut and its abdominal side is skinned (1). Skinning is finished and the animal is hoisted to a hanging position (2). Organ removal and carcass dressing are at area 3, from where the carcass is transferred to refrigerated storage (B). After thorough cleaning of the rooms and equipment, the carcass can be brought back to slaughter area for quartering and cutting.



The principle of an approved game handling establishment. Carcasses are hanging in preliminary refrigeration (A), from where they are transferred on rails to (B) skinning area (1) and further to organ removal/trimming (2). From refrigerated storage (C) carcasses are transferred on rails to cutting area (D) and the cut meat further to cold and freezer storages (E, F). Separate access from changing rooms to slaughter and cutting areas. Toilets do not open directly into food-handling areas.

Slaughterhouse self-monitoring plan is a written description of how risks can be avoided in these operational stages.

During the writing of a self-monitoring plan, the risks of game meat handling are identified. After this they can be managed with correct procedures (Hazard Analysis and Critical Control Point; HACCP system).

4.10.7 Slaughterhouse food safety risks

- **Biological hazards**
  - **Bacteria**

    Most food poisoning bacteria are intestinal bacteria that live in the intestines of all mammals. They are also found on the skin, fur coat or feathers of animals. If they contaminate meat at a slaughterhouse, it is due to mistakes in slaughtering.

    Bacterial contamination can occur by way of hands, tools, work surfaces or water, or through pest faeces. Food poisoning bacteria can proliferate in meat during all working and storing stages, especially if the temperature is favourable. Through contact, clean or already processed products can also be contaminated by bacteria. The situation is particularly difficult if already cooked, ready-to-eat food is contaminated. Biological hazards are controlled by good slaughter hygiene and by following and monitoring temperature requirements. It must be remembered that *Listeria* and *Yersinia* bacteria can also proliferate at refrigeration temperature.
  - **Parasites**

    The risk to be infected by parasites that cause food poisoning is greater in game meat than when common production animals are consumed as food. People may get parasitic infections if they eat uncooked or poorly cooked meat. The infectious forms of many parasites in muscles are almost always impossible to see with a naked eye. They can stay infectious in raw meat for long periods of time. The most common parasite that causes food poisoning found in game meat is *Trichinella*. Some species of *Trichinella* also sustain freezing. Risks caused by *Trichinella* are managed by careful meat inspection, in particular *Trichinella* testing, of species that are susceptible to this parasite. Many other intra-muscular parasites, such as *Toxoplasma* or *Cryptosporidium*, cannot be detected in meat inspection. Thorough cooking of meat before consumption is the best way to avoid human infection.

    Echinococcus parasite cannot be contracted by eating meat. Be careful in handling fur-coated (carnivore) game in areas where *Echinococcus* is prevalent. The fur of game (carnivore) animals may contain eggs than come from faeces.
- **Chemical hazards**

  Chemical hazards in game meat can be caused by chemicals that pollute the environment. Toxins produced by plants or microbial proliferation may also cause chemical hazards. Chemicals may also enter meat via game shots (lead, nickel, tin).

  At the slaughterhouse, meat can be contaminated by chemicals that mainly come from detergents used for cleaning and disinfection, from packing materials and pesticides, and also from flaking paint.

  These hazards are avoided by following regulations issued for the use and storage of chemicals as well as by careful trimming of carcasses.

- **Physical hazards**
  Physical hazards in game meat mainly occur due to game shots. Bullet particles, pellets and shattered bones are common. Careful meat inspection and sufficiently extensive removal of damaged tissue areas are important. It is possible, although rare, that foreign objects enter carcasses during slaughtering. This may happen if, for example, metal chips from broken knives or saw blades, or rail particles, grease or rust get into meat.
  These hazards can be reduced or increased at all stages of game slaughtering, depending on operational procedures.


Carcass rails must be designed in such a way that carcasses will not be contaminated with lubricant.

The self-monitoring plan contains simple descriptions of how various slaughterhouse operations are performed and which tools and chemicals are used in order to reduce risks. The self-monitoring plan must include descriptions of slaughtering techniques, cleaning and disinfection of facilities, utilities and equipment, temperature monitoring, pest control, and waste disposal. In addition to information on individual animals, carcass documentation must include the date and place of killing, hunter details and possible health certificates that come with carcasses. The appointment of a person in charge of operations is important in order to ensure the implementation of self-monitoring.

4.11 Training of hunters

Requirements for the hygiene competence of hunters that take part in a hunt vary according to how and where the game is meant to be delivered. In all cases, the hunter is responsible for the meat he or she hands over.

Competence requirements are higher for game meat intended for common consumption or food establishments than if the meat is intended only for the private use of the hunters. Also in case game is to be delivered unskinned or unplucked, the requirements are not so high.

In all cases, hunters need to be sufficiently informed about the ecology and behaviour of game animals, their diseases and symptoms, and pathological changes in animals, in order to enable the hunters to assess the health of game animals before and after the kill. It is important to identify risks for the health of humans or other animals, and to know and observe the correct practices of slaughter hygiene. Hunters can acquire this kind of competence at various food hygiene courses and at hygiene training courses offered to hunters.

4.12 Hunting hygiene abroad

Disease situation and diseases found in game animals at hunting destinations abroad are often considerably different from what a hunter is used to in his or her home region.

Some of these diseases are dangerous and easily transmitted viral diseases, such as foot-and-mouth disease or classical swine fever. A group of other animal diseases, such as bluetongue disease and West Nile virus, are found in some parts of Europe. The spread of such diseases into one's home

Contacts with production animals must be avoided for a few days after returning from abroad (Photo: Susanna Pesonen).

country can have a serious effect on production animals, game animal populations and use of natural products. Therefore, it is advisable to take certain precautions for contagious diseases if hunters take part in hunts abroad.

New pathogens can also spread through imported animals, foodstuffs, equipment and clothing. Special care must be taken with imported hunting trophies and game meat. Before the trip, one should seek information about possible import restrictions and the disease situation of the destination country. Souvenirs that are especially hazardous are raw meat and uncooked products made from game meat as well as untreated animal parts such as hide or antler trophies. Unpasteurized dairy products must not be imported.

As far as viral transmission is concerned, items that are at special risk are raw and uncooked game meat products.

Zoonotic pathogens may be more abundant in some countries both in nature and in animals. Salmonella infections or *Trichinella* and *Echinococcus* parasites can be common, and tuberculosis and brucellosis are found more often in southern Europe than in middle and northern parts.

When hunting abroad, it is always advisable to be cautious in handling killed game. You should protect yourself by maintaining hygienic practices and using protective clothing and gloves. In more exotic regions, you should protect yourself from haematophagous insects. Do not taste raw meat, and avoid contact with game animal faeces or digestive tract content. Equipment, clothes and footwear that have been used when handling game animals abroad must be thoroughly washed before they are used at home. Contacts with production animals must be avoided at least for a few days from returning home. Some viruses can survive for long periods of time in clothes or even in human respiratory tract, for example.

Every year mass outbreaks of diseases caused by *Salmonella* and *Trichinella* are reported in many areas. Uncooked game meat products from certain countries, such as wild boar salami, have proven common sources of infection.

All game meat consumed abroad must be well cooked and served hot. A rule of thumb is that game meat is safe when it is cooked so well that its juices are no longer pink.

4.13 Dog hygiene

One part of hunting and wild game hygiene is the use of hunting dogs and dog health care. In most cases, a dog gives you time to view game animals and their behaviour and note possible abnormalities before taking a shot.

Using dogs also contributes to aspects of animal protection. Extra time makes it possible to deliver accurate, orthodox game shots and ensures quick loss of consciousness to the game animal. Dogs are efficient helpers in finding wounded game and ending their suffering.

On the other hand, prolonged chase or use of several dogs simultaneously can put unreasonable strain on the game animal, thus causing a problem with animal protection and endangering meat quality by causing dry, firm and dry meat (DFD).

Dogs must not be allowed to bite or tear the killed animal. Harmful bacteria get into the game animal's meat from the dog's mouth or the animal's own fur or hide. It is also dangerous if a game animal gets to bite the hunting dog, for instance, during bear hunt. Bite injuries caused by game animals must always be regarded as serious and they must always be properly treated.

Dogs can be host animals or transmitters of many game animal diseases or parasites to other dogs, game animals and sometimes even to humans. Parasites may also cause disease to dogs themselves. Therefore, certain precautions are necessary.


Using a dog for hunting is part of hunting hygiene.

A dog is put on a leash at the kill site. It is not allowed to bite or tear the killed animal. Harmful bacteria get into the game animal's meat from the dog's mouth or the animal's own hide.

