© Borgis New Med 2023; 27(1): 24-42 DOI: https://doi.org/10.25121/NewMed.2023.27.1.24

*Paweł Kowalczyk[1], Grzegorz Bełżecki[1], Malwina Kocot[2], Karol Kramkowski[3], Beata Szynaka[4], Rafał Lizut[5], Krzysztof Michalski[6]

Can fish scales be a potential source of pathogenic microorganisms for human health?**

Czy rybie łuski mogą być potencjalnym źródłem mikroorganizmów chorobotwórczych dla zdrowia człowieka?**

[1]Department of Animal Nutrition, The Kielanowski Institute of Animal Physiology and Nutrition, Polish Academy of Sciences, Jabłonna, Poland
[2]Faculty of Automatic Control, Electronics and Computer Science, Silesian University of Technology Gliwice, Poland
[3]Department of Physical Chemistry, Medical University of Bialystok, Poland
[4]Department of Histology and Embryology, Medical University of Bialystok, Poland
[5]Institute of Nuclear Physics Polish Academy of Sciences, The John Paul II Catholic University of Lublin, Institute of Mathematics, Informatics and Landscape Architecture, Poland
[6]Faculty of Management Rzeszów University of Technology, Rzeszow, Poland

Keywords

fish scales, fish diseases, human health, aquarium fish, diagnosis, treatment, control

Summary

Resistance of fish to diseases in natural conditions is much higher than in artificial breeding conditions. The appearance of pathogenic bacterial flora in fish in combination with dangerous parasites is the result of a biocenotic imbalance. One of the factors causing fish diseases are abiotic factors. Human interference in fish farming (e.g. feeding, fertilizing, aeration) sometimes also disturbs this balance. Decaying food and plant debris promote putrefactive processes and the creation of favorable conditions for pathogenic microorganisms including bacteria, viruses, fungi and also specific protozoa that threaten fish health and often lead to their sleep. Being in the natural environment, fish carry diseases between themselves and other organisms living in the aquatic environment, such as snails, crayfish, etc. Catching from natural conditions to artificial conditions for culinary and demonstration purposes (domestic aquariums or in zoos) can cause many dangerous zoonoses for humans. The review of the work discusses the main fish diseases induced by bacterial, fungal and viral pathogens found on fish scales that can cause zoonotic diseases in humans. Therefore, their knowledge of the scales, their color, shape and stiffness may indicate specific fish diseases caused by the pathogenic microorganisms described in this paper. The most frequently mentioned pathogenic and potentially pathogenic bacterial agents isolated from fish include: mycobacteria (*Mycobacterium* spp.), streptococci (*Streptococcus iniae*), vibrio vulnificus (*Vibrio* spp.), *Aeromonas* spp., *Salmonella* spp., *Listeria monocytogenes*, *Clostridium botulinum* and many more. Careless aquarists who do not follow certain hygiene rules may become victims of opportunistic bacteria. The aim of the article is to present the current state of knowledge

**This research received was supported by a grant from the Medical University of Białystok B.SUB.23.359 and National Science Center, Poland project OPUS No. 2021/43/B/NZ7/01903.

regarding fish diseases and their health implications for humans. Typically, ichthyosis infections are most common among aquarists and swimming pool users. Knowledge about human infections caused by fish scales is insufficient, diagnostic procedures are late and often ineffective, and therapy is long and difficult. Tropical fish placed on the market in an aquarium should have a certificate that they are free from mycobacteria and other potential diseases that threaten human health and life. Therefore, this study clarifies these issues.

Słowa kluczowe

rybie łuski, choroby ryb, zdrowie człowieka, ryby akwariowe, diagnostyka, leczenie, kontrola

Streszczenie

Odporność ryb na choroby w warunkach naturalnych jest znacznie wyższa niż w sztucznych warunkach hodowli. Pojawienie się u ryb chorobotwórczej flory bakteryjnej w połączeniu z niebezpiecznymi pasożytami jest skutkiem braku równowagi biocenotycznej. Jednym z czynników powodujących choroby ryb są czynniki abiotyczne. Ingerencja człowieka w hodowlę ryb (np. karmienie, nawożenie, napowietrzanie) również czasami zakłóca tę równowagę. Rozkładająca się żywność i resztki roślin sprzyjają procesom gnilnym i tworzeniu korzystnych warunków dla patogennych mikroorganizmów, w tym bakterii, wirusów, grzybów, a także specyficznych pierwotniaków, które zagrażają zdrowiu ryb i często prowadzą do ich snu. Przebywając w środowisku naturalnym, ryby przenoszą choroby między sobą a innymi organizmami żyjącymi w środowisku wodnym, takimi jak ślimaki, raki itp. Odłów z warunków naturalnych do warunków sztucznych w celach kulinarnych i demonstracyjnych (akwaria domowe lub w ogrodach zoologicznych) może powodować wiele niebezpiecznych chorób odzwierzęcych dla człowieka. W przeglądzie pracy omówiono główne choroby ryb wywołane przez patogeny bakteryjne, grzybicze i wirusowe występujące na łuskach ryb, które mogą powodować choroby odzwierzęce u ludzi. Zatem znajomość łusek, ich barwy, kształtu i sztywności może wskazywać na specyficzne choroby ryb wywołane przez opisane w tej pracy mikroorganizmy chorobotwórcze. Do najczęściej wymienianych patogennych i potencjalnie chorobotwórczych czynników bakteryjnych izolowanych z ryb należą: prątki (*Mycobacterium* spp.), paciorkowce (*Streptococcus iniae*), vibrio vulnificus (*Vibrio* spp.), *Aeromonas* spp., *Salmonella* spp., *Listeria monocytogenes*, *Clostridium botulinum* i wiele więcej. Nieostrożni akwaryści, którzy nie przestrzegają pewnych zasad higieny, mogą stać się ofiarami bakterii oportunistycznych. Celem artykułu jest przedstawienie aktualnego stanu wiedzy na temat chorób ryb i ich konsekwencji zdrowotnych dla człowieka. Ryby tropikalne wprowadzane do obrotu w akwarium powinny posiadać certyfikat stwierdzający, że są wolne od prątków i innych potencjalnych chorób zagrażających zdrowiu i życiu człowieka. Dlatego niniejszy artykuł wyjaśnia te kwestie.

Introduction

The development of intensive aquarium fish breeding in commercial hatcheries is associated with their unnatural concentration and feeding with artificial feed. Such feed is not always suitable for fish of some species, which may cause a reduction in their survival later in aquarium farming. Tropical fish kept in aquariums in Poland and around the world are most often affected by infectious diseases caused by bacteria, viruses, fungi and protozoa. The most common and popular disease entities include: mycobacteriosis, fin necrosis, stomatitis, vibriosis, peptic ulcer, thrush, afanomycosis and ichthyophone. In the aquatic environment, mainly in bottom sediments and in microparticles of organic substances floating in the water column and on stones and plants belonging to many known and unknown, but not yet described species, there are excellent living conditions for fish pathogenic microorganisms. Examples are heterotrophic bacteria, e.g. *Aeromonas hydrophila*, which use organic compounds for energy production, and chemoautotrophic bacteria, e.g. some *Flexibacter* spp. For the proper functioning of the aquatic environment, also in the aquarium, it is necessary to break down organic substances by heterotrophic bacteria. Toxic compounds formed during this process, such as ammonia and hydrogen sulfide, undergo chemotropic bacteria; such as denitrifying bacteria or sulfur bacteria that convert toxic substances absorbed by fish into less toxic compounds.

One of the most important features of some aquatic bacteria that allowed them to survive in the process of evolution is their ability to adhere to the surface of the substrate due to their ability to produce lipopolysaccharides or produce the appropriate proteins. The feature is of great importance not only in the colonization of solids found in water and external fish scales. Bacterial colonies, e.g. of the genus *Pseudomonas*, produce large amounts of viscous polysaccharides, which also protect them against various competing microorganisms. The so-called polysaccharide biofilm also protects them against therapies (1). Without these bacteria, the presence of plants and the life of fish in the aquarium would not be possible.

Some species of these aquatic bacteria have specialized to live on the skin, gills and the gastrointestinal tract of fish. It is believed that some of them have developed, through evolution, traits that allow them to be classified as conditionally pathogenic or even pathogenic. Clinical symptoms and pathological changes usually occur in fish only when the functioning of immune mechanisms is impaired. Therefore, many of these bacteria are most often referred to as conditionally pathogenic. Individual strains of aquatic bacteria within species differ significantly in fish pathogenicity. Inadequate nutrition, improper water composition, stress, and especially constant pollution of the environment with toxic substances lead to weakening of immune barriers and development of bacterial diseases. Excessive density of fish favors the spread of infection by water. In a given population, mainly fish are affected, which have a genetically determined weakest immune system in the skin and a weakened specific immune response. It is also believed that the disappearance of microscales in the epidermis and epithelial cells covering the gills makes it easier for the lice bacteria to colonize the skin and gills in depth.

Tropical fish kept in aquariums in Poland and around the world are most often affected by the following infectious diseases: mycobacteria, fin necrosis, stomatitis, vibriosis, peptic ulcer, thrush, afanomycosis and fish phonosis.

