Diversity and Distribution of Sturgeon Parasites

Subjects: Biology

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Sturgeon species have inhabited the world's seas and rivers for more than 200 million years and hold significant taxonomic significance, representing a strong conservation interest in aquatic biodiversity as well as in the economic sector, as their meat and eggs (caviar) are highly valuable goods. Currently, sturgeon products and byproducts can be legally obtained from aquaculture as a sustainable source. Intensive farming practices are accompanied by parasitic infestations, while several groups of parasites have a significant impact on both wild and farmed sturgeons.

Keywords: sturgeons ; parasites ; pathology ; statistical distribution ; freshwater

1. Introduction

Sturgeons are members of the *Acipenseriformes* order, which is over 200 million years old and comprises twenty-seven species and two families, the *Acipenseridae* and *Poyodontidae* [1]. The species has a long life cycle and is native to the Northern Hemisphere [2][3]. The natural habitats of sturgeons are the freshwaters of Europe, Asia and North America. The species inhabit inland water, bays, estuaries, and the coastal regions of seas and oceans. Although most sturgeon species migrate and spawn in freshwater, they also spend a significant amount of their life cycle in brackish water. The Caspian basin accounted for up to 90% of caught sturgeon, but as many fisheries have collapsed, many individual species or populations are now endangered. Two such examples are the *Huso* and *Acipenser* genera, with a total of 17 species [4], the most well-known of which are *Acipenser ruthenus*, *Acipenser stellatus*, *Acipenser gueldenstaedti*, *Acipenser oxyrhynchus*, *Huso huso*, *Acipenser persicus*, *Acipenser sturio*, and *Acipenser naccarii*. Sturgeon species differ significantly from other fish species not solely because of their anatomy, but also because of their longevity and behavior. The Danube is a well-known habitat for sturgeon populations, although in recent years only four species were found [5] out of the six previously known [6]. Such decreases in sturgeon populations are mainly due to dams, pollution, and overfishing [7][8]. With the effective wild population decreasing, the sturgeon parasitic infestations are becoming more important and, like in many other fish species, they are becoming more prominent as aquaculture is expanding [9].

Sturgeons are host to many parasites, such as protozoans, trematodes, nematodes, monogeneans, helminths, and argulidaes [10]. These parasites are among the most significant factors responsible for weight loss, impotence, strange behaviour, deformed gills, and epithelial lesions [11], ultimately resulting in the diminishing of wild stocks or in financial losses in the case of fish farming. In addition, external parasites have the potential to spread bacteria, viruses, and other pathogens, resulting in a boost of secondary fungal, bacterial, and viral infections [12][13]. Sturgeons are susceptible to viral, parasitic, and bacterial infections, fungal infections being generally rare [14]. Parasites and parasite communities are important environmental quality bioindicators because they are part of the aquatic biodiversity and are influenced by it, either directly or indirectly, through their hosts, despite the fact that they are frequently ignored as a biological component for ecological assessment [15]. Therefore, environmental monitoring programs are more effective when parasites and parasitic fish communities are also regarded [16].

Protozoan parasites are a diverse group of single-celled organisms that can reside either inside or on the surface of their host. They do not always cause disease in fish, but they may be present in a subclinical or carrier state [17][18]. Certain species of ciliate protozoa are known to consume bacteria and other microorganisms that may cause infections in fish. By controlling the population of potentially harmful microorganisms, these protozoa may contribute to supporting fish health. On the other hand, some protozoa can be harmful to sturgeon, causing disease and other health problems, for example, *Ichthyophthirius multifiliis*, which can infect sturgeon as well as other fish, causing the white spot disease that causes the skin and gills of these species to be susceptible to other parasites during different stages of rearing, thereby severely affecting their normal growth and development [12]. Due to their varied life cycles, which include time spent in freshwater, brackish water, and marine water, sturgeon in the wild are more disease-resistant than other fish species [19] but still subject to parasitic infestation.

2. Sturgeons and Parasites

2.1. Protozoa, Monogenea and Crustaceans

Protozoa comprise a diverse group of predominantly single-celled eukaryotic organisms [20]. Depending on their species, protozoa can be either ectoparasites or endoparasites. Among cultured fish, ectoparasitic protozoa are the most commonly encountered parasites [21]. These parasites induce a reactive hyperplasia of the fish epithelium, and excessive mucus infestation can lead to gill hyperplasia, including epithelial hyperplasia of the entire gill filament, inflammation, hemorrhage, and necrosis [22]. Protozoa pose a significant threat to fish health, causing diseases in both farmed and wild populations [23]. Within fish populations, parasitic protozoa can rapidly spread, particularly those with direct life cycles and broad host specificity [24]. Some protozoa act as ectoparasites, residing on the skin, fins, and gills, while others invade internal organs, such as the intestine [25]. Parasite invasion can impede fish development, cause weight loss, and disrupt reproductive processes. In severe cases, infections can lead to long-term mortality and substantial damage to fish populations [26].