Immunization must be in order. The risk of catching rabies is considerably higher for hunting dogs than for ordinary pets. The risk is particularly high for cave hunting dogs. An infected dog transmits this serious disease easily to people or other animals through saliva or bites. If the disease breaks in man, there are virtually no treatments available.

Canine distemper or parvovirus can be transmitted from wild animals to dogs, or dogs can spread the disease to wild animals. Fox, wolf, raccoon dog, mink, stoat and wolverine can be disease carriers.

Bacterial diseases such as tularaemia can be transmitted to dogs if they eat the flesh or secretions of diseased hares or rodents. Such situations occur often during hunts. The symptoms of dogs resemble those of humans: temperature and enlarged lymph nodes are common. The disease is zoonotic and can be transmitted to humans from a dog who is diseased or has been chewing a hare that has died from the disease.

Dogs can carry in their mouths or intestines many zoonotic bacteria that come from game animals, for example from slaughter by-products. Most bacteria endure freezing well. Cooking is the only way to destroy them.

Hunting dogs must be regularly treated with antiparasitic drugs before and after the hunting season. The antiparasitic drug must be effective against tapeworms, particularly echinococci, as well as against intestinal roundworms.

This is especially important if dogs visit countries or areas where echinococci parasites are prevalent. Dogs can be primary hosts of echinococci parasites and transmit the infection to other animals or humans through eggs in their faeces.

To secure the health of both dogs and their owners, hunting dogs must be given antiparasitic drugs regularly.

Other larger, even meters long tapeworms found in carnivores, wolves for instance, can be harmful to dogs, even if there is no danger of human transmission. Herbivorous game animals are intermediate hosts of many of these parasitic worms. Dogs get infected from raw meat or slaughter by-products, but also by eating moles or mice. Due to this parasitic and microbial hazard, dogs must not be given uncooked game meat or slaughter by-products. Freezing destroys most infectious forms of tapeworms and protozoa, but some species of *Trichinella* prevalent in Northern Scandinavia (*T. nativa*) can endure freezing. Therefore, freezing is not a sufficient treatment for securing the safety of meat of animals that are susceptible to *Trichinella*. The symptoms of trichinosis in a dog mostly go unnoticed. Humans can

Due to infectious parasites or bacteria, dogs must not be given uncooked game meat or slaughter by-products.

catch *Trichinella* infection from a dog only by eating the raw meat of an infected dog. This occurs commonly in ethnic groups or cultures where dog meat is eaten.

Many ectoparasites can be transmitted from game animals to dogs. These are, for example, mites that cause scabies, lice and biting lice, fleas and deer keds. The risk of ectoparasitic infection is great particularly for cave hunting dogs. Game animal ectoparasites may also temporarily have a taste of human skin, but the infection will usually not last long. Antiparasitic treatment is advisable for hunting dogs that have been exposed to ectoparasites.

Haematophagous insects, such as mosquitoes and ticks, can also transmit diseases to dogs. These diseases are called vector-transmitted diseases, and global warming is often considered the reason for their spread and prevalence.

In the beginning of hunting season, ticks and haematophagous insects are commonly found both in nature and in game animals' fur. They are vectors of many pathogens, some of which can infect dogs. An example of such pathogens is *Borrelia* bacteria

Dogs should be checked for ticks every day in castor bean tick area. Dogs can be protected from ticks and other blood-sucking insects with insect repellents. Nowadays they can also be vaccinated against Lyme disease.

Water with cyanobacteria blooms is a risk for hunting dogs. If possible, dogs should not be allowed to drink or swim in water that contains cyanobacteria.

that can also infect people. In many countries tick-borne *Ehrlichia*, *Bartonella* and *Anaplasma* bacteria and *Babesia* protozoa have been found in dogs. Fleas may transmit canine tapeworm infection by acting as intermediate hosts. Mosquitoes transmit several animal roundworm infections. Most well-known canine insect-borne parasitic diseases are heartworm and leishmaniasis, both common in Southern Europe. Canine heartworm (*Dirofilaria immitis*) and subcutaneous worm (*D. repens*) are closely related to, for example, bear mediastinal worm (*Dirofilaria ursi*) and they are insect-borne. Leishmaniasis is a disease caused by *Leishmania* protozoan. It is spread by sand flies (Phlebotominae). Leishmaniasis is prevalent in South Europe and in the Mediterranean area, but it has also already been found much further north. All these are chronic diseases that cause serious symptoms and are difficult to heal.

In insect and tick season, hunting dogs must be protected from blood-sucking insects. This is particularly important if dogs accompany hunters to hunting trips abroad. In South Europe, preventive medicine for insect-borne roundworms and vaccination against leptospirosis is also necessary. Dogs that move a lot in tick areas can also be protected against Lyme disease with vaccines.

The general condition of hunting dogs must be taken care of. Healthy dogs work better and are helpful in harvesting game animals correctly. Hunting is both mentally and physically strenuous to dogs.

Their nourishment must be of high quality, dense and digestible. This guarantees them sufficient energy for long chases, recovery and tissue repair. The nourishment of hunting dogs is richer in fat and protein than that of a normal dog. Dogs may suffer from overexertion and overtraining. To prevent this, dogs must be kept in good condition all year round and they must be allowed enough time for rest during hunting season.

Game handling by-products are often reserved for dogs. They should be used cautiously. Often titbits are enough to stir up their enthusiasm for hunting. The nutritional value of by-products such as tendons, membranes or lungs is minor.

Nourishment meant for dogs must be chilled and stored in the same way as human food. Due to lead residue, dogs must not be given by-products that come from removal of bloodied areas caused by shots or organs from the shot area. Raw meat may contain pathogens, and therefore cooking is recommended.

A great amount of raw meat can also cause intestinal symptoms and apathy to dogs that are not used to it, and thus weaken their hunting ability. A dog's ability to eat is limited, and increased amount of meat may disturb its nutritional balance.

A dog's long-term performance is based on aerobic muscular function, for which the most important source of energy is fat. Proteins are the building blocks of tissues. Excess protein is broken down into ammonia and urea that are toxic substances. Kidneys must work hard in trying to remove them from the body and, at the same time, excrete large quantities of water. This leads to dehydration of the body.

You must also be cautious in giving bones to dogs. Too many dogs have ended up on the operating table with serious intestinal dysfunctions or bowel obstruction caused by bones.

Bones have low nutritional value and poor digestibility. Small joint bones and particularly the keratin hooves are hazardous. If you wish to give your dog bones, long large bones are preferable. Bones should never be given to a hungry dog.

4.14 Game animal welfare

Hunters are multi-skilled woodsmen whose basic competence comprises observing and understanding the basics of biological and ecological interaction between animals and nature, and changes occurring in this interaction. Hunters are in key position as they move around in nature in all seasons, making observations on animal reproduction, helping in estimating the number of game animals and maintenance, and volunteering for many scientific studies. In hunting season, hunters must also know the basics of food hygiene and pathology.

Ensuring the living conditions and welfare of game animals is the only way for the continuity of hunting. No hunter can deny being a conservationist.

The biggest threat to wild animal welfare is environmental change. Activities such as use of natural resources, agriculture and forestry, mining and traffic construction have decreased and fragmented animal habitats. The chemicalization of the environment has increased and brought along identified and unidentified hazards.

Global warming is an issue on its own, and its hazardous effects are most powerfully directed against arctic animal species. All these factors and their interaction can have a damaging effect on the nourishment supply and proliferation, and the transmission and tolerance of diseases and parasites of animal populations.

In general, all actions relating to environmental conservation also improve the welfare of game animals. Many of these actions are under the authority, and therefore the responsibility, of national and international communities, and concern also industry and traffic.

On national level decision-making, the welfare of wild animals can be taken into consideration. Actions must be based on broadly accepted population management plans. These plans should include definitions of animal welfare actions and estimations on their effect. More than ever, these plans should focus on the follow up of wild animal health, diseases and welfare.

Preservation and improvement of the genetic diversity of species is one of the most important factors concerning the vitality of animal populations. This can be taken into account when hunts are planned, with regard to game migration between summer and winter pastures. Overhunted populations with biased sex or age distribution, or populations isolated by fragmentation are in danger of descending into recession caused by inbreeding. In context of road and game fence building, more attention can be paid to preservation of existing

It is presumed that global warming is particularly harmful to northern ecosystems.

animal routes and, if necessary, creation of new routes. These actions are important also for reducing car/traffic accidents involving wild animals.

In forestry activities, favourable wild animal habitats must be considered both on local and national level. Attention is to be paid to the damage susceptibility of reforestation and methods to prevent forest damages.