Fish scales functions

Fish scales – they are usually arranged in longitudinal and transverse rows, overlapping as thin plates, forming a kind of armor. Their small dimensions usually do not hinder the animal's movements (1). Most fish have a different structure, size and origin. There are three main types of scales: posteroid, ganoid and flexible (1). Each of them has different functions and role. The basic function of fish scales is to protect the body against mechanical injuries. Many demersal fish have lost all scales, while others have only a partially covered body. During evolution, the scales transformed into shields, thorns or bone plates, which are also a type of protective barrier. The scales in the lateral organ perform a specific function. The holes in them connect the side line channels with the external environment. In many species, the color of the scales acts as a mask. The scales together with the mucus covering them reduce the resistance of the body of the fish moving at low speed. At high speeds, the scales do not show favorable hydrodynamic features (2). The most primitive scales and of different classes and types microorganisms living on it among today's scales are rhombic or round scales. In contrast, posteroid scales are arranged on the skin in loose rows. They occur in cartilaginous fish. They are homologous to vertebrate teeth (2). In paleoichtiology, complex (aggregate) scales are also distinguished: protacrodontic, xenacanthus and hybridodonic (found in cartilaginous fossils) (2-5). Chenoid scales (1, 3, 4) with a rough surface in touch and a shape similar to a rectangle, on the back edge there are comb teeth showing numerous modifications in various species (1-4). They appeared in the Cretaceous period and occur in most modern fish (1) (fig. 1).

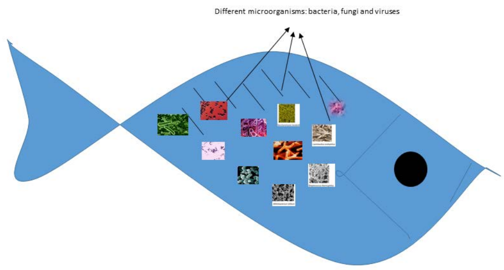

Fig. 1. Fish scales and microorganisms living on it

Diseases caused by improper feeding

In countries with a warm climate, some aquarium fish are bred and kept in hatcheries or in stocks outside the hatchery. Due to the lack of a thermal barrier limiting the development of tropical pathogens, they are often infected with water by various pathogenic microorganisms and parasites from endemic fish (1-3). The development of intensive breeding of aquarium fish in commercial hatcheries is associated with their unnatural concentration and feeding on man-made food. This food is not always suitable for some fish species, which may reduce their survival in later aquarium breeding. Fish bred in an intensive system are constantly exposed to fluctuations in the physicochemical properties of water, biotic and abiotic stresses, and transport. All these factors lead to a weakening of the immune system after some time (4). This can result in the dynamic development of various types of diseases that rarely occur in clinical form in nature. Diseases of aquarium fish cause serious financial losses not only due to the increased mortality of valuable individuals, but also because they lead to the degeneration of subsequent breeding generations. Growth retardation, loss of color, increased spawning and premature hatching, and finally infertility are observed in the offspring of these fish.

Proper feeding of a nutritious diet is important for growth and prevention of nutritional deficiencies and for dealing with various pathogens (5-7). Diseases associated with nutritional deficiency are non-specific (1, 4). Affected fish provide favorable environmental or physiological conditions that may be predisposed by organisms to infection. Excessive supply of nutrients causes their loss and increases water pollution, which can change water chemistry and lead to serious health threats to the entire fish population (7-9). It rarely occurs naturally when diets are not well formulated and prepared based on species requirements. Ascorbic acid deficiency is a preliminary cause of scurvy in fish and is a non-infectious condition in nature. The use of a diet of another species in the absence of a proper formulated diet for species may cause its deficiencies (10). It is known from the literature that spinal deformity associated with ascorbic acid deficiency occurs naturally in *Cromileptes altivelis* larvae in Indonesia. This usually applies to fish in mature stages, but spinal deformity occurs in the larval stages. Anorexia, erosion of fins and pads, short muzzle, eye and fins bleeding, staring eyes, abnormal skull, swollen abdomen, sagging throat and branches, severe emaciation and abnormal spine, poor growth are signs of fish suffering from scurvy disease. High doses of vitamin C may provide increased resistance to diseases against several pathogenic species of bacteria and viruses in fish (7).

Inadequate nutrition of fish and water composition, biotic and abiotic stress, and in particular continuous pollution of the environment with toxic substances lead to weakening of immunological barriers and development of bacterial diseases. In infected fish that have a genetically determined weakest immune system in the skin and a weakened specific immune response – systematic distribution is necessary for proper functioning in the aquatic environment, including in the aquarium organic substances through heterotrophic bacteria. Toxic compounds formed during this process, such as ammonia and hydrogen sulfide, are subject to chemotropic bacteria, such as denitrification or sulfur bacteria, transforming into non-toxic substances absorbed by plants. It turned out that this feature is of great importance not only in the colonization of solids in the water and the outer shell of fish. Bacterial colonies, e.g. of the genus *Pseudomonas*, produce large amounts of sticky polysaccharides, which also protect them against the various microorganisms that feed on these bacteria. Without these bacteria, the presence of plants and the life of fish in the aquarium would not be possible. Some species of these aquatic bacteria have specialized in life on the skin, gills and gastrointestinal tract of fish. It is believed that some of them have developed, through evolution, traits that allow them to be classified as conditionally pathogenic and even pathogenic. Clinical symptoms and pathological changes usually occur in fish only when the functioning of the immune mechanisms is disturbed. Therefore, many of these bacteria are most often referred to as conditionally pathogenic. Individual strains of aquatic bacteria within the species differ significantly in fish pathogenicity.

Types of diseases in fish induced by various groups of microorganisms

Fish diseases can be divided into two basic groups: external diseases – affecting the skin, gills and fins – easier to recognize and thus to treat and internal diseases – requiring careful observation, more difficult to diagnose and treat. The most common diseases of aquarium fish include: diseases caused by adverse environmental factors: gas, acid, alkaline, diseases caused by bacteria, viruses, fungi or protozoa.

Chilodonellosis

Chilodonellosis is a disease of the gills and skin of fish caused by the ciliates of *Chilodonella cyprini* and *Chilodonella hexasticha*, which are the parasites of the gills and skin of many fish. In poor environmental conditions of pond breeding, slowly living cattle can settle on the carp of the genus *Chilodonella cucullanus* and *Ch. uncinata*. Chaffs of the genus *Chilodonella* resemble the shape of a leaf or coffee bean with a convex dorsal side and a clearly concave ventral side. The ventral side of the parasite is covered with longitudinal rows of cilia arranged in parallel around the useless surface, the so-called manhole. Their number is characteristic for the species and in *Ch. cypress* is 7-15 on the right and 8-14 on the left when in *Ch. hexasticha* the number of cilia on the right and left side of the body is 6-10. The length of the cilia is 40-80 µm, width 20-70 µm. In winter or adverse physicochemical conditions, the parasite may lose cilia and throat equipment and surround itself with a film forming resting cysts that are on or outside the host's body. Cyst formation takes 3-4 hours. Cysts in the aquatic environment can maintain their vitality and invasiveness for a long time. The parasites reproduce by conjugation and autogamy on the body of the fish, which means that their number on the host's body can increase. In conjugation between two individuals, a vegetative nucleus and an exchange of a part of the cytoplasm exchange are formed. When the parasite moves to water at 23-25°C, it loses its invasive ability within 2-3 days. After this time, some of them die, some form cysts, others adapt to new living conditions, after a while they can cause disease in fish even in water at 22-27°C. In water free of fish at 28°C, the parasite dies within 3-5 days. Some authors also indicate that strong lighting can inhibit the development of ciliates. These organisms occur in many species of fish both in natural reservoirs and in breeding ponds or aquariums. The hosts for:

- *Chilodonella pisciola* which appears on the skin and gills of fish are sea trout, brown trout, peluga, tench, common carp, carp, common carp, silver carp, silver carp, silver carp, zander, scalar,
- *Chilodonella hexastricha* is found on the gills and skin of species such as tench, carp, grass carp, goldfish, carp, silver carp, silver carp, silver carp, gambusia and *Girardinus januaris*,
- *Chilodonella cuculanus* and *Chilodonella uncinata* parasite on the skin and carp gills. Due to the presence of these parasites in breeding carp, these parasites often enter the aquarium together with natural feed collected in the ponds.

Chilodonellosis is a disease that occurs in most cases in weak fish, during poor nutrition and high density of fish in a small area. Infection usually occurs through direct contact or through water. These cysts play an important role here, from which, when transferred from water at 3°C to water at 20°C, the parasites hatch after 10-14 days. These cilia cause damage and detachment of epidermal and gill epithelial cells, mucus secretion increases, large defects occur, and in some cases the gill epithelium is completely destroyed. The fish's back and head have a cloudy, milky coating and large patches of skin. In the dead part of the epidermis, secondary invasion of Saprolegnia mold often occurs. As a result of gill perforation, adjacent gill plates form a spongy mass, and tissue necrosis often occurs. These changes impede gas exchange, hypoxia, weakness, weight loss and drowsiness. Infected fish gradually lose their appetite and often rub against the ground or objects in the aquarium. With a large invasion, it happens that they jump above the water surface. There is also "sticking" to the fins on the outer shells and a whitish-bluish coating appears. Chilodonellosis develops quickly at high fish density, therefore, for prophylaxis, proper stocking should be taken, whether it is an aquarium or a breeding pond. In commercial agriculture, fish should be fed in early spring when the water temperature reaches 4-5°C. Before winter restocking, the fish should undergo veterinary examination, if this disease is detected, the fish should be moved earlier from wintering ponds to summer ponds, where smaller ones will be planted the number of fish, which prevents high density and effectively prevents the spread of the disease. For treatment, baths in medicinal solutions with a high concentration of the therapeutic agent are used to remove parasites. Fish that are subject to massive invasion are usually weakened, so too much chemical concentration of therapeutic agents is not used in long baths. Before treatment, it is good to strengthen the fish by feeding them with healthy, natural food. If they are thermophilic fish, you can raise the water temperature to 30-32°C shortly before the procedure, which will cause extinction of a large proportion of parasites.