In a study conducted by Vasile et al. (2019) [27], the protozoan parasite *Ichthyophthirius multifiliis* was identified in *Acipenser stellatus* at a research hatchery in Romania. *Ichthyophthirius multifiliis* is a parasitic ciliate that was initially described by the French parasitologist Fouquet in 1876. This parasite has the ability to infect a wide range of freshwater fish species, including sturgeon. Upon infecting sturgeon, the parasite attaches itself to the skin and gills, where it feeds on bodily fluids, resulting in the formation of visible white spots on the outer layer of the fish, commonly referred to as “white spot disease”.

Ichthyophthirius multifiliis can cause significant harm to the fish, including irritation, inflammation, tissue damage, reduced growth, weakened immune function, and even death [28][29]. The disease caused by this tissue-feeding parasite is referred to as ichthyophthiriasis [30].

The parasite possesses cilia arrangements on its body, which include a distinctive ring of denticles, morphological features that are crucial for species identification. Additionally, this parasite is classified as an ectoparasite that exhibits rapid movement on the gills, fins, and body surface of its host (in certain species, it can even inhabit the urinary tract). The *Trichodinidae* family, to which this parasite belongs, is known to cause trichodinosis [31] (also known as trichodinads), characterized by hyperplasia of the epithelium [32].

Apiosoma sp. parasites are not typically considered highly dangerous, but they can still inflict damage on sturgeons by attaching to their fins, gills, or skin surface, which leads to the destruction of the epithelial tissue and impairment of organ function. These ciliates are ectocommensals, living on the gills and body surface of aquatic organisms, particularly the fry of freshwater fish [33]. They are large, bell-shaped organisms measuring approximately 50–70 µm in length and 18–40 µm in width. The species have a free-living lifestyle but frequently attach themselves to various organisms in the water, including fish [31]. When sturgeons become infected with *Trichodina* sp. and *Apiosoma* sp., mucus accumulates on the skin surface, especially around the pectoral fin, gills, and gastrointestinal tract, as well as the oviduct and urinary bladder [30].

In aquaculture-related studies conducted in Romania, a total of 22 species of *Gyrodactylus* sp. within the monogenea group have been identified [34]. However, it should be noted that some sources report 145 species for the *Gyrodactylus* genus [35], while others mention up to 400 species [36]. The exact number remains uncertain due to synonyms and variations in taxonomic interpretation [36]. *Gyrodactylus* sp. is an ectoparasitic flatworm with a length of less than 1 mm and a body width of approximately 0.1 mm. It is characterized by a four-lobed head and an opisthaptor, which includes one prominent pair of large hooks and up to 12 smaller hooks. Infections caused by *Gyrodactylus* sp. can result in skin irritation and tissue damage.

The copepod crustacea *Ergasilus sieboldi*, commonly known as “fish lice” [37], has been reported to infect sturgeons [38]. This parasite can have detrimental effects on the gills, as it attaches to the skin or gills and can cause physical damage, potentially leading to suffocation. Pazooki and Msoumian (2018) [39] identified the protozoa *Haemogregarina acipenseris* and *Cryptobia acipenseris* in *Acipenser persicus* and *Acipenser guldenstadti* in the southern part of the Caspian Sea. *Haemogregarina acipenseris* has an oval body shape, measuring 6.5–8.2 × 2.2–3.0 µm, with two rounded ends or one rounded and one sharpened end. The nucleus typically consists of a few chromatin granules, and it is commonly found in erythrocytes. *Haemogregarina acipenseris* has been previously recorded in sturgeons in the Caspian and Black seas, and it has been found in sterlet in the Volga and Danube rivers [40]. *Cryptobia acipenseris* is a parasitic protozoan measuring 11–16.4 µm in size [41]. The vegetative and sexual stages of this protozoan have been found in the blood of various sturgeon species [39]. While the majority of *Cryptobia acipenseris* live in the host’s blood, some can also be found in the

intestines and gills. Infections caused by *Haemogregarina acipenseris* and *Cryptobia acipenseris* can lead to severe consequences, including anemia and, finally, death [42].

2.2. Cestode, Trematode and Nematode

Fish-borne cestodes that can infect humans primarily belong to the order *Diphyllobothriidea* and are commonly referred to as broad tapeworms. These tapeworms have a three-host life cycle, with teleost fishes (excluding spirometra) serving as the second intermediate hosts and a source of human infection [43]. The larval form of the cestode penetrates the tissue of a crustacean host and undergoes metamorphosis into a proceroid. The fish becomes infected by consuming the crustacean. Once inside the fish, the adult cestodes gradually migrate to body organs and intestines, causing diseases and reducing the fish's lifespan [44].