Game animal welfare can be advanced by every hunting party and each individual hunter as well as other people that move around in nature. When you move around in the wilds, it is important to stay on marked routes. If, for example, snowmobile traffic causes a moose to leave its feeding ground during thick snow, it will be in trouble.

Wire fences that have broken down or fallen to the ground must be cleared away. If not, they are death traps to animals. Fences around fields must be kept in good condition. It would also be important to find ways for improving the visibility of new fencing in the forest to prevent wild animals from barging into them.

Wild animal welfare must be considered when hunting methods are chosen. Hunting must not put game animals under unreasonable strain. This can happen if several dogs are used in the hunt, or new dogs are brought in when the first dogs get tired. Unreasonably long chases also cause considerable damage to game meat quality.

In dog hunting, such situations where dogs get to savage living or wounded animals must be avoided, if possible. Anyhow, from the viewpoint of animal protection, there are more reasons in favour for the use of dogs in hunting than against it.

When shots are taken, make sure that the target is the one intended, and that there are no other animals in danger zone. The existence of cubs or a calf is not always easy to detect. Shooting at running animals or herds often results in wounding and unnecessary suffering is caused to animals.

Attention can be paid to game animal routes and protective fences in road building and maintenance.

Disused wire fences left in nature are deadly traps to animals.

In shooting situation, it must be seen to that cubs or calves do not follow their mothers. Miscalculation leads to tight spots, additional work and problems with animal protection (Photo: Teuvo Hietajärvi).

4.15 Game feeding

Game feeding by hunters is an old tradition. The original purpose of game feeding is to lure prey within a better range for the hunter, or to increase game density in an area by feeding. Hunting at a feeding site makes selective hunting and accurate, planned game shots possible. Considering the game animal's meat quality, it is favourable that the animal has not been under strain before the kill. Transport of downed game to the slaughterhouse must be considered already when a feeding site is planned. Later, game feeding has been justified by emergency feeding in severe winter conditions, or if a species cannot survive on their own in the natural conditions of the area.

Feeding is also carried out in order to prevent damages caused by game animals (e.g. farming damages or traffic accidents). Feeding can be used for luring wild animals away from critical zones.

One recent game feeding innovation is to provide service to tourism by organizing opportunities for watching and photographing wild animals at feeding grounds.

There is not much scientific evidence on the pros and cons of game feeding. The increase of natural population density and mutual contacts between wild animals due to game feeding has been a cause of concern. This has a direct effect on the spreading of diseases and parasites, and disease outbreaks have been reported (tuberculosis, chronic wasting disease, parasites).

Overdense populations can also cause animals stress through increased intra-species competition and thereby have a harmful effect on the health and reproductive behaviour of animals. Suspicions have also been voiced that game feeding can lead to animals getting used to the presence of humans, and this way it can change their natural behaviour and increase disturbances. Unphysiological nourishment or method of providing it can also cause stress to animals. Unfavourable consequences can also rise

One motivation for game feeding is the prevention of traffic or forest damages caused by wild animals. This picture is from Norway, where moose are lured away from railways with feed (Photo: Skarphedinn G. Thorisson).

from the fact that wild animals are physiologically adapted to using different sources of nourishment in different seasons.

Abnormal food can cause indigestion, such as protein or carbohydrate poisonings, decrease tolerance of diseases and make animals susceptible to various communicable diseases and parasites. It is likely that the importance of feeding-induced indigestion to wild animal welfare has so far been underestimated.

Carrion feeding means using animals that have died or been killed at farms in game feeding. This may increase the risk of spreading animal diseases or resistant pathogens, for example MRSA bacteria, to animals and the environment.

There has also been discussion on the fact that game feeding can cause blurring of the line between game meat and production animal meat. It has been noted that intensive game feeding induces changes in the flavour and nutrient composition of game meat, making it resemble the meat of ordinary production animals.

There are plenty of means for reducing the harmful effects of game feeding. Increased research on the effects of the quality of nourishment to animal physiology and behaviour is important.

Nourishment offered to wild animals must be at least of similar quality to the nourishment offered to domestic animals. Spoilt, old silage or mouldy grain can be hazardous. The feeding of ruminants must be started cautiously so that the microfauna in their rumen can get used to the new nourishment. It is advisable to use automated feeding devices that dispense out amounts of feed that can be consumed at once. This reduces the possibility of overeating and feeding disorders. It is advisable to have many feeding grounds in order to reduce social conflicts, mastery of dominating animals and spreading of possible diseases and parasites.

Nourishment must not be offered from the ground where it can be contaminated by animal faeces containing parasites and bacteria. It must also be possible to change feeding grounds every year to reduce risk of infection from contaminated ground. A move of around ten metres at the time may be sufficient. Ploughing the old feeding ground is also beneficial.

In bear carrion feeding, which is common in some northern countries, the natural nourishment of the animals must be used as much as possible. Meat and fish could be offered only in spring and autumn, preferably that of wild animals, for example, the carcasses of moose and deer that are victims of traffic accidents. In summer, berries and vegetation are the physiologically correct nourishment for bears. If sweetened with molasses, they will certainly be happily eaten.

If carcasses of farmed animals that have died on their own accord are used for feeding, it must be ensured that they do not contain dangerous or infectious pathogens or drug residue. Carrion maintenance, i.e., chilling, transporting and quality maintenance of large amounts of carcasses before serving them to animals, is a challenge. Spoilt animal parts must not be offered to animals. Many bacteria produce strong toxins, such as botulin, when they multiply in rotting muscle tissue.

Keeping carrion feeding grounds unchanged year after year can also cause problems. The eggs of many endoparasites stay in the soil for long periods of time, causing infection pressure to grow considerably.

Suspicions have been raised that game feeding can lead to wild animals getting used to human presence and thereby increase behavioural disturbances (Photo: Linda Laaksonen).

5. Food poisoning

Food poisoning is a disease or poisoning acquired from food or drinking water. Food poisoning can be caused by bacterial, viral or mould microbes or prions, or their toxic metabolic substances. Parasites, plants, fungi or toxic chemicals in food can also be the cause of food poisoning. The agents can be present already in the live animal, or be introduced or multiply to a hazardous level during the handling and processing of game.

When game meat is mainly consumed in the households of hunters, portions cooked at one time are usually small, and the product life cycle is short: from the slaughterhouse to the freezer and from there to be cooked. Risks to get foodborne diseases are low.

The situation is different in countries where the state of the environment and the disease situation is different, and game meat consumption is greater. It is common that game finds its way to other consumers through many steps, and traditional preparation methods of game meat, such as sausages, may contain hazards.

When game meat is consumed mainly by the hunter's family and their acquaintances the production chain from the woods to the table is short and has low risks. Traditional game cooking methods are usually healthy and safe.

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5.1 Viral food poisoning

Viruses that cause diseases via foodstuffs mainly come from the intestines of mammals. They are commonly called diarrhoea viruses.

This group of viruses comprise, among others, noro-, rota-, adeno-, astro- and enteroviruses and hepatitis A virus. The viruses of this group multiply in the epithelial cells of the intestine, damage them and cause diarrhoea. These viruses are extremely durable against both physical and chemical factors, and they may survive in nature for long periods of time.

The presence of viruses in game food is usually a sign of human faecal contamination at some point of game handling, for example, due to poor personal hygiene. Hepatitis E virus is naturally found in wild boars of Central Europe.

5.2 Bacterial food poisoning

Food poisoning caused by bacteria originating in game meat can be the consequence of poor slaughter hygiene and deficiencies in meat refrigeration or storage.

Conditions such as temperature, moisture and high meat pH favour the proliferation of food poisoning bacteria in meat. The presence of oxygen favours bacteria, although some food poisoning bacteria do not need it (*Clostridium* bacteria). Food poisoning bacteria proliferate particularly well if they get to contaminate meat that is already cooked.

Food poisoning bacteria are treacherous, because they cannot be smelled or tasted the way the proliferation of actual spoiler bacteria can.

Bacteria that cause food poisoning can get to the meat through bloodstream already during shooting, if the hit has occurred in the intestines, dogs have got to savage the prey, or bleeding technique has been poor. Removals of the intestines and skinning, as well as refrigeration, are the most critical stages.

Although careful cooking destroys most of the bacteria (not *Clostridium* spores) the meat contains, meat can be re-contaminated or contaminate other foodstuffs through work surfaces, dishes or utensils. These bacteria endure freezing very well.

When circumstances are optimal, bacteria can double their numbers every half hour. Some bacteria can cause disease in very small quantities: for example, 10 *E. coli* 0157 bacteria are sufficient for causing severe disease. In case of some other bacteria, very large numbers are required in order to cause disease.