Costiosis (called Kostioza or Kostiosis)

Kostioza – a parasitic disease of fish caused by flagellates of the genus *Ichthyobodo*. There are two species of flagellates of the genus Ichthyobodo: *Ichthyobodo necatrix* and *Ichthyobodo pyriformis*, the first of which is the most common cause of causing this disease. The name comes from the previously used generic name Costia. Kostiosis is a disease that occurs in artificial breeding and mainly affects young fish. This is due to very small flagellates (parasite length 10-20 µm and width 6-10 µm). Ichthyobodo has the shape of a kidney on a dead host, and on the outside the parasite takes on a more spherical form. When it encounters a living host, its tapered end acts as a sucker, clinging to the skin. When he leaves the host, he lives only about 30-60 minutes. However, it can produce specific spore cysts (7-10 µm) that can survive for a very long time. Most often it appears on fish skin, fins, less often on gills. In aquarium culture, it appears very rarely due to the temperature in the aquarium, usually attacking the fry. At 30°C and higher, the parasites die. The source of the spread of this disease is most often infected fish. In pond farming, there are cases of spreading disease by birds carrying dead fish infected with costosis from one reservoir to another. Ichthyobodo necrosis multiplies by longitudinal division, temperature dependent, the fastest at about 25°C and water giving a more acidic pH (pH) 4.5-6.0. The development of the disease causes general weakness of fish. A white biofilm appears on the surface of the body due to the release of excessive mucus associated with the skin's defense response to the invasion of parasites. In places where the invasion took place, the skin shows hyperemia and ecchymosis. The fish rub against plants and objects trying to get rid of the "intruder", and their movements become uncertain. The gills slowly disappear due to large amounts of mucus appearing and the fish shows signs of breathlessness. Floats in the best oxygenated places, almost does not catch air from the water surface. Fish stop eating and lose weight quickly. At an advanced stage, dead foci may appear on the skin, fins and gills. In the prevention of flagellates, special attention should be given to the health of imported fish. To prevent disease, new fish should be bathed in 1% table salt for 30 minutes for several days. It is a good idea to repeat this procedure at intervals of 2-3 days.

Ichtioftiriosis

Is one of the most common diseases of freshwater aquarium fish, is smallpox caused by the protozoan (*Ichthyophthirius multifiliis*). The whole body of the fish is covered with raised white spots the size of a pinhead. In sick fish, we only observe the adult form of the parasite, which attaches to the body of the fish under the skin. The protozoa in aquarium water reproduce very quickly and then attack the fish again. Sometimes this disease is sometimes called "white spots" or "grits". However, some of them are dangerous parasites for fish life. The adult form is evenly arched, it has the shape of a pear or a ball, which is why the name "bullets" was adopted. Kulorzęsek can parasitize all freshwater fish. Its location can be in many places. Most often this parasite is found under the epidermis and connective tissue of the gills. The parasite lives in the host's epidermis or gill epithelium in empty places. In breeding conditions it is the most dangerous for fry. In addition to the species *Ichthyophthirius multifiliis*, protozoa of chtiophtirius marinus can also be parasitized on marine fish.

It differs in the structure of the macronucleus (it is divided into segments and has 4-8 patches). *Ichthyophthirius multifiliis* breeds at 10-25°C – about 5-30 days. The strongest fish invasions occur in the summer, when the rate of reproduction of parasites is the highest. The infected fish is restless, sometimes makes sudden movements that rub against the bottom or objects. As a result of skin damage, bloodshot cavities appear on the abdominal surface of the body. The surface of the body is covered with larger mucus and a small, white-gray bloom, the size of sand grains. The disease first appears on the fins or the back of a fish. Already at an early stage, the fish fold their fins and try to get rid of the parasites, rubbing against plants and decorations. Sick fish have signs of reluctance (anorexia) to eat. Small spots of whitish color appear on the body, reminiscent of semolina (attached white "balls"). Over time, their quantity increases. The fish do not want to eat, and the invasion quickly intensifies. Fish show signs of breathlessness ("so-called swallowing air") because of the reduced oxygen absorption capacity of diseased fish. Eyes may be blurred. Changes in the form of eruptions also occur on the conjunctiva and cornea, which can sometimes cause blindness in sick fish. The fins are clearly jagged. The gills change color and are dark. As a result of the invasion, they become swollen and covered with a lot of mucus. In the case of severe invasion, they may show foci of gray forms with defects (necrotic lesions).

Diagnosis of ichthyroidriosis is sometimes impossible to recognize. Similar symptoms also occur with other diseases, e.g. white spots on the outer shell of a fish may also occur with other diseases: saprolegniosis (fungal disease; thrush), plistophorosis (protozoa of spores; rapids parasitic disease).

The basis for treating sick fish is to know the length of the period in which Kulorzęsk stays on fish in specific temperature ranges. Diagnosis of the disease is based on the presence of typical, small bumps on the skin and on the basis of microscopic examination of secretions, e.g. mucus from fish skin. This disease can be cured if the parasite has not yet penetrated the internal organs. Sick fish should be bathed for 2-3 weeks. During this treatment, the water is heated to a temperature at which fish species found in this aquarium (aquarium) and properly aerated can be found. The most preferred temperature is 28-30°C.

By raising the temperature, slowly flowing parasites are killed. Baths are used until the white spots disappear. They are produced in one of these preparations:

- malachite green (Ichtiosan) 0.005 g/100 dm³ of water (without refilling),
- chloramine 1 g/200 dm³ water (can be topped up every 2-3 days in 1 g/500 dm³ water),
- trypaflavin (acrylavlavin) 1 g/100 dm³ of water (add 1 g/250 dm³ of water every 5-6 days),
- rivanol 1 g/500 dm³ water (top up every 5-6 days with 1 g/700 dm³ water),
- methylene blue 0.3 g/100 dm³ water (no topping up required),
- FMC (10-15 ml/100 l water),
- quinine hydrochloride solution (1 g per 100 m³ of water).

Velvet disease, oodiniosis, golden sand disease, rust disease – invasive parasitic disease caused by protozoa from the furrow group. Three species of furrows cause this disease:

- for freshwater fish – *Oodinium pillularis* or *Oodinium limnetioum*,
- for marine fish – *Oodinium ocellatum* and is called coral disease.

Grooves of the genus *Oodinium* occur in nature in three basic forms: sedentary, i.e. parasitic, in the form of developmental cysts and dinospores. *Oodinium pillularis* attacks the skin and also occurs under the epidermis, causing local bulges. Appears on the fins, around the eyes or in the olfactory openings. Sometimes also occurs under the epithelium of the oral cavity, as well as in gills or gill arches. Parasites are dangerous primarily for young fish.

In most cases, oodiniosis is chronic. The most favorable conditions for dinospores are 23-25°C. At this temperature it retains the greatest vitality and the ability to invade fish for a period of 12-24 hours. After this time, the chlorophyll dinospory reserves run out and die. During the greatest activity, dinospores swim very quickly in search of a new host. The length of the entire Oodinium development cycle (as well as its individual stages) depends on the temperature and light intensity. Shortly after the invasion of the new fish and the settlement of the dinospores, the parasite stays on the fish until a new host is found, again starting the entire development cycle. In good conditions (23-25°C), the parasite's growth period on the fish's body (from anchoring the dinospora to leaving the fish) lasts 3-4 days. During the second invasion, dinospores usually attack the same areas of the fish body where the previous invasion took place. Optimal conditions for the development of *O. pillularis* are 22-25°C, for *O. ocellatum* a temperature above 20°C. At higher or lower temperatures, the development cycle of parasites slows down (22-26°C, the entire development cycle lasts 8-10 days, 23-25°C, 6-8 days). In the case of infection, increased mucus production and the presence of small, dark yellow brown spots, sometimes gray, can be observed throughout the body and fins. With a high concentration of invasion, a dark or slightly golden coating appears on the skin. In the light, you can observe the coating in the form of a fine powder, and in places particularly affected by discoloration or peeling of the epidermis. The most effective method of treatment is a quarantine period of at least 10-14 days. After this period, you can use a preventative bath to eliminate any carrier status. If very young fish are bought, it is advisable to keep them in a separate tank until they reach an increase of min. 1.5-2.5 cm. If oodiniosis is found in the general aquarium, all fish should be placed in a new aquarium without healing treatment.

During this time, the aquarium with plants remains heated (25-27°C) and illuminated and remains without fish along with the given disinfectant, e.g.:

- Aquaseptin, Abioseptin, MFC,
- Trypaflavin (acrylavlavin) – 1 g per 100 liters of water – 2-12 hours or long-term bath (5 days) – 1 ml per 5 l of water; after 2 days, repeat with 1 ml,
- Methyl blue – 1 ml for 4.5-5 liters of water or long-term bath for 8 days in an amount of 1 g/100 ml water,

- Chloramphenicol (detreomycin) – 50-80 mg per 1 l of water (8 hours) or 6.6 mg/l water (long-term bath for 8 days),
- bathing in 10-15 g/l table salt solution,
- Tetracycline – 1 tablet per 50 l of water for several days.