The trematode *Diplostomum spathaceum* is responsible for a disease called diplostomatosis, or eye fluke disease [45]. This parasite has been found to be widespread among fish in Utah [46]. *Diplostomum spathaceum* has a complex life cycle involving multiple hosts and can cause significant harm. It attaches to the eye tissue of the fish and feeds on blood, leading to inflammation, swelling, and the formation of dark spots on the eye's surface [47]. Choudhury (2009) [48] identified the trematoda *Pristicola bruchi* in *Acipenser fulvescens* in Wisconsin, USA. *Pristicola bruchi* is smaller in size (ranging from 1.660 to 2.110 µm) than *Pristicola sturionis*. It possesses a single row of prominent peg-like oral spines instead of two rows, and its vitelline follicles dorsally converge over a small region without extending beyond the posterior testes. This is the first recorded occurrence of this genus in North America and appears to be the first report of the genus in sturgeon since the description of *Pristicola sturionis* in 1930 [49].

Nematodes and trematodes were identified in sturgeon by Sattari et al. (2006) in *Acipenser Persicus* (Persian sturgeon) in the southwest of the Caspian Sea, off the Guilan province of Iran [50]. The nematodes *Cucullanus sphaerocephalus*, *Eustrongylides excisus*, and *Anisakis* sp. were identified, along with the trematodes *Skrjabinopsolus semiarmatus* and *Skrjabinopsolus nudidorsalis* [51] in *Acipenser ruthenus*, and the monogean trematodes *Diclybothrium armatum* and *Nitzschia storionis*. Of particular zoonotic significance was *Anisakis* sp., a parasite capable of infecting humans and causing anisakidosis [52].

2.3. Copepods

Small crustaceans called copepods are commonly found in freshwater and marine habitats [53]. The calanoid copepod is the most common form of copepod found in sturgeon fish. It is a tiny planktonic creature that is an important food source for many fish species, including sturgeon. Cyclopoid copepods, Harpacticoid copepods, and Poecilostomatoid are other copepod species that can be found in sturgeon fish. In addition, copepod parasites have been shown to affect the physiological health of the sturgeon and cause anemia. In particular, these ectoparasites can reduce host osmotic competence both directly by damaging and necrosing the epithelium and indirectly by increasing host stress hormone levels [54].

Ergasilus sieboldi, *Paraergasilus rylovi*, *Lernaea cyprinacea*, *L. elegans*, *Caligus lacustris* and *Argulus foliaceus* are also copepods that occur on different fishes and are well known to be pathogenic to fishes in aquaculture. Three species are specific to sturgeons, but only one of them, *Pseudotracheliastes stellatus*, is pathogenic. A rather high infection of *A. stellatus* and *A. gueldenstaedtii* by *Pseudotracheliastes stellatus* was noted in the Azov sea. Infection by these species results in quantitative and qualitative changes in white and red blood cells, as diseased fish present anemia [55].

2.4. Hirudinea and Polypodiozoa

The Hirudinea *Caspiobdella fadejewi* was identified in wild *Acipenser oxyrinchus* specimens in the Drwêca river, Poland, by Bielecki et al. (2011) [56]. *Caspiobdella fadejewi* can cause physical harm to fish, particularly sturgeon. These leeches attach themselves to the skin of sturgeons and feed on their blood, which can lead to irritation, inflammation, and tissue damage. In severe cases, a large number of leeches can weaken the fish, making it more vulnerable to other predators or diseases.

Raikova (2002) [57] identified the polypodiozoa *Polypodium hydriforme* in *Acipenseriformes* in the Volga river as well. This is the only cnidarian species adapted to intracellular parasitism in fish oocytes. It is a diploblastic animal that possesses stinging cells known as cnidocytes, with a life cycle that consists of two stages: a parasitic stage and a free-living phase. The parasitic stage occurs within host oocytes throughout oogenesis, starting from early previtellogenesis until the hatching stage. The parasite reproduces through longitudinal fission, with the number of tentacles doubling before each

division [58]. *Polypodium hydriforme* can affect the reproductive health of the sturgeon in particular, with the infected female sturgeon experiencing reduced egg production and poor egg quality [59][60].

2.5. Hyperoartia

Hyperoartia, commonly known as lampreys, are parasitic jawless fish that feed by attaching themselves to the body of fish and sucking their blood and body fluids [61]. When lampreys attach themselves to sturgeons, they create open wounds that can become infected and weaken the fish. This makes the fish more susceptible to predation and disease and can also impair their ability to swim and reproduce. Lampreys can also compete with sturgeons for food and habitat, further contributing to population reduction [62].

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