5.3 Parasitic food poisoning

Most common food poisoning contracted via animals are caused by broad fish tapeworm, the parasitic worms *Trichinella* and *Echinococcus*, and the protozoa *Toxoplasma*, *Giardia* and *Cryptospridium*. Uncooked game meat can act as direct source of *Trichinella* and *Toxoplasma* parasites and some other protozoan infections. A few days' freezing destroys most infectious forms of parasites in meat, but not necessarily all infectious forms of some species of *Trichinella* or feline faecal *Toxoplasma* parasites.

In many cases, humans as well as game animals can act as intermediate hosts of parasites, and the infection is contacted via nourishment contaminated by primary hosts, most commonly carnivores. An example of this is *Echinococcus* parasite.

5.4 Safe and healthy nourishment from game

The nutrient composition of game meat is more favourable than that of the meat of production animals. The protein content of lean game meat is high, varying between about 22% in venison and about 28% in wild boar. The biological value of these proteins is high. They contain a harmonious balance of vital amino acids. This content is particularly high in the meat of lagomorphs and beavers.

The intra-muscular fat content in game meat is low. Venison is especially low in fat, only 0.5%. The fat content of beaver and wild boar lean meat is the highest of game meats, varying between two and 5%.

As far as health is concerned, fat quality is more important than quantity, particularly the proportion of saturated and polyunsaturated fats. Game meat fat contains less unhealthy saturated fats (30-42%) than the fat of production animal meat (about 44-46%). According to present knowledge, also the proportions of omega-3 and omega-6 polyunsaturated fatty acids are considered favourable to human health.

The cholesterol content of game meat is not much different from that of production animal meat. But the low quantity of fat and saturated fatty acids as well as the higher quantity of polyunsaturated fatty acids, particularly that of omega-3 fatty acids, makes game meat a healthy alternative.

Game meat is also a good source of B vitamins and micronutrients. The iron, magnesium, zinc and selenium content of game meat is higher than that of production animal meat.

Prevention of food poisoning includes hunting and game hygiene, meat inspection and cutting, further processing, food preparation, and preservation of prepared food. Game meat is healthy and safe when it has been hunted, handled and prepared correctly: the entire production chain from the woods to the table has to be in order. If you hunt abroad, it is necessary to be familiar with the situation and possible hazards existing in the area.

Traditional preparation methods for game meat are frying, boiling and braising in the oven or in a pan, and warm-smoking. These methods are safe and they also preserve the healthy qualities of game meat. Eating rare or medium game meat was not favoured earlier.

Safe preparation and storage methods of game meat are essential. Cooking destroys most microbes and parasites. Low temperatures prevent them from proliferating. Characteristics of major bacterial foodborne pathogens are given in Table 2.

A cornerstone of safe processing of meat from game is proper heat treatment:

- The meat of game mammals must be cooked well, at least up to 71 to 74 °C and wildfowl meat at least up to 74 °C. The use of meat thermometer is advisable. Game meat often cooks quickly, and the use of meat thermometer stops it from getting overcooked and dry. Drying can be also prevented by using aluminium foil or larding.
- Before serving, ready-cooked game dishes must be kept in temperature of over 60 °C, or they must be chilled as quickly as possible, in no more than four hours, to temperature under 6 °C and after that kept in refrigerated temperature, 2-4 °C.
- Reheated food must be heated to over 70 °C.
- Game meat keeps 8-12 months in the freezer.
- Thaw frozen meat slowly in the fridge or quickly in the microwave oven, not at room temperature.
- Meat thawed in the microwave must be immediately cooked.

Table 2. Most common bacterial food poisoning. Food poisoning bacteria are more treacherous than spoiler bacteria, because they cannot be smelled or tasted.

Cause	**Incubation period**	**Disease duration**[1]	**Symptoms**[1]	**Common sources**
Campylobacteria, *Campylobacter* spp.	3-5 days	2-7 days	stomach pain, diarrhoea (bloody), headache, fever	poultry, meat, milk, water, dog, cat
Botulism, *Clostridium botulinum*	12-36 hours	of long duration	difficulty swallowing and breathing	preserved food (in jars, canned, bottled) and vacuum-packed smoked fish
Clostridium perfringens	10-12 hours	about 24 hours	stomach pain, diarrhoea	casseroles, roasts, dry foodstuffs, spices
E. coli O157	12 hours - 10 days	can be of long duration	stomach pain, diarrhoea (bloody), may lead to kidney damage	ground meat, meat, unpasteurized dairy products, vegetables
Listeria monocytogenes	3-21 days, even longer	varies	fever, headache, miscarriage, meningitis	vacuum-packed fish, soft cheeses, poultry (proliferates at refrigeration temperatures)
Salmonella spp.	12-36 hours	2-20 days	stomach pain, diarrhoea, fever, nausea	meat, poultry, eggs, dairy products, vegetables
Staphylococcus aureus	2-6 hours	12-24 hours	vomiting, stomach pain, diarrhoea	humans, meat, (skin contamination, cuts) produces toxin that sustains heating
Yersinia enterocolitica	3-7 days	1-3 weeks	diarrhoea, stomach pain, fever, vomiting	pork, poultry, raw foodstuffs(proliferates at refrigeration temperatures)

[1] Does not include sequelae.

The meat of game mammals must be cooked well, at least up to 71-74 °C and wildfowl meat at least up to 74 °C.

Game meat often cooks quickly, and the use of meat thermometer stops it from getting overcooked and dry. Drying can be also prevented by using aluminium foil or larding (Photo: Walter Pschill and Rudolf Winkelmayer).

An important principle is to keep cooked and uncooked meat separated during both storage and cooking in such a way that they will not come to contact with each other through hands, utensils or surfaces. Take special care to avoid contact between cooked meat and dirt-covered vegetables. Cooked meat is an excellent breeding ground for food poisoning bacteria, because it does not contain competing strains of bacteria. Raw meat must not contact other foodstuffs, particularly those that are served or stored uncooked.

- Cleaning (and disinfection) of surfaces will prevent or reduce transfer of spoilage or pathogenic bacteria:
- Hands must be thoroughly washed before food preparation and after handling raw meat or dirt-covered root vegetables, for example.
- Vegetables must be thoroughly washed with plenty of clean water, and root vegetables must be peeled.
- There must be separate cutting boards and knives for root vegetables, vegetables and other foodstuffs. Utensils that have been used must be thoroughly washed.

Raw material for traditional game cooking (Photo: Walter Pschill and Rudolf Winkelmayer).

Game meat can be processed into traditional cooked cured meats. E.g. roe deer pie and meat jelly from pheasant (middle) (Photo: Rudolf Winkelmayer).

It is also important to watch what you put into your mouth:

- When game is slaughtered, remember not to touch your mouth with your fingers.
- This is especially important when hunting abroad.
- Do not taste raw ground meat or other raw meat.
- Avoid the use of unpasteurized milk or dairy products.
- Do not use unboiled surface water for drinking or washing game or vegetables.
- If you have a meal in a restaurant, return cooled or poorly cooked game meat to the kitchen.

There are serious risks concerning the use of preserves and vacuum-packed game products, especially those made at home. There is a risk of botulin poisoning and *Listeria* bacteria. In order to control these bacterial hazards, the following rules and precautions have to be observed:

- The temperature of home-made preserves must be kept at least at 112 °C for at least 23 minutes.
- Preserves must be stored in refrigerated temperature.
- Preserves must be reheated before use.
- The destruction of botulin poison in food requires a temperature of 90 °C for 15 minutes or 100 °C for 5 minutes.
- Bulging tins must not be used.
- Vacuum-packed products must be kept in the fridge in 0-3 °C and the cold chain must be unbroken.
- Bulging vacuum-packed meat or fish products must not be consumed.

The moose has always been an important spirit animal for north European hunters (Photo: Seppo Ronkainen).

6. Game animals

The definition, which animal species are hunted, varies within Europe, and is essentially subject to national legislation. The selection of species is caused by tradition, and restrictions due to species conservation. Depicting all European game animals species would require a full book – experienced hunters might want to add: one book for each single species. Thus this chapter discusses only the most relevant species for north Europe in some detail.

6.1 Cervids (Cervidae)

Moose, red deer, white-tailed deer, western roe deer, fallow deer and wild forest reindeer are cervids. They are ruminants and have bony antlers. Except for reindeer, only males have antlers. Among the hooved animals, this group is the most important producer of game meat in Europe. For example, in Finland, more than 100,000 hunters take part in moose or deer hunts every year.