Spironukleosis have whitish granulomatous nodules in liver and kidney (10-50). In large fish, the livers and kidneys show multifunctional necrosis with oedema, congestion, haemorrhages and fibrosis. In advanced infections, fish have severe muscular degeneration, cholangiocephalitis and perihepatitis, encephalitis and meningitis. In Chinook salmon systemic infections, flagellates appear in the blood, the liver can exhibit petechial haemorrhages oedema, congestion and inflammation and the renal interstidium can be hyperplastic (51). In *Salvelinus apinus* infected by *Spironucleus barkhanus*, despite huge numbers of flagellates in the heart and in the vasculature, the tissues of the organs were remarkably unaffected in contrast to systemic spironucleosis in farmed Atlantic salmon (51-61) which may have enteritis, liver necrosis and serous exudates in the abdominal cavity, whereas in aquarium fish the parasite can produce mortalities and invade the blood and other parts of the body (61). Tropical fish can show eneritis, gall bladder inflammation, gastritis and perforation with serosal granuloma in the stomach (61).

Viral and bacterial diseases

In addition to diseases caused by protozoa, diseases induced by bacteria and viruses have a special place. The main disease entities induced by bacteria are presented in table 1.

Mycobacteriosis (fish tuberculosis) caused by *Mycobacterium* spp. bacteria. E.g. *Mycobacterium marinum* is caused by bacteria present in saltwater aquariums. It is a disease often found in aquariums. The bacteria that cause it easily adapt to a changing environment, which gives them the opportunity to infect people. *Mycobacterium marinum* causes a chronic, progressive disease in fish. It occurs in every aquatic environment. Weight loss, non-healing open sores, bloated abdomen, loss of appetite, fin erosion, unnatural coloration, bulging eyes, spinal deformities and lethargic behavior can all indicate infection. Unfortunately, it sometimes happens that an infected fish does not show any external symptoms and still dies for reasons unknown to us. The autopsy would then detect characteristic growths on and inside the internal organs; especially in/on the kidneys, spleen and liver (61-65). While mycobacteriosis leads to fish losing weight, apathy and ultimately death, it causes other symptoms in humans. Bacteria easily enter the human body through cuts and abrasions of the epidermis, directly into the blood vessels. When manipulating the aquarium, you must also be careful not to cut yourself on decorations, scales or fish fins. In case of a cut, drain some blood from the wound and disinfect it. Pink or purple spots appear on human skin, most often on the hands. They appear as spots and can be painful. The disease in humans usually develops within two weeks of infection, but its development may take up to two years. Of course, the disease is curable with the antibiotics rifampicin and isoniazid, but the therapy may last up to a year. You can protect yourself against *Mycobacterium marinum* by following basic hygiene rules. Care procedures should be performed in special long gloves, which are available in aquarium stores. After performing planned care activities, hands should be washed thoroughly with soap and hot water (64, 65).

Closed water systems with a high density of fish and warm water (this is what you would call an average home aquarium) are conditions particularly conducive to infection. Poor water quality and any nutritional deficiencies may additionally contribute to the development of this pathogen. *Mycobacterium* can be found in the ground, in every puddle of water, and also in unsanitary swimming pools. This bacterium is also present in your aquarium and you need to take appropriate action.

Proper care, i.e. strict compliance with quarantine, a varied and high-quality diet, regular cleaning of the aquarium, and constant water filtering:

1. Remove the activated carbon from the filter.
2. Limit the amount of food given throughout the treatment period.
3. Follow the prescribed doses and method of using medicinal products.
4. Regularly monitor the nitrite content in the water (if it increases, change the water).
5. Change the water (50% of the aquarium content) after treatment and put the activated carbon back into the filter.
6. Add anti-nitrite bacteria to enhance biological filtration.
7. Do not add new fish to the aquarium immediately.

The proposed treatments can help keep the tank free of this bacteria.

The best way to protect your fish against it is to keep them healthy and have a strong, well-functioning immune system. Regular water changes, combined with the removal of dirt and detritus, careful observation, control of parameters and providing nutritious food are recommended preventive measures.

Mycobacteriosis in humans and another fish diseases

In humans, mycobacteriosis caused by infection with *M. marinum* and other mycobacteria found in fish is local; after infection in a swimming pool, lesions appear on the knees and elbows. Most often, it manifests itself in the form of difficult-to-heal inflammatory lesions and skin defects that usually do not improve after the use of conventional medicinal preparations. However, if the infection occurred while cleaning the aquarium – on the fingers and hands. The most common symptoms of infection in humans are a single lump or a series of smaller nodules, usually appearing on

Tab. 1. Viral and bacterial disease

Type of disease	Type of bacteria	Type of dieseases	Occurrence	Causes and symptoms	Medication or treatment used
Mykobacteriosis	*Mycobacterium marinum*, *M. fortuitum*, *M. chelonae*	Can cause disease in people	Mycobacteriosis occurs in fresh waters as well as in saltwater.	A disease similar to the symptoms of sepsis in fish or ichthyosporidiosis. In the diagnosis should also take into account nokardiosis. The disease manifests as loss of appetite and weight loss. Distended belly, general weakness. Fish "standing" in the corner of the aquarium or between dense vegetation make vibrating movements of the caudal fin. Sometimes imbalances can be observed. The colors become cloudy, the fish lose their vivid color. In some parts of the body you can observe damage and loss of scales, and even skin defects. Hyperemia and open wounds may appear.	The so-called staring eyes, following these changes that may cause blindness. A longer period of the course of this disease leads to general cachexia and emaciation. In acute form, in microscopic examination on the surface of internal organs (kidneys, heart, spleen, liver) numerous, gray, small bumps (bumps) are visible. Inflammatory exudate collects in the swim bladder and body cavity. Kanamycin – at a dose of 10 mg per 1 liter of water (for 7-10 days) streptomycin – 10 mg per 1 l of water (7-10 days) oxytetracycline (terramycin) – 13 mg of pure antibiotic per 1 l of water (7-14 days) sulfadimethoxin.
Fin necrosis	*Pseudomonas fluorescens*, *Aeromonas*, *Flexibacter* water fungi grow on the diseased fins, e.g. *Saprolegnia* spp.		Water pollution, too low its temperature, improper feeding and fighting of fish, as a result of which fins are damaged.	Hyperemia of the blood vessels of the fins is observed, followed by the clearing of their peripheral parts. Shortly thereafter, tissue fin necrosis occurs between their bone rays.	Aquarium salt, phenoxyethanol, malachite green, methylene blue, antibiotics (chloramphenicol, oxytetracycline, tetracycline).
Flexibacteriosis also called mouth rot	*Flexibacter columnaris*		Mechanical injuries of the skin, mouth, inappropriate water reaction, high concentration of nitrogen compounds, low oxygen concentration and lack of vitamins.	Bacteria begin to develop, gray spots on the head and fins or in the gills are observed. After some time, the lesions, mainly on the edge and inside the mouth and on the edge of the scales, begin to look like dense hyphae of cotton wool. Clusters of bacteria sometimes occur around the base of the dorsal fin. Untreated flexibacteriosis leads to death of the fish. *Flexibacter columnaris* can also be one of the causes of gill damage.	Aquarium salt (many catfish are salt sensitive), copper sulfate, acryflavin, furan, antibiotics, e.g. terramycin (in feed and bath).

Vibriosis	*Vibrio anquillarum*		In inland fish, this disease is relatively rare, but it is common in sea fish.	At the beginning of the disease, the fish lose their appetite, they breathe with difficulty. Death occurs shortly after ecchymosis in the skin. In more resistant fish, experiencing the first pathological changes, there is widening of the eyeballs and ulceration of the outer shells. During the section they have swelling of internal organs and inflammation of the digestive tract.	(Oxytetracycline, erythromycin, ampicillin, chloramphenicol), nalidixic acid, sulfonamides, nitrofurans, trimethoprim.
Peptic ulcer disease	*Aeromonas salmonicida*, *Aeromonas hydrophila*, *Pseudomonas fluorescens*, *Pseudomonas putrefaciens*, *Mycobacterium marinum*, *Flexibacter columnaris*, *A. salmonicida* var. achromo-genes			Skin ulceration in aquarium fish. Ulceral lesions occur not only on the body of the fish, but also on the fins, cornea of the eye and on the gill covers.	In fish with an efficient immune system and in good condition, various bacteria can be present for a long time in the form of asymptomatic carrier.

Other human disease entities: Smallpox carp, Cotton disease, flexibacteriosis, Mycobacteriosis of fish, Nocardiosis of fish, lymphocytosis, Sepsis in fish (so-called ascites), contagious dermatitis.

the hand and progressing towards the arm. Less common is a joint infection that causes symptoms similar to arthritis. The latter type of severe infection occurs when, for example, a wound after a catfish sting or any other deep, open wound after a hand being pricked with a fish thorn becomes infected, or the sharp ray of its fin (64, 65).