6.1.1 Moose (Alces alces*)*

Distribution:

- The moose is the only member of its family that originates in Asia. It is found throughout the boreal forests of the Northern Hemisphere with an estimated total population of 2 million individuals. (According to genetic studies, the moose came to Europe from the east (Russia) and the north (Europe via Scandinavia) about 9,000 years ago).
- The moose has always been an important prey animal, and a popular image in rock paintings and boat figureheads. The species is found throughout Scandinavia and eastern Europe. Since the 19th century, there has been great variation in population size: at times, the species has been nearly extinct. In the 21st century, the computational winter population of moose in Finland has been about 100,000 individuals.
- It is assumed that moose have benefitted from Fennoscandian silvicultural measures, particularly clear cutting in forestry. They have found plenty of nourishment from the sprout forests at clear cut sites. In winter, moose eat conifer saplings, pine in particular, and at some places this has caused considerable damages at forest renewal areas. Another significant social problem concerning moose is traffic accidents. For example in Finland in the beginning of the 21st century, there were about 2,000 accidents involving moose every year. The balance between forestry, road safety and the interests of hunters has influenced the regulation of the moose population significantly.
- Decreased genetic diversity caused by population decline poses a threat to the future of the moose. Other factors that have an effect on this are hunting, fragmentation of habitats, and inability to migrate. From the viewpoint of preserving genetic diversity and avoiding harmful changes, the best method for population management would be stronger harvesting of young individuals. At the same time, the number of downed males and females should be equivalent.
- Another significant threat to moose welfare is global warming. The ability of this large, arctic ruminant to adapt to heat stress and increasing number of parasites is unknown, but connections

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have already been made between climate change and population crashes of the North American moose.

Physical description: Large higher-in-front cervid (height 150-230 cm), with females weighing 200-450 kg and males 240-600 kg (800 kg). Antlers palmate, dendritic or a mixture, long, moving muzzle and drooping nose. Colouration varies, calves are reddish brown.

Food habits: Feeds on tree shoots, roots, bark (willow, aspen), in summer water plants, in winter coniferous trees and their needles, and shoots of forest berries, particularly blueberries. Uses most of its time awake for eating.

Senses: Poor vision, distinguishes moving targets best, excellent hearing, large ears that move 180 degrees, accurate smell.

Behaviour: Solitary, calves follow their mothers. In winter often lives in herds. Mostly active at sunrise and sunset. Good swimmer and strong runner. Usually inhabits a single home range, distance between summer and winter pastures about 20-40 km, but migrations up to 300 km possible. Preyed upon by large carnivores, adults good at defending themselves with antlers and hooves. Males and females utter sounds during the rut and when females and calves communicate.

The moose has adapted to subarctic climate. Global warming is believed to be a threat to moose (Photo: Petri Timonen).

Reproduction: Oestrus in September/October, gestation period 8 months, delivery in May/June. Gives birth to 1, 2 or even 3 calves, birth weight 11-16 kg, calves grow about 1 kg per day. Calves follow their mothers about 12 months. Lifespan 8-12 years (max. 22).

Hunting: Most common hunting method is the use of a dog that stops prey at bay, often combined with sitting, or group chase and sitting. Moose are also hunted by skulking at their feeding grounds, for example at game fields or along their routes. More demanding hunting methods are calling by imitating their vocalizations or getting at shooting range by following their tracks. A slowly chasing, no more than 28-cm-high dog can also be used.

Harvest: Most important prey animal in Finland. During 2000-2011 an average of 58,000 individuals were harvested per year, which is equivalent to 10 million kg of meat. Most of the catch is consumed in the households of hunters or their acquaintances, and only a small amount ends up in common consumption.

Notes: Deer ked, fibropapillomatosis, wasting, contusions/fractures, tumours, meningeal worm, *Onchocerca* and *Setaria* parasites, fatty liver, eye diseases, lung worms. There has been no cases of the chronic wasting disease in Europe. The liver of adult cervids or kidneys of any cervids are not recommended for human consumption.

*6.1.2 Red deer (*Cervus elaphus*)*

Distribution: Red deer is found in most regions of Europe, in southwest Asia and in a particular area of North Africa (Atlas mountains). It has been introduced in New Zealand, Australia and in South America (Argentine). It is the largest wild ruminant in Central European countries. There are several subspecies with different regional distribution. Although the species as such is not endangered, some subspecies seem to decline in numbers. Red deer migrates from lower regions in the winter to higher regions in the summer. Migration also occurs to explore new regions and will allow genetic mix of populations. These trails have been quite constant over decades and centuries. In Central Europe, human activities, such as highways, etc., hinder these movements. Winter feeding is common, for various purposes. Red deer is also one of the most common farmed large game species.

Physical description:
- Average size and weight of red deer differ according to subspecies, i.e. the subspecies from the Caucasus region (Maral) being the largest, and those from Corsica and Sardinia island being the smallest; and gender (i.e. males being heavier than females). However, there are distinct variations within subspecies, not only according to age, but also depended on the habitat quality. As a very rough rule, the live weight of adults exceeds 100-150 kg, and the length of the animal is >150 cm. The summer and winter coat differ not only in thickness, but also in colour (reddish-brown vs. greyish).
- Only males carry bony antlers, which are shed in end of winter/early spring and then start re-growing. The velvet covering the antlers is removed around July to August (Central Europe). Antlers are valued as trophies; the velvet is used in Asian medicine.

Food habits: Red deer is not a selective forager (unlike roe deer). Foraging takes ca. one third of the day (mostly early morning and late evening), rumination ca. one quarter.

Senses: All senses are well developed.

Behaviour: Crepuscular. Red deer forms groups of the same sex. During the mating season (August to winter), mature males compete for the attraction of females (hinds), this includes fights as well as making typical sounds ('roar'), that can be heard early morning or late evening. Males may keep up to a dozen or more hinds ('harem') during the mating season. 'Successful' males are then often exhausted and enter the winter in poor body condition.

Red deer males may keep up to a dozen or more hinds ('harem') during the mating season. No wonder that successful males are then often exhausted and enter the winter in poor body condition (Photo: Hans-Friedemann Zedka).

Reproduction: Females give birth to one, occasionally two calves after 240-262 days of gestation. Calves stay with their mothers for one year or more. The smallest stable social unit is the 'family', i.e. a mature hind with yearling and the new calf. Red deer can breed with Sika deer. The lifespan of red deer can exceed 10 years, and reach 20 years.

Hunting: Methods are similar to that described for moose.

Notes: Deer ked, fibropapillomatosis, tuberculosis, EHEC, *Yersinia* sp., *Toxoplasma gondii*, liver fluke, lung worms. To date, chronic wasting disease has not been detected in red deer in Europe.

6.1.3 White-tailed deer (Odocoileus virginianus)

Distribution: The white-tailed deer originates in the USA and South Canada. White-tailed deer is a non-native species introduced to Europe in the 19th/20th century. The Finnish population is unique in Europe and originates from one male and three female deer that have produced a healthy population. Their distribution area is South and West Finland. The computational winter populations have been 20,000-32,000 individuals in the 2000s. Finnish white-tailed deer population is greatly dependent on additional feeding in winter. Constant attention must be paid to both the feeding operation and the quality of offered food.

Physical description: Male weight 70-140 kg, female weight 40-90 kg, height 90-105 cm. Grey in winter, reddish brown in summer. White fur on top of the nose, on throat and belly. Long, white patch beneath the tail, white rump used as escape signal and following sign. Fawn reddish brown with white spots, a model for Bambi. Narrow hooves, thus moving in snow is difficult. Antlers strong and dendritic with inward pointing tines.

Finnish white-tailed deer population is a successful introduced species, and a unique population in Europe (Photo: Hannu Huttu). They are believed to be greatly dependent on additional feeding in winter.

Food habits: In spring and winter feeds on green plants. In autumn root vegetables and nuts, in winter sprays and buds, beard moss and lichen from trees. Intensively fed grains and root vegetables, etc., on its distribution area.

Senses: Extremely well developed sense of smell, also excellent hearing and vision.

Behaviour: Crepuscular. At winter feeding grounds makes pathways between feeding areas and daytime bedding sites. Lives in small herds, has small home range, not territorial, but young animals migrate to new habitats. Males utter sounds during the rut, females and fawns to each other. Preyed upon mainly by the lynx and wolf.

Reproduction: Are in heat in November/December, 1 to 3 fawns born after 6-month gestation period. Lifespan about 6 years, few reach the age of 10 years in the wild, but live up to 20 years when farmed.

Hunting: Skulking at feeding grounds, chasing dog (max. 28 cm), sneaking and prowling, with rifles and shotguns.