In people with weakened immunity, even in extreme cases, death may occur. People with HIV, AIDS, cancer patients undergoing chemotherapy and anyone else with a weakened immune system should exercise particular caution. If you belong to one of these high-risk groups, consider using the services of a company that will service your aquarium because due to the slow development of this bacteria, symptoms of the disease may appear 2 weeks to 4 months after infection. Therefore, you should pay attention to each morning to make sure that it is healing properly and is not exposed to infection (64, 65). Some strains of mycobacteria can sometimes cause the disease also in people with a functional immune system. This was confirmed by the research of Slany et al. (65), which showed that VNTR profiles (variable number of tandem repeats), i.e. a variable number of repetitions of tan- demos in genomes containing repeated nucleotide motifs ACTACTACTACT... isolates of this bacterium from aquarium fish and from their owners suffering from mycobacteriosis were identical (65).

Another fish disease that is equally dangerous to humans is salmonellosis, which can be infected during tank maintenance activities. This disease occurs sporadically in humans due to contact with an infected reservoir. It may also occur in aquariums with turtles. If you notice any disturbing symptoms, you should immediately see a dermatologist. Treatment involves the use of specific antibiotics, the long-term use of which may lead to serious gastric problems related to the digestive tract, including diarrhea and intestinal ulcers.

Erysipales is a disease caused by Gram-negative bacteria in: *Erysipelothrix rhusiopathia* in the form of hairy rubella. Causes bacterial folliculitis. The greatest risk of illness occurs primarily in veterinarians, employees of meat processing plants and fish processing plants. The disease-causing bacterium is extremely resistant to drying, salting and curing. The sources of infection are mainly pigs and fish, mice, poultry. In the summer months it has the ability to multiply in fertilizer. The source of rubella infection is animals, mainly pigs (the embryo is excreted in the urine and faeces of animals), as well as poultry, mice, fish and crabs. Infection usually occurs through wounded skin that has been in contact with pork meat or fish scales. Erysipales is a zoonotic disease that occurs very often in our country, considered an occupational disease mainly by veterinarians and butchers who have contact with sick animals or meat. In humans, they are most often in the form of skin rose; causing skin changes on the patient's body, especially around the hands and fingers. Less often we observe septicemia, which is much more dangerous because in its course endocarditis occurs, which in turn can lead to death.

Rose causes painful, widening erythema, sometimes bladder, to appear on the skin. Then there is swelling and pain in the surrounding joints and lymph nodes. The changes are accompanied by severe itching, intensifying under the influence of heat. Sometimes there are general symptoms in the form of fever or malaise. An enteric rose variety that occurs as a result of eating infected pork, giving symptoms of acute gastroenteritis is also possible. In general, the rose appears suddenly and has a sharp or subacute course. Then rhombus-shaped patches appear on the skin, which indicate the presence of urticaria erysipelas. In turn, the chronic nature of erysipelas is associated with skin necrosis, acute arthritis and endocarditis. In general, skin lesions that accompany the disease heal properly, although in some cases complications may occur, e.g. sepsis. Very often, rubella is confused with roses due to the spread of peripheral erythema, which is quite clearly separated from the rest of the skin. The difference is that the rose usually touches the skin of the face and cheeks, while the rose in the palm area.

People with suspected erysipelas should consult a dermatologist who will make a preliminary diagnosis based on a detailed patient history and clinical examination. It is important to inform your doctor if you have had contact with meat or animal products before, otherwise the doctor will not be able to say that the disease is zoonotic. This is important information because erysipelas are common confused with a rose. In the case of initial suspicion of erysipelas, microbiological tests are required. In newborns, blood is taken from the heel.

Preparations in the form of penicillin, imipen and ciprofloxacin are used to treat erysipelas. The guarantee of good prognosis is well-established diagnosis and implementation of appropriate medicines. The same is true for sepsis – correct diagnosis is also important here. The disease causing bacterium is resistant to antibiotics administered in endocarditis, i.e., aminoglycosides and glycopeptides. Incorrect administration of these preparations can weaken the body, which can even lead to death.

Smallpox carp (*Epithelioma myxomatosis cyprinorum*)

A viral disease of fish caused by viruses of the family Herpesviridae, constantly present in the joint and latent, which can lead to epidermal cancer. Is the most common disease in fish in breeding conditions than in natural water bodies. In ponds it is most common in two-year old carp and carp fish (*Carassius carassius*), bream (*Abramis brama*), tench (*Tinca tinca*), roach (*Rutilus rutilus*), pikeperch (*Lucioperca lucioperca*), smelt (*Osmerus eperlanus*), European catfish (*Silurus glanis*), common pike (*Esox lucius*). Smallpox can cause losses in farming, as it significantly reduces fish growth. This disease can also occur in ornamental fish in aquarium farming. Poor living conditions in the aquatic environment of fish are a consequence of the occurrence of related diseases. The occurrence of disease symptoms in farmed fish occurs in spring. Changing the temperature and chemical parameters of water (silted and overgrown ponds, a small amount of calcium compounds in water), insufficient amount of natural food along with their slow growth are most often a factor contributing to this disease. The lack of vitamins in food in fish under breeding conditions can contribute to the development of smallpox. With further deterioration of conditions and weakening of fish, another relapse can be expected. The incubation period is not exactly known. It is considered quite long and can last up to a year. Eruptions in the form of whitish, milky or pinkish herpes appear on the skin and fins of sick fish. Initially single, usually limited around the mouth, they expand and spread over a large area of the skin over time. On the histological picture, the proliferation of epidermal tumor cells can be observed. The tumor tissue resulting from this growth consists of cells homologous to the outer layer of the epidermis. Deeper cells are not affected by these increases. However, in the advanced period of the disease, changes may occur in the deeper layers of the dermis (45). There are no changes in internal organs. Smallpox carp is not causally treated. Fighting this disease depends only on its prevention. It is recommended to keep farms and ponds in good condition. Fish should be kept in favorable and optimal living conditions. Sick animals with extensive lesions should be eliminated from further breeding. In aquarium farming, preventive treatment with an appropriate preparation should be carried out to prevent transmission of this disease to other fish (45).

Bacterial diseases

Fish sepsis, ascites: a disease causing swelling of the abdominal part of the fish and the scales stand out from the body (looking like a cone). Bacterial septicemia is especially dangerous because it is contagious. Common effects are the so-called “staring eyes” – the fisheye seems to come out of orbit.

A similar but less contagious disease is skin ulceration caused by bacteria from the *Aeromonas* family that affect the entire body of the fish. Bacteria use aquarium pollution to infect fish. The fish loses scales; redness of the skin forms which changes to white over time. There may also be inflammation/infection of the mouth in which swelling of the mouth appears, initially covered with a white coating, then it rots and turns black. Fins lose their transparency, become irregular and jagged. Fin necrosis progresses. Rotting is caused by *Flexibacter* bacteria. Other microorganisms use the weakening of infected fish with these bacteria to attack them (46).

Sepsis

Sepsis – “water ascites” – a disease of aquarium fish caused by the bacteria *Pseudomonas punctata*, occurring in all types of water, but most often on farms. This disease also occurs in aquarium culture. In 1971, sepsis virus was isolated for two disease entities: bacterial and viral. It is caused by a virus that causes spring viremia and bacteria of the genus *Aeromonas hydrophila* that cause erythrodermatitis (erythrodermatitis). Bacteria most often attack the internal organs of fish, mainly the circulatory system. The immunity of such a fish is significantly weakened, and then inflammation begins to appear (47). Body fluids leak and accumulate in the body cavity. Only a weak or old fish develops the disease. The fish become pale, listless, have an enlarged belly, most often they are found at the bottom of the aquarium, between plants. The fish's eyes bulge, no other symptoms (no abscesses or nodules). Visible lightening on the skin, there may be flat blisters under the skin. The scales stick out, sometimes they are damaged. Gill screens protrude in it, sometimes they tarnish. The abdominal cavity is filled with fluid, as a result of which the whole body is stretched. Fecal-like threads, redness sometimes appears around the anus. In very advanced condition, bone deformities may appear (47). Yellowing of the yolk bubble can be seen during frying. Infected fish (in advanced stages of disease) must be killed. For very valuable species of fish, you can try to treat them with a long bath in:

- auromycin (chlorocycline) – 1.3 g/100 dm^3 of water or
- chloromycetin (detromycin) – 5 g/100 dm^3 (MFC decontamination solution),
- crystalline penicillin 600,000 units/100 dm^3 water,
- crystalline streptomycin 600,000 units/100 dm^3 water,
- metronidazole (0.5 g per 50 l of water).

Cotton disease (flexibacteriosis, flexibacteriosis) – bacterial disease of fish

Visually, this disease is similar to another type of thrush. Fish are starting to show changes in behaviour. Fish hide in the corners, rub against various types of objects causing "self-mutilation". In the first stage, the skin on the surface of the whole fish is frayed due to necrosis of parts of the epidermis. Turbidity appears on the skin in the form of whitish patches (17). A sick fish, rubbing against sharp objects, loses scales, thus creating an opportunity for bacterial action on the body. A coating of balls of "cotton" appears around the mouth. These "cotton balls" also appear in other parts of the body, most commonly on the gills and around the caudal fin. In places exposed to a lack of scales, in addition to bleaching, there are various types of redness and congestion (48). On the head, above the eyes in the frontal area, small white spots appear over time, taking up more and more space around the eyes. This disease is treatable at an early stage. A suitable therapeutic agent used by breeders is:

- chloromycetin in an amount of 40 mg/l (3 days),
- sulfatiazole 100 mg/l (2-4 days),
- chlorotetracycline 13-130 mg/l – bath for 2-5 days.