Notes: Wasting, contusions/fractures, liver fluke, ergot poisoning, predators. The liver and kidneys of adult cervids are not recommended for human consumption. White-tailed deer is considered susceptible to many viral diseases and therefore active monitoring of their health is important.

The white beneath-tail signal works also for the spotted white-tailed deer fawns (Photo: Jukka Tobiasson).

*6.1.4 Western roe deer (*Capreolus capreolus*)*

Distribution: A total of some 15 million individuals are found in Europe and Great Britain. A bigger subspecies is found in Siberia.

Physical description: Adult weight 15-25 kg and height 60-85 cm, males slightly bigger. Coloration reddish brown in summer, grey in winter, white rump, black nose, short tail. Fawn reddish brown and striped with cream spots. Adult males have typically straight, tuberculate (<30 cm), three tined antlers.

Food habits: Selective feeder (small rumen requires concentrated feed), prefers the freshest of sprouts (even 1000 species), also tree saplings, grains, garden plants. Twigs and sprouts and food offered by humans in winter.

Senses: Excellent smell and hearing, distinguishes moving targets well.

Behaviour: Diurnally and nocturnally active. Moves around alone or in small herds, especially in winter. Territorial (females also), marks territory with scent glands, bucks defend their territories. Utters barking sounds when frightened.

Reproduction: Estrus in July/August. Western roe deer is the only cervid that has latent period of pregnancy, embryo is dormant for 5 months before development continues. Fawns are born in May/June, 1-2 (3-4) fawns. Lifespan 10-12 years.

Hunting: Skulking at feeding grounds, chasing dog (max. 28 cm), sneaking especially during spring hunts of bucks.

Notes: Wasting in winter, contusions/fractures, intestinal infections, general infections, *Setaria* parasite, predators, ticks. The liver and kidneys of adult cervids are not recommended for human consumption.

Western roe deer, maybe the prettiest of our cervids, is a selective feeder, eats only the freshest parts of plants (Photo: Ari Tervo). The species is a survivor and makes do with quite fibrous food in the thick snow in winter.

Finnish fallow deer population originates from individuals released from farms.

*6.1.5 Fallow deer (*Dama dama*)*

Distribution: Fallow deer come from the Middle East and southern Europe. Introduced to many countries and originates from individuals released from farms. Due to their impressive looks, fallow deer were popular as farmed animals. The population has not grown significantly in Scandinavia. The animal has not adapted to snowy winters. The population is also diminished by predators.

Physical description: Males weigh 70-100 kg, females about 45 kg, height 85-95 cm. Coloration reddish or yellowish brown with light spots in summer, greyish brown without spots in winter. Black stripe on the back. White rump with black edges, black stripe runs down the tail. Large, multipoint antlers that are palmate at the tips.

Food habits: Feeds on grasses, root vegetables, fruit, acorns, garden plants, fungi, berries and grains. Sprays, needles and food offered by humans in winter.

Senses: Sharp senses of smell and hearing, good vision.

Behaviour: Devoted to location, gets easily used to humans. Likes to stay in dense forests bordering on open areas. Diurnally active, gregarious animal, dispersed during the rut when males fight and groan loudly. Preyed upon by larger predators, mainly the lynx in their distribution area.

Reproduction: Estrus in October/November, gestation period about eight months. Usually gives birth to one fawn. Lifespan 12-16 years.

Hunting: Skulking at feeding ground, chasing dog (max. 28 cm).

Notes: The liver and kidneys of adult cervids are not recommended for human consumption.

*6.1.6 Finnish wild forest reindeer (*Rangifer tarandus fennicus*)*

Distribution:

- The *Rangifer* family of wild deer comprises one species, deer (*Rangifer tarandus*), that includes many subspecies. The domesticated subspecies that are found in Scandinavia and North Asia are called reindeer, and the North American subspecies are called caribou. The Finnish wild forest reindeer is the only wild deer found in Finland. A wild deer called the mountain reindeer (*Rangifer tarandus tarandus*) is found in our neighbouring countries. The domesticated reindeer is a descendant of this species. A third European *Rangifer* subspecies is the Svalbard reindeer (*R. t. platyrhynchus*) that lives in the Spitzbergen.
- In Finland, the Finnish wild forest reindeer used to be an important game animal, a source of meat, hides and tools. By the beginning of the 20^{th} century, the species had been hunted to extinction. In 1950, the Finnish wild forest reindeer returned to Kuhmo from Russia. Finnish wild forest reindeer were introduced to Suomenselkä area in 1979-1980, when eight does and two bucks were transferred there from Kainuu. Today, populations are found in Kainuu, Suomenselkä and Russian Karelia. The crash of the Kainuu population diminished the population from 1,700 individuals in 2001 to a total of about 800 individuals in 2013. At the same time, the growth of the Suomenselkä

population has halted to a total of about 1000 individuals. The causes for the Kainuu population crash are not entirely known, but predators, diseases and the fragmentation of habitats are the most likely reasons. Today, the Finnish wild forest reindeer is classified as near extinct.

Physical description: Height 100-140 cm (10-20 cm higher than the reindeer). Does weigh 60-110 kg, bucks 150-250 kg. Generally taller, slimmer and of darker colouration than the reindeer. Body structure adapted to the deep snow of woodlands: long legs, wide hooves. Head longer, nostrils bigger and antlers darker and narrower than those of the reindeer.

Food habits: Grasses and sedges in summer, mainly lichen in winter.

Senses: The Finnish wild forest reindeer has very well-developed sense of smell, large nostrils and nasal cavities. Excellent hearing, good vision, can distinguish moving targets accurately.

Behaviour: In summer, Finnish wild forest reindeer are solitary or live in small herds, often around marshes. They winter in lichenous areas, where they migrate walking in typical line formations. Winter herds can be large, comprising several dozens of individuals. Separate herds are formed by males, and females with fawns. Finnish wild forest reindeer are shyer than reindeer and their escape distance is greater: when threatened, they escape to open areas such as frozen lake ice. Do not utter sounds as much as reindeer.

Reproduction: In heat in September/October, when dominant bucks gather large herds of up to 40 does. In spring, does return to their own calving grounds where, after a seven-month gestation period, they give birth to one fawn. Able to breed with reindeer, and therefore reindeer management area is bordered with fences.

A typical fawn/doe herd of Finnish wild forest reindeer in northeastern Finland (Photo: Petri Timonen). Predators and fragmentation of winter foraging areas cause problems to the species.

Female Finnish wild forest reindeer travel faithfully to their calving areas, and gather into herds again for the winter (Photo: Arto Juntunen).

Hunting: There is some hunting of Finnish wild forest reindeer at Suomenselkä area, mainly by sitting at feeding grounds.

Notes: Deer ked, *Setaria*, *Rumenfilaria*, preying by predators, wasting. The liver and kidneys of adult cervids are not recommended for human consumption.

6.2 Brown bear (*Ursus arctos*)

Distribution: To the ancient Finns, the bear was a dreaded, holy and valued animal. They called the bear by several names, many of which were euphemisms. In total, about 200,000 brown bears are found in the world, around 120,000 in Russia, 32 500 in the USA and 22,000 in Canada. Around 14,000 brown bears are found in Europe, with 4,500-5,000 individuals in the Carpathian Mountains. The brown bear is classified as Vulnerable in Europe. In Finland, areas of densest populations are in eastern and northern Finland. At the end of 2010, the estimated minimum population in Finland was about 1,300-1,400 brown bears.

Physical description: The brown bear is a large, sturdily built, round-eared and stump-tailed plantigrade carnivore. It is the largest European predator; height 90-125 cm, length from head to rump 130-250 cm, females weigh 90-170 kg, males 95-300 kg. North American subspecies grizzly *(Ursus arctos horribilis)* and Kodiak bear *(Ursus arctos middendorffi)* can weigh 600 kg. The black bear is a different species. Fur colouration varies from black to creamy grey. Five toes, long, strong nails. Footprints, particularly hind footprints, resemble large human footprints. The front footprint width of females, young males and cubs is less than 13 cm. If the bear front footprint is more than 13 (14.5) cm wide, it was left by a male.

Food habits: Omnivorous, they mainly feed on plant foods, but also consume birds and mammals. Particularly in spring and during the rut their diet is rich in meat: moose and deer. They also eat insects, larvae, honey and ants as well as fungi and grain. Berries are the most important food when bears are putting on fat in autumn.

Senses: Excellent sense of hearing and smell, vision sense is poorer.

Behaviour:

- Shy and careful animal. Solitary, cubs follow their mother who protects them ferociously. Diverse selection of vocalizations: roars, growls and whistles. Silent and fast mover, can reach a running speed of 60 km/h, good swimmer and climber. Male home range can be 4,000 km^2, that of females a few hundred square kilometres.
- Hibernate in dens that they may dig into the ground or anthills. Uses moss, grasses, etc., for padding. Young bears may den under trees. Winter sleep lasts from October/November to March/April, about 6 months, if energy reserves are good. Winter sleep is energy-efficient, because the bear is a poor predator in snow and plant food is not available. Just before denning bears stop eating and empty their bowels. During winter sleep their body temperature drops down to around 33 °C, which is much less than that of true hibernators. Heart rate drops to less than 10 beats per minute from the normal 40 beats. During winter sleep bears do not urinate or defecate; liquid is recycled in their bodies. Fat burning results in more than one gram of water per each gram of fat. The fat

Brown bear is a large, sturdily built, round-eared and stump-tailed plantigrade carnivore. Its footprints resemble those of humans.

reserve is big enough for up to 6 months; dozens of kilos of fat burns off during the winter sleep. Proteins from muscles and connective tissues are also broken down. The resulting toxic urea does not accumulate to the body. Bears recycle it via their bloodstream to the bowel where microbes change the urea into amino acids used as building blocks of new proteins.
- The bones of bears do not become brittle during the long sleep. This fact interests researchers of osteoporosis.

Reproduction:
- Sexually mature at the age of three years. In heat in early summer, males fight over females, polygamous. Gestation period can be up to 270 days, delayed pregnancy. Gives birth to 1-4 cubs in winter den, 2-4 years apart.
- Blind and hairless new-born cubs weigh a few hundred gram. Mature sexually between 3-5 years of age, can live for 30 years, in zoos over 40 years. Cubs remain with their mothers until the second spring of their lives, sometimes even longer. In order to pass on their own genes, male bears sometimes kill young cubs.

Hunting: The most common method of bear hunting is the use of a barking dog that stops prey at bay. Chasing and skulking is also common. Bears are hunted with rifles.

Notes: *Trichinella*, bear mediastinal worm.

6.3 Lagomorphs (Lagomorpha)

Distribution: Lagomorphs found in Europe are mountain hare (*Lepus timidus*), brown hare (*Lepus europaeus*) and European rabbit (*Oryctolagus cuniculus*). The brown hare spread to Finland in late 19th century from Europe. The mountain hare is found everywhere in Finland, the brown hare as far as River Oulujoki. Great variation in population size is typical to lagomorphs. The reason for that is not known.

Physical description: Lagomorphs are mammals that have long ears, large eyes and strong hind legs that enable a bouncing method of movement and great speed. They are important prey animals for various predators in the wilderness. Their fur changes seasonally; mountain hare have white winter fur, brown hare have silver. In winter, the tips of mountain hare ears are black. The long ears reach the tip of the nose, but they cannot touch each other. The ears of the brown hare are longer, and their tips can touch each other around the nose. Mountain hare have snowshoes, they can spread their toes.

Food habits: Lagomorphs have adapted to seasonal changes. In summer they feed on grasses, in autumn and winter on dry grasses, bark and woody plants. Ornamental, cultivated and garden plants also suit them well. It is typical for them to gnaw shoots crosswise, leaving shoots with slanted cut surfaces. The lagomorph digestive system is different from rodents, as they use their food twice by eating their caecotrophes (caecum faeces). The caecum contains microfauna that breaks down plant fibres (cellulose).

Senses: Lagomorphs have excellent senses of hearing and smell. They see moving targets well.

Lagomorphs are mammals that have long ears, large eyes and strong hind legs that enable a bouncy method of movement and great speed. In the cycle of nature, they are important prey animals.

Behaviour: Lagomorphs are mainly crepuscular and nocturnal, but they sometimes move around during the day, especially in heat. The mountain hare is adapted to forested habitats, the brown hare likes cultural landscapes. Give warning by thumping the ground with hind feet. Rabbits escape to burrows when threatened, hares trust their speed or ability to hide. Good swimmers.

Reproduction: Do not dig dens. The mountain hare has 1-3 litters with 2-8 young per year, the brown hare 2-3 litters with 2-4 young. The young are born sighted. Livespan 13 years.

Hunting: Usually hunted with chasing dogs, but also by tracking to their daytime bedding site or by skulking at feeding grounds. Usually with shotguns.

Notes: Lungworm, tularemia, EBHS, RHD, toxoplasmosis, accidents, population variation. The liver and kidneys of lagomorphs must not be used as human food due to high foreign substance content.

6.4 Seals (Phocidae)

Distribution:

- The ringed seal (*Phoca hispida botnica*) and gray seal (*Halichoerus grypus*) as well as occasionally the harbour seal (*Phoca vitulina*) inhabit the Finnish sea area. An endangered subspecies of the ringed seal is found in Lake Saimaa area (*Phoca hispida saimensis*).
- In the old days, seal hunting and seal meat and blubber were very important in North Europe. Seal populations declined due to hunting and environmental toxins, and seals were placed under protection. The grey seal became common again after the year 2000.

- Seals are susceptible to environmental toxins found in the sea. Pollution is a major threat to their populations. Global warming and shrinking ice cover can cause trouble to their reproduction, especially in case of the ringed seal. Grey seal is harmful to fishing and fish farming.

Physical description:
- Seals are smooth, plump and spindle-shaped sea mammals. They are predators whose smooth bodies have adapted to moving in water. They have thick, strong necks and teeth specially adapted for eating fish. Their fore flippers formed from wrists and hands and hind flippers formed from ankles and feet that are not suited for moving on the ground. Their thick, short fur and thick layer of fat provide them good insulation in cold conditions.
- Valvular ears, large eyes, good vision and sensitive whiskers are adaptations for diving in dark waters. During dives (max. about 10 minutes) their heart rate drops and oxygen consumption is reduced. At the same time their veins contract to maintain blood pressure. Grey seals can be differentiated from ringed seals by their larger size and slim body. The head of the grey seal is bigger, and nose is longer and straighter. Male grey seal is 2.5-3.3 m long and weighs up to 300 kg, females are smaller, 1.6-2 m long and weigh 100-150 kg. The ringed seal is the smallest seal species in the world. Compared with the grey seal, its body is short and stout. It is 100-160 cm long and weighs 45-90 kg.

Food habits: Preys under water. Can dive to a depth of 100 m. Feeds on shrimps, squids and fish, big seals also hunt sea birds and smaller seals. Cause problems for fishing and fish farming industries.

Senses: Excellent vision.

Behaviour: Spend large part of their time under water. Big herds of grey seals rest on rocks in May/June, when they moult. Population calculations are made from planes in spring. Long seasonal migrations are typical of grey seals. The ringed seal lives solitary or in pairs in open sea, sometimes also in outer archipelago, and manages well in frozen sea areas even in harsh winters.

The ringed seal is the smallest seal species in the world. It has adapted to live in seas that freeze over. It can be distinguished from grey seal by its rounder body (Photo: Petri Timonen).

Reproduction: Sexually mature at the age of 3-6 years. When they are born in February/March, grey seal pups are white and weigh 10–12 kg. On average, ringed seal pups weigh 5 kg at birth. The Baltic Sea grey seal usually give birth on ice, sometimes also on land, either alone or in herds on rocks. Ringed seals give birth under accumulated snow in ice packs or in snowdrifts and survive through breathing holes in ice-covered areas.

Hunting: Seal hunting was started again in Finland 1998, when populations had recovered. Seal hunting is strenuous prowling or skulking either on spring ice or, during open water, on rocks. Good rifle shooting skill is required.

Notes: Toxoplasmosis, erysipelas, seal finger, trichinosis and brucellosis. Sometimes mass deaths are caused by phocine distemper virus. Seals are at the top of the food chain and environmental toxins, particularly dioxins and PCBs, accumulate in them. The visceral or subcutaneous fat of seals must not be used for human consumption.

In May/June, during moult, grey seal spend time on rocks (Photo: Petri Timonen). Then it is easy to do a population count from a plane.

6.5 Wild boar (*Sus scrofa*)

Distribution: Wild boar is a big ungulate and the wild ancestor of the domestic pig, with which it can still hybridize. It is mainly found in the mild deciduous forests of Europe, Asia and North Africa. In addition to hunting, deep snow and frozen ground limit the spread of the wild boar in winter.

Physical description: Females weigh around 100 kg, males up to 300 kg. Length around 180 cm, height up to one metre. Piglets have striped fur until the age of four months, and are reddish brown until the age of one year. Adult wild boars are dark grey in winter and lighter in summer. Stiff, long bristles of the fur coat are typical of wild boars. Tusks protruding from the upper and lower jaw continue to grow throughout their lives.