The temperature in the treatment tank is about 3-5°C higher. During treatment, thoroughly feed diseased fish with washed, cleaned and disinfected food. Preferably artificial food, rich in various minerals, vitamins (Supervit, Bio-vit, Ichtio-vit, Ovo-vit preparations).

Moritella viscosa

Gram-negative bacterium is considered the main causative agent of winter ulcer, a disease that mainly affects salmonids in seawater during cold periods. The disease is initially characterized by local swelling of the skin, followed by the development of systemic changes. Bacteria were detected in muscle/skin gills, head kidney, spleen and liver, intestines. Immunohistochemical analysis using polyclonal anti-M. viscosa antiserum showed generalized luminal staining with some positive mononuclear cells. Antigens recognized by the antiserum could have been derived from extracellular bacterial products and be part of bacterial invasion strategies by suppressing immune responses (49, 50). The overall causal picture induced by this bacterium is currently being investigated by the Norwegian Veterinary Institute (49, 50).

Tenacibaculum sp.

In spring and early summer 2010, several salmon outbreaks with significant skin and tissue damage were identified. These outbreaks were recorded in a large geographical area throughout Scandinavia. Infected fish showed injuries mainly in the head area, but also on the sides and fins (51). After direct microscopy of skin and tissue scratches, long, thin rod-shaped bacteria can be observed. After cultivation on marine agar, these bacteria were identified as closely related isolates of *Tenacibaculum* spp. (formerly *Flexibacter* spp.). Isolates are closely related, but probably not identical to *Tenacibaculum* spp. Previously associated with winter ulceration. *Tenacibaculum* spp. (different from *Tenacibaculum maritimum*) has been identified over several years in connection with a disease called winter ulceration in Norway. In total, the Norwegian Veterinary Institute registered *Tenacibaculum* spp. in 19 marine sites holding salmon and 4 marine sites holding rainbow trout in 2010. Not all isolations were associated with significant mortality and/or ulcer development. During 2010, related *Tenacibaculum* spp. were also identified in halibut, cod and wrasse with ulcers and in mixed infections with *Moritella viscosa* from classical "winter ulcer" in rainbow trout in western Norway (52).

Flavobacterium psychrophilum

Relatively few cases of *F. psychrophilum* were diagnosed in Norwegian aquaculture in 2010. In 2008, there was a sharp increase in the number of cases of systemic infection of *Flavobacterium psychrophilum* in rainbow trout hatcheries (*Oncorhynchus mykiss*) in Norway, which is associated with significant losses. In 2009, diagnoses in both fresh and marine waters were confirmed. Affected fish were large (1.5-2 kg). Death revealed cutaneous blisters and enlarged spleens. Systemic clinical symptoms similar to those considered typical for “winter ulcers”, i.e., open ulcers penetrating the entire surface of the fish, have been observed in some fish (52). *Moritella viscosas* has also been identified in a single fish. Larger skin lesions, including bloody “blisters”, open sores and rotting fins have been observed. Fish often showed an enlarged stomach due to anemia or swelling. In large hatchery rainbow trout grown in seawater, typical lesions include large oil-filled, subcutaneous “blisters” in affected fish. Microscopic examination of the affected tissues showed necrosis and swelling. In infected fish, areas with inflammatory cell infiltration could be observed in the skin and skeletal muscles. Necrotic pericarditis with spread to the heart muscles is also observed. Earlier rainbow trout isolates of *F. psychrophilum* tested in 2010 previously showed reduced sensitivity to oxolinic acid, a characteristic not found in salmon isolates. In 2010, *Flavobacterium psychrophilum* infection was registered in three salmon hatchery. In two of these cases, the infections were systemic in nature and led to increased mortality (54). In one of these places there was a problem with the O1 Yersinia ruckeri serotype. In Atlantic salmon (*Salmo salar*), brown trout (*Salmo trutta*) and arctic carbur (*Salvelinus alpinus*) *F. psychrophilum* is usually associated with ulceration and “fin rot” or as part of a multifactorial etiology. In 2008 and 2009, isolated cases of systemic salmon infection were identified. Internationally, systemic infections are treated primarily with antibiotics, in addition to establishing routine production that impede the development of the disease (good water quality, hygiene barriers, minimizing stress, etc.). Autogenic *F. psychrofilum* vacin has been developed, approved and introduced for use in rainbow trout. Other commercial vaccines are not available on the Norwegian market (54).

Yersiniosis

Yersiniosis is caused by *Yersinia ruckeri* infection and can lead to increased mortality in salmon and rainbow trout throughout the juvenile breeding phase. Infected fish moved to the sea can infect other fish. Intestinal disease (ERM, jeriniosis) is one of the most important diseases of salmonids and leads to the formation of “jaundice” in fish with significant economic losses (22). The disease is caused by Y*ersinia ruckeri*, a Gram-negative rod-shaped enterobacteria that was first isolated from rainbow trout (*Oncorhynchus mykiss*) in the Hagerman Valley in Idaho, USA (33) and is currently found throughout North and South America in Europe, Australia, South Africa, the Middle East and China (24, 25).

Piscirickettsiosis

Piscirickettsiosis is caused by the bacterium *Piscirickettsia salmonis*, and was one of the largest disease problems in fish farming in Chile during 2010. In recent years, this disease has been only occasionally registered in Norwegian aquaculture, with associated mortalities much lower than that experienced in Chile. In 2010, two incidences of piscirickettsiosis were recorded in Norway. infected fish show loss of appetite, emaciation, lethargy, swimming in circles and swimming near the surface or on the sides of the net or pen is often a sign of disease (55). An increase in mortality is also seen. Characteristic pathological symptoms are: progressive skin lesions, from raised scales to white raised plaque, to shallow ulcers on the sides and head darkening of the skin and pale gills, swollen abdomen, swollen spleen and kidney, mottled liver (due to diffuse bleeding) or white or pale yellow ring-shaped changes (granulomas and areas of necrosis), ascites (fluid in the abdomen), signs of peritonitis, including generalized diffuse abdominal inflammation, adhesions and increased volume of free abdominal fluid, ecchymotic (point) haemorrhage, gastrointestinal bladder and visceral fat. The microscopic image gives characteristic pathological symptoms which include vasculitis and hepatic and renal necrosis; inflammatory infiltration of macrophages. Presence of rickettsia-like organisms in macrophages and epithelial cells (56).

Other bacterial infections

In all Norwegian farmed salmon are vaccinated against vibriosis, cold water vibriosis and furunculosis. In 2010, no outbreaks of cold-water vibriosis, furunculosis, or typical *Aeromonas salmonicida* infections were detected in salmon. In 2010, a seizure caused by *Vibrio anguillarum* O2a serotype was recorded in one salmon hatchery after a short period of sea water consumption, while *V. anguillarum* O1 serotype was isolated from another eight rainbow trout farms in sea water. Systemic infections caused by motile *Aeromonas* spp. (*Aeromonas hydrophila*/cavia) have been diagnosed in juvenile salmon at two freshwater sites. Fish developed ulcers and high mortality was reported (57).

Gill inflammation

Flavobacterium psychrophilum causes typical gill inflammation. The etiological agent of bacterial coldwater disease (CWD) is *F. psychrophilum*, formerly known as *Cytophaga psychrophila* and *Flexibacter psychrophilus* (15). This disease can cause significant losses to fish both in freshwater and when moved to the sea. In hatcheries, gill inflammation problems are often associated with poor water quality. In many cases, however, the etiology remains unknown. Although algae and jellyfish toxins also cause damage to the gills, little is known about the importance of such factors. Many fish farming companies report losses associated with gill disease, but official statistics are not available. Weakened fish appear more susceptible to gill inflammation. There are three *Flavobacterium* spp. That are the main pathogens for freshwater hatchery and wild fish populations: *Flavobacterium columnare*, cause of column disease, *Flavobacterium branchiophilum*, cause of bacterial gill disease, and *Flavobacterium psychrophilum* cause of coldwater bacterial disease. Together, the diseases and mortality caused by these pathogens constitute one of the widest host ranges and geographical coverage of all bacterial pathogens for fish. *Flavobacterium* spp. pathogenic to fish are considered ubiquitous in moderately freshwater aquatic environments and occur at water temperatures from just above zero (*F. psychrophilum*) to 30°C and above (*F. columnare*). At least one of these pathogens can affect most, if not all, of freshwater fish species. Other members of the *Flavobacteriaceae* family were associated with fish diseases. For example, *Chryseobacterium piscicola* is an emerging pathogen of *Flavobacteriaceae*, reported from Atlantic salmon (*Salmo salar*) and rainbow trout (*Oncorhynchus mykiss*) (1, 2). Bacterial gill disease, caused by *F. branchiophilum* (6-8), is primarily a disease of young farmed salmonids; is not recognized as a problem in wild fish populations (9-13). In endemic areas, outbreaks of bacterial gill diseases in aquaculture occur regularly and often in combination with increased host stressors. Although bacterial gill disease has been experimentally induced in healthy fish of all ages (14), many workers have noted that this disease usually occurs in combination with certain predisposing factors, such as overcrowding in aquariums, reduced dissolved oxygen, increased levels of ammonia and particulate matter in water (9, 10, 13). Therefore, it has often been shown that alleviating steroids reduces the severity of active epidemics. Mortality can increase rapidly and be high if breeding conditions do not improve or treatment is not applied immediately. Bacterial gill disease is common in spring, which coincides with production cycles in fish hatcheries when they have the largest number of small fish after spawning and before restocking. Experienced employees can accurately diagnose bacterial gill disease by simply knowing the history of previous bacterial gill hatchery disease and observing the characteristic symptoms of diseased fish. Infected fish are usually lethargic, they will be high in the water column and hardly catch the air on the surface, leveling nearby and into the incoming water, all of which are obvious signs of difficulty breathing.

Fungal diseases

Fungi attack fish whose skin, fins or gills have already been damaged as a result of bacterial or parasitic infection or after injury caused by attack by another fish, capture or transport. In most cases, fungal infections can be recognized by the presence of soft, white, grey, or brownish patches on the skin or fins. Saprolegnia causes thrush. Branchiomyces attacks the gills (58-61) (tab. 2):

- ichthyosporidiosis (ichthyophonosis),
- Saprolegniosis, thrush (caused by fungi of the genus *Saprolegnia*).

Saprolegniosis

Saprolegniosis is a white fungus, thrush – a fish disease caused by fungus-like protists of the *Saprolegniaceae* family. Low temperature promotes thrush. Ringworm or thrush attacks various species of fish and is a secondary disease.

Tab. 2. Fungal diseases

Type of disease		Development conditions	Impact of the disease	Causes and symptoms	Medication or treatment used
Trush	*Saprolegnia* and *Achlya*	They develop not only on the outer shells of live fish, but also on dead fish, dying eggs, faeces of aquatic animals and food residues.	Thrush is a disease of roe, hatching and older fish of all species whose external coatings have been damaged by mechanical, chemical (e.g. ammonia from a poorly functioning filter), infectious and invasive. Untreated fish die within a few days due to loss of fluid and body salts (skin invasion), suffocation (gill invasion) and hunger (mouth invasion). It is also believed that saprolegnia produces substances that weaken the immunity of fish.	Hot-water fish grown at high temperatures are particularly sensitive to *Achlya* mushrooms, which can grow at temperatures above 24°C. In contrast, the invasion of fungi of the genus Saprolegnia usually occurs at a temperature of about 15°C.	Non-iodized table salt (in the early stages of the disease), zinc-free malachite green (not recommended for sensitive fish, e.g. husky fish), malachite salt and green, potassium permanganate (in a tank without plants and as long as the water pH is not high), Fulvinex, methylene blue solution and copper sulfate (in a tank without plants and if the water is not soft).
Afanomykozis (epizootic ulcerative syndrome – EUS)	*Aphano-myces invadans*	Afanomycosis causes among Asian fish, mainly in serpentine fish living in flooded, heavily fertilized and well-heated rice fields.	Develops initially in the epidermis and skin.	After some time petechia appear on the fins and skin. Later scales are observed. In the areas of the invasion of the fungus, the skin darkens. Ten days later, flaky hyphae of the mushroom appear. Soon, ulceration occurs at the sites of invasion skin and muscle and eventually penetrates into the body cavity, causing fish to die.	There is no treatment. Despite numerous treatment attempts, the mortality rate of diseased fish is often 100%.

This fungus develops primarily on damaged fish tissues (mechanical damage or bacteria, parasites). In addition, these fungi often deposit on roe seeds. It is caused by fungi from the *Saprolegniaceae* family, of the genera *Saprolegnia*, *Achlya*, *Aphanomyces*, *Thraustothecea*, *Dictyuchus* and *Leptomitus* classified in former taxonomic systems to the class of algae – Phycomycetes, subclass Oomycetes. Thrush is most often caused by the species: *Saprolegnia parasitica* and *Saprolegnia ferax*, *S. delica*, *S. diclina*, *S. mixta*, *S. monoica* and *S. thureti* (58-61).

Species of the genus Achlya are most often found on fish and eggs: *A. debaryana*, *A. polyandra*, *A. flagellata* and *A. prolifera*. Mushroom-like protists only attack wounded fish. Gray-white mycelium is visible in various damaged areas of the skin, on fins, gills, eyeballs and nostrils. Fish are lethargic, inactive, rubbing on objects. In places attacked by thrush, you can see fluff like "dirty cotton". Sometimes their fins stick. It appears especially on the edges of the fins, and from there it extends to the entire body. Then next to the eyes and around open, partially healed wounds. When gills are infected, fish usually die of suffocation. In the further course of the disease, the skin and even meat tissue are destroyed. The corneal surface of the eye may be cloudy and the eye is normal. Only under the microscope you can see individual threads of mold. The hyphae of such a spindle or cylindrical mycelium end in sporangia (zoosporangium), in which zoospores are produced (58-61).

Small flocs or threads of mold also cause clouding of the gills. The disease is not curable if the mycelium covers too large parts of the body. During the whole treatment cycle it is advisable to raise the temperature to 28-30°C. After the treatment, maintain a higher temperature for some time and ensure good oxygenation of the water. These baths should be repeated 2-3 times a week until the mycelium is liquidated.

Diseases caused by fungi Saprolegnia cause fungal nephritis and by *Ichthyophonus hoferi*, *Exophiala* sp., Bladder mycosis. Gill mycosis is registered sporadically, with Saprolegnia spp. Infections being registered in freshwater farming in 2010, including in the brood herd after returning to fresh water. In infection studies, significant variation has been demonstrated between mushroom fungi and stress, as well as mechanical injuries as a condition for the development of the disease. This is especially true for low virulence strains. Identification of low or non-pathogenic strains as a result of disease outbreaks may therefore indicate adverse environmental conditions or other factors that reduce the fish's natural resistance to infection.

Saprolegnia sp. was found in fish eggs and on the skin. Symptoms can be minimized partly by repeated formalin treatment.

Ichthyosporidiosis

Ichthyosporidiosis (fish scale) – a fungal disease of fish caused by the parasitic fungus *Ichthyosporidium hoferi* (*Ichthyophonus hoferi*). Occurs in both fresh and salt waters.

The origins of identifying the disease and the pathogen causing it date back to the early 20th century. In 1905, the parasite was identified in marine fish and was named *Ichthyosporidium gasterophilum*. In 1911 it was classified as a mushroom and was given the name *Ichthyophonus hoferi*. Most often affects internal organs, rarely gills, muscles and skin. The *I. hoferi* mushroom forms an oval or spherical plasmodia 6-20 µm long (young) and up to 110-210 µm in the elderly. It takes various forms as a result of the ability to adapt to various changes taking place in a given environment. The path of infection of fish with this fungus is through the digestive system. The organs attacked by this fungus are most often: liver and kidneys, rarely muscles. This fungus was also found in the spleen, heart, gills, brain, nervous tissue of the eye, gonads and dermis. The cause of infection can also be "live food" such as copepod or Water flea (61).

The first symptoms usually appear after about 14 days from the moment the fish enters the digestive tract of invasive forms. Sick fish in aquarium breeding accumulate in the corners of the aquarium. At first, there may be only dark patches on the skin or darkening of the whole body. Fish are weakened and neutralized. They gradually lose weight, while swimming there are movement and balance disorders. The fish sways or moves "suddenly". If the fungus settles in the orbit, it widens the eye and then destroys it. When attacking the gills, fish may show signs of breathlessness (choking) (61).

During the invasion of the outer shells, there is a characteristic roughness of the scales (caused by the presence of small bumps on the skin), fraying and necrosis of the fins. In the final stage of the disease, the whole body can be overgrown with loose mycelium with protruding spherical cysts. In places where the outer coating is damaged, secondary thrush invasion is sometimes observed. The fins of sick fish are pale with folded or slightly jagged edges.

In aquariums, the treatment of diseased fish is possible with phenoxetol (2-phenoxyethanol). This agent can be given to fish as food or it can be given directly to the aquarium water. It is prepared from a 1% solution of this agent by adding 10-20 cm^3 of this solution per 1 liter of water (for about 5 days). At the same time, fish should be given dry food, soaked in a 1% solution of fenoxetol. A second therapeutic agent with similar effect is para-chloro-fenoxetol. This medicine is administered in an amount of 50 cm^3 of a 1% solution per liter of water.

Diseases caused by protozoa

Velvety disease, oodiniosis: the fish appear to be covered with a yellow-brown layer, as if sprinkled with gold. This disease is caused by oodinium, an organism similar to the one causing fishpox, with the difference that it is also a parasite with some algae characteristics. It can survive in the aquarium for a long time, even if there are no fish in it.

Velvet disease, oodiniosis: fish appear to be covered with a yellow-brown layer, as if sprinkled with gold. This disease is caused by oodinium, an organism similar to that causing fishpox, with the difference that it is a parasite that also has some features of an alga. It can survive in an aquarium for a very long time, even if there are no fish in it. Chilodonellosis: the fish rubs against decorations placed in the aquarium. A milky white residue appears on her skin. The fins stick together visibly. Sometimes, in particularly serious cases, breathing problems occur. These types of symptoms are caused by several types of protozoa. Weak or stressed fish are particularly at risk; Sick animals pose a threat to other aquarium inhabitants.