Food habits: Omnivorous, feeds on roots and vegetables, fungi, potato fields, small rodents, carrion (*Trichinella*!), etc.

Senses: Good sense of smell, digs.

Behaviour: Crepuscular and gregarious animal, males usually solitary. Can be aggressive when threatened or wounded – tusks are dangerous. Utters grunting sounds.

The wild boar is a crepuscular and gregarious animal, but boars are also solitary.

Reproduction: Female wild boars are sexually mature at the age of one year, males later. Gestation period 115 days. Makes a den. A litter of piglets once a year in spring, gives birth to 1-6 piglets depending on the mother's age. Lifespan is long, can live up to 25 years if farmed.

Hunting: Usually hunted by lurking at feeding or foraging grounds, also pursued by hunters or sometimes chased with dogs, rifles used. Hunting is dangerous to dogs.

Notes: *Trichinella*, classical and African swine fever, Salmonella, tuberculosis toxoplasmosis, erysipeloid, EHEC, hepatitis E.

6.6 Beavers (Castoridae)

Distribution:

- One genus of beavers (*Castor*) that includes two species, the Eurasian beaver (*Castor fiber*) and the American beaver (*Castor canadensis*). Beavers were important prey animals in the Stone Age, together with cervids and seals. Their fur, meat and castoreum, the chemical from their castor sacs, were valued.
- The Eurasian beaver was hunted near to extinction in Europe in late 19th century, but is now being re-introduced throughout Europe. In 1933, four American beavers from the USA and 17 Eurasian beavers from Norway were imported to Finland. Later, more individuals were introduced from the same countries. Presently, Eurasian beavers are found in Europe and Scandinavian and in western Finland. The main populations of the American beaver in Europe are found in Scandinavian and in East and Southeast Finland as well as in Central Finland, but the species is spread as far as Lapland. There is no evidence of cross breeding.

Physical description: The second largest rodent in the world, weight 10-30 kg, but individuals of over 40 kg have been found. Length 65-105 cm. The tail is flattened and covered with scales, 22-28 cm in length. The rear feet are webbed. Both ears and nostrils are valvular and can be closed during dives. Colouration yellowish dark brown, undercoat grey and ventrally lighter. The American beaver is darker and its tail is shorter, but the difference is difficult to see.

Food habits: Herbivores, feed on aspen and birch bark, water-lily roots, marsh trefoils, bog arums and tree shoots.

Senses: Hearing and smell are well-developed, vision less good.

Behaviour: The beaver is a shy and industrious nocturnal animal. They live by the water, swim and dive (up to 6 minutes) well. When disturbed, they give warning by slapping their tails. Often live in colonies, but there are also solitary individuals. Their lodges are up to 3 metres high mounts of mud and twigs with an underwater connection or cavern in the bank. Beavers build up to hundreds of metres long dams to raise the water level. This makes it easier for them to float food to the lodge. Beavers harvest quite big trees and cut them to the length of one metre, and use them for winter storages. When food is used up in an area, beavers move to new habitats.

The beaver is an industrious aquatic engineer who is especially partial to aspen (Photo: Hannu Huttu).

Reproduction: Sexually mature in their second winter, oestrus in January/February, gives birth to 2-4 (the American beaver to 4-5) young in May/June. Sometimes gives birth also in autumn. Can live up to 30 years of age.

Hunting: Beaver hunting is based on prowling with rifles or shotguns at paths and feeding grounds.

Notes: tularemia, *E. multilocularis*.

6.7 Birds (Aves)

Distribution: The most important Finnish game birds comprise ducks (*Anatidae*, also including geese), landfowl (*Galliformes*) and doves (*Columbidae*). Great variation in populations is typical of birds, particularly of grouse (*Tetraonidae*). By the amount of harvested individuals, birds are by far the largest group of game, although the commercial value of their meat is low.

Physical description: Birds are structurally well adapted to flight. Their skeleton is lightweight and strong, and they have powerful flight muscles attached to a sturdy keel. Their plumage is possibly developed from the scales of reptiles, it is lightweight and shelters birds from the cold and getting wet. The breathing of birds is efficient due to large air sacs. Their sexual organs wither outside the reproductive period, thus making flight easier. The forelimbs of birds evolved into wings, and their hind legs have adapted to their habitats, either for walking on land or into webbed feet suitable for swimming.

The mallard (*Anas platyrhynchos*) is the largest of our dabblers (Photo: Olli Lamminsalo). They are our most harvested birds. The start of duck shooting is the highlight of the year for many hunters.

Food habits: The digestive system of birds is different from that of mammals. They do not have teeth, and food is ground with the help of swallowed stones in the gizzard. Birds eat stones almost daily from the ground, often from roads. In winter, landfowl feed on conifer needles and buds, and the catkins and buds of deciduous trees. In summer, they forage various plants and their shoots, leaves, fungi, insects and small invertebrate animals. Autumn berries are particularly important to landfowl. They also find grain, especially oats, tasty. Insects are the most important source of nourishment for young landfowl. The food of mallards comprises plant seeds, water plants and grass as well as grain seeds. Their diet also includes various molluscs, such as clams, shellfish and slugs, insects and small aquatic animals. Doves are mainly herbivores. Their diet contains seeds, leaves and berries. In autumn, grain and berries are special treats.

Senses: Signal colours and sounds have a great meaning for birds that have excellent vision and hearing.

Behaviour: Game birds are naturally shy, but some species can be tamed by feeding, for example. Elaborate displays during courting either in groups or between couples are typical for birds. During the breeding season, many species defend their territories. Bird calls and songs are often characteristic to males, although there are no real singers in game birds. Our migratory game birds are ducks, doves and the woodcock (*Scolopax rusticola*) that belongs to waders (*Charadriiformes*), and the crane-like black coot (*Fulica atra; Gruiformes*). The conditions in their wintering areas can have a major effect on their populations. Grouse are not migratory, but some species, black grouse in particular and sometimes also capercaillies, may migrate some distances in large flocks in winter. Grouse are very well adapted to extremely cold weather for they can overnight in snow roosts beneath the snow surface.

The whooper swan (*Cygnus cygnus*) is the national bird of Finland. During migration, they live in harmony with bean geese (*Anser fabalis*) (Photo: Olli Lamminsalo). What the situation is at their nesting areas remains an open question.

Reproduction: Nesting time is preceded by display, during which birds copulate. Birds do not have external sexual organs (with the exception of male mallards). Birds mate by joining their cloaca. Male birds have two testes, and female birds have only one ovary. The fertilized egg cell travels to a long oviduct that functions like a conveyor belt; over a period of 20 hours, the albumen (white), two egg membranes, shell and finally colours are added. The finished egg passes through the vagina to the cloaca. Landfowl and ducks can lay a large number of eggs, even clutches exceeding 10 eggs. Their success is dependent on environmental conditions. Many species are capable of double-clutching if

The capercaillie (*Tetrao urogallus*) is the largest of European landfowl (Photo: Teuvo Hietajärvi). Some people regard it as big game.

The willow ptarmigan (*Lagopus lagopus*) has its own snowshoes (Photo: Olli Lamminsalo).

the first clutch is destroyed, and many species, such as some ducks and doves, may produce several litters of offspring in a summer. Birds hatch their eggs in nests that they have built. The yolk contains the nourishment needed for the embryo to develop. The nests of most game birds are rudimentary, and the chicks leave the nest quite soon after hatching. The behaviour of doves is different, for the parents nurture and feed the young in the nest with 'crop milk' secreted by the lining of their abdomen.

Hunting: Birds are most often hunted using barking or flushing dogs, or pointers and retrievers. It is also popular to hunt by sitting e.g. during evening flight using dummies, or at feeding places.

Notes: Coccidiosis, sarcocystosis, botulism, influenza A.

The black grouse (*Lyrurus tetrix*) renew their ranking order every year during spring display (Photo: Olli Lamminsalo).

About the authors

Dr Sauli Laaksonen is a veterinary surgeon who specialised in game animal health care. He lectures cervid diseases at the University of Helsinki, Finland. Sauli Laaksonen is an internationally recognised scholar and lecturer, and the creator of the Finnish hunters' hygiene training. He has published approximately 50 articles on game animal health in international scientific journals. Sauli Laaksonen has practiced veterinary medicine for over 30 years, including game and reindeer meat inspections and hygiene control of primary production and food industry facilities. The health and welfare of livestock, domestic and wild animals alike is close to Sauli Laaksonen's heart. He is an experienced hunter and breeder of Karelian bear dogs.

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