Ichthyophthirius multifilis

Disease caused by the infection of *Ichthyophthirius multifiliis*. The most common disease in home aquarium. White spot disease is caused by a protozoa called *Ichthyophthirius multifiliis* which the life cycle have three phases because white spot is susceptible to treatment at only one stage of the life cycle. The parasite is embedded in the skin or gills of fish, causing their irritation and the appearance of small white bumps. When the parasite begins to grow, it feeds on red blood cells and skin cells. After a few days, it falls from the fish to the bottom of the aquarium, waiting for the next host to form a cyst that undergoes rapid cell division. After this phase, around 1,000 young, young swimming parasites come out of the cyst and look for a host. If the host is not found within 2 to 3 days, the parasite dies. Once the host is found, the whole cycle begins again. All the transformation phases of the parasite last about 4 weeks at 70°F, or 5 days at 80°F. It is therefore recommended to raise the water in the aquarium to about 80° during the procedure. Typical signs of infection are salt-like spots on the body or fins, breathing problems (parasites attack the gills), clenched fins, loss of appetite, abnormal behavior such as unusual swimming patterns. Proper treatment consists in choosing the appropriate growth phase of this parasite and applying specific measures regarding it, which include hydrochloride or quinine sulfate or malachite green at a dose of 30 mg per liter, and raising the temperature of the aquarium to 80°F which will significantly reduce the time of the free swimming phase of the parasite (25-34).

Trichodinia sp.

They have a round shape with a cilia strip around the perimeter measuring 40-60 microns in diameter rotating. They have a disk with many teeth, which they use to “hook” on the host. Parasites most often attack plaques of infected fish, which causes severe invasions and great difficulty breathing or stationary “hanging” on the surface. Typical signs of infection are lethargy fish and scratching the fins on any suitable object. The fins often close or fold. The body of infected fish shows darker colors than normal. There is an excess of mucus in the gills and on the skin in the form of pale blue spotted sludge, caused by the accumulation of a large amount of microorganisms. A typical treatment involves using a salt bath in a 1% solution of malachite green in an amount of about 30 minutes repeated for several days or in formalin at a concentration of 37-40% for about an hour. You can also apply an add-on acriflawine or methylene blue from 50-100 ppm in a water bath for 2-4 days (45, 52, 61).

Ichthyobodo sp. or *Costia* sp.

Disease caused by infection by *Ichthyobodo* sp. or *Costia* sp. To flagellum consisting of 3-4 flagella. It affects both the skin causing its milky opacity or gray-white opacity, and fish gills. Fish suffering fish show the classic signs of lethargy, clenched fins, friction and flickering. The best treatment for this disease is 0.2 mg copper per liter (0.2 ppm), which should be repeated once every few days if needed. You can also use acriflawine in a 0.2% solution (1 ml per liter). Because acryflawine can sterilize fish and copper can lead to poisoning, water should be gradually changed after healing. A solution of a 3% salt bath and heating the water to 80-83°F for several days is also recommended (17-24).

Chilodonella sp.

Disease caused by *Chilodonella* sp. Infection can cause mass mortality in fish, especially in over-planted ponds and aquariums. Protozoa are the most dangerous of all known microorganisms of this type. It has a diameter of 40 to 60 microns. It causes clouding of the skin, creating a milky white precipitate, especially between the head and the dorsal fin. He attacks the gills to destroy them completely. Affected by sick fish can show classic signs of flickering and friction with decorations in the aquarium, the fins stick clearly. Recommended treatments are salt baths in 3% malachite green, formalin and potassium permanganate (16, 60-61).

Legal acts concerning the examination of fish scales and pathogenic microorganisms living on them

Assessing the risk and likelihood of iridoviruses in aquatic ecosystems is essential to planning for an outbreak. European scientists developed methods for diagnosing this phenomenon and proposed measures to ensure safety.

Iridoviruses get their name from the iridescence-like effect they cause in heavily infected insects. Although their primary hosts are invertebrates, fish species can also be infected by iridoviruses. As very little is known about the pathogenesis of iridoviruses in fish, the EU-funded RANA initiative aimed to assess the risk of systemic iridovirus infection in farmed and wild freshwater fish and amphibians in the EU. To answer this question, the project team conducted a series of experimental trial infections on a number of important European freshwater farmed and wild fish species as well as wild amphibians. Immunological diagnostic methods have been developed to facilitate the characterization of pathology and pathogenesis for each of the susceptible species and to enable rapid diagnosis in the event of a future outbreak in the European Union. Molecular methods have also been developed to distinguish highly pathogenic viruses from weaker viral isolates. By applying epidemiological principles, the project team was able to develop a risk assessment model to assess the impact of viruses and potential transmission pathways. Moreover, it was analyzed to what extent trade in marine pets for pet farming could be responsible for the introduction and spread of the disease. While further work is needed to finally validate the risk assessment data, the RANA project has made recommendations for future actions needed to prevent the emergence and spread of serious iridovirus diseases in the EU.

Any intensification of breeding can have an unmistakable impact on the health conditions of fish during this process, which is an important component evidence of the welfare of these aquatic animals. Hence the need for guidance and document good veterinary practice in the field of health protection and veterinary supervision over the conditions of fish farming and farming. Goal the primary objective of this action is to ensure the safety of food fish. This problem concerns not only fish and fish products, but also, and perhaps especially, mammals and poultry. It proves no only the production volume of these animals, but also the data contained in the most recent published report by the European Food Safety Authority (EFSA) on zoonoses occurring in the EU in 2011 (Osek, Wieczorek, 2013), which shows that the most frequently reported diseases were: pylobacteriosis (231,391 cases) and salmonellosis (98,183 cases). Next in order were poisonings against the background of verotoxic *E. coli* strains (9,485 cases), yersiniosis (7,128 cases), listeriosis (1,545 cases), echinococcosis (789 cases), brucellosis (362 cases) and trichinosis (268 cases) falls. There are several other very dangerous diseases on the list like *M. bowis* tuberculosis, toxoplasmosis and rabies in much smaller numbers cases. However, no disease is mentioned in this report found in freshwater fish.

Food safety issues have been, are and undoubtedly always have been will be a very important and still up-to-date element of supervision over and processing carried out by the relevant veterinary services in every country. In recent years, they have become particularly large importance for fish due to the significant increase in size production of these aquatic animals as well as in our country, as well as in other European Union countries, updating the regulations in the field health requirements for aquaculture animals and products and the prevention and control of these diseases – which results from necessity adjustment of activities and legal regulations in this field to the requirements of veterinarians of the European Union, which are included in Directives 91/493 EEC, 93/54 EEC, 95/22 EEC, 97/79 EEC, 98/45 EEC, 2006/88/EC and others. These nudes together with the subsequent regulations and decisions of the EU Commission (Commission Regulation, 2008; Commission Decision, 2008) comprehensively regulate health requirements for aquaculture animals (including fish) and aquaculture and the prevention of certain diseases in aquatic animals and combating these diseases.

It should be noted that they include both veterinary requirements for the production (breeding and breeding) of fish, such as and conditions for placing these animals on the market as stocking material surface waters or other breeding ponds, raw material for processing or their direct consumption. Poland, like every country acceding to the European Union, was obliged to adopt the entire acquis of the Union. This, of course, applies to legal regulations in the field of fish health protection and conditions for fish farming which undoubtedly have a significant impact on their well-being and quality and health safety of fish intended for consumption, their creation and trade (Bykowski, Lorek, 2004; Rudy, 2006; Żelazny, 2006). Therefore, in 2008, the act was amended on the protection of animal health and combating infectious animal diseases (Act, 2004; Act, 2008) in accordance with the recommendation of the Council Directive (2006). A number of regulations of the Minister of Agriculture and Development were also issued.

Refers to this is especially the veterinary requirements for business in the field of aquaculture (regulation, 2008b), the method of determining veto- identification number (Regulation, 2008a), over-veterinary supervision over fish farming and farming (Regulation 2008a and 2009), a method of combating infectious, particularly dangerous animal diseases aquaculture government (regulation, 2009) and other related issues with this type of economic activity. Legislation defining health conditions, determining placement on the market of fish and fish products from the so-called water cultures, further specify still other actions and necessary documents, viz the nature and circumstances of inspections by veterinary experts Community regulations, model transport documents for live fish, their pro-reproductive ducts and how fish health is monitored by the Veterinary Inspection (Council Directive 2006; Act, 2004; Act, 2008).

Conclusions

The apparently unique sensitivity of tropical fish can be remedied. With appropriate and healthy living conditions, the fish's body defends itself more easily against diseases. Pathogens develop when fish do not have appropriate living conditions. Weakened or stressed (e.g. due to transport) they become less resistant. When a fish is sick, you should consider the reasons why it does not feel well in the aquarium and improve its living conditions by introducing appropriate changes to the environment. Sick fish can be treated. The ideal solution is to isolate sick individuals from others in an aquarium specially prepared for this purpose ("water hospital").

Pathogens develop when fish do not have adequate living conditions. The seemingly exceptional sensitivity of tropical fish to diseases induced by pathogenic microorganisms can be cured by providing adequate nutrition and breeding. Weakened or stressed fish become less resistant.

The ideal solution to cure fish is to isolate sick individuals from healthy individuals in a specially prepared aquarium ("water hospital").

Man working in the aquatic environment may be subject to infections caused by microorganisms derived from fish in the form of specific or non-specific zoonoses.

Conflict of interest
Konflikt interesów

None
Brak konfliktu interesów

Correspondence
Adres do korespondencji

*Paweł Kowalczyk
Instytut Fizjologii i Żywienia Zwierząt
im. Jana Kielanowskiego
Polskiej Akademii Nauk
ul. Instytucka 3, 05-110 Jabłonna
p.kowalczyk@ifzz.pl

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submitted/nadesłano:
9.01.2023
accepted/zaakceptowano do druku:
30.01.2023