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Review

Study of parasites and diseases of sturgeons in Russia: a review

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Russia has been known since ancient times for its rich aquatic natural resources, including the sturgeon species inhabiting many of its rivers, lakes and inland seas. Examples of the remaining richness of the fish fauna are represented in Russia by two genera of sturgeons *(Huso* and *Acipenser)* with a total of 11 species (Sokolov, 2002) as well as three species of the genus *Pseudoscaphirhynchus* in the Aral Sea basin (Kazakhstan) (Berg. 1948). One American species, *Polyodon spathula,* was introduced into Russia for aquaculture purposes (Sokolov, 2002). All sturgeon species differ in their ecology from many other native fish species not only because of their anadromy but also because of their longevity and life styles.

During the past century species abundance of this valuable resource diminished at an alarming rate caused by overfishing, lack of management control, habitat alterations (e.g. hydrodam construction) and other human impacts such as industrial and domestic pollution. While yearly catches reached about 10 000 tonnes in the 1960s, the decline in the early 1990s resulted in a catch of no more than about 6500 tonnes. This downward trend has continued in recent years (Luk'yanenko et al., 1999).

Because of this decline, aquaculture for ranching purposes was introduced in Russia during the second half of the twentieth century. It is obvious that this development was also accompanied by disease outbreaks, including those unknown prior to cultivation. Unfortunately, the documentation and study of prevailing diseases in sturgeons had not received much attention in the past and. therefore, our understanding of their prevalence, distribution, origin and ecological significance is fairly limited. It is therefore appropriate that intergovernmental organizations (e.g. FAO) and scientific societies (e.g. EAFP, European Association of Fish Pathologists) are urging that greater attention be given to disease problems (La Patra et al., 1999).

This paper provides a brief overview of the status of knowledge on parasites and diseases in sturgeons in Russia and the former USSR, their occurrence and distribution. Although many Russian scientists have worked on and arc currently studying the disease issue, knowledge is fragmentary. This contribution is also an attempt to identify gaps and research needs in this area, particularly in Russia. One of the obvious gaps in Russian sturgeon disease research and management programmes is the lack of a sound design for a nation-wide electronic databank that could serve as a tool to monitor and analyse causes and trends in disease occurrences and overall epidemiology.

Parasites and parasitic diseases occurring in natural sturgeon populations in Russia

By area. Russia is one of the world's largest countries. During the second half of the nineteenth and in the early twentieth century, research was supported in many basic natural science disciplines, with numerous expeditions to collect and document fauna and flora in many parts of Russia. A wealth of material was collected as can be witnessed in the various zoological collections, including the 'Kunstkammer' and the 'Zoological Museum' in Saint Petersburg. Several prominent biologists from outside of Russia participated in this early work at the invitation of the Russian Academy of Sciences. Two of these scientists, P. S. Pallas (1741-1811) and I. T. Koelreuther (1733-1806), contributed extensively to the current knowledge of parasitology. particularly that of helminthology. The brief report published in 1781 by Pallas, 'Bemerkungen ueber die Bandwurmer in Menschen und Tieren" ('Remarks on Tapeworms in Humans and Animals') contained a first description of a number of new species of cestodes; among them were *Caryophyllaeus laticeps, Cyathocephalus truncata, Triaenophorus nodulosus, Fimbriaria fasciolaris,* all species for which the taxonomy is still valid. One species identified as *Macracanthorhynchus hirudinaceus* was later reassessed as belonging to the acanthocephala. The calendar of 1781 contains first contributions in Russian with support of the Academy of Sciences entitled, 'On the Best Ways for Liberation from Helminths'. This article well-illustrated in great detail the information on three species of human tapeworms and samples of these were also prepared by Pallas. This in-depth interest in helminthology was typical of Pallas already during his formative years as a scientist whereby his 1760 dissertation was dedicated specifically to this field of science. The well-known 'father of helminthology', K. Rudolphi (1771-1832), described himself as a student of Pallas, highly valuing his work on parasitic worms. Koelreuther (1771), while working in Russia, was the first to determine the specific organization of acanthocephalans while also creating the generic name *Acanthocephulus.* Pallas (1775) authoritatively adopted this discovery and recognized the new genus also in another host species *(Rana temporaria).* Thus, research on parasitic worms in Russia was initiated by the early work and publications of Pallas and Koelreuther.

Data on the occurrence of parasites in sturgeons within Russian water bodies as well as in waters of adjacent countries have been gathered since the beginning of the nineteenth century. There has never been a systematic approach to these studies to identify patterns of change caused by environmental

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changes, introduction of species, riverine and reservoir construction and culture management schemes. Historically, scientists were initially looking more for ectoparasites such as crustaceans and larger endoparasites such as parasitic worms, mainly because of ease of detection and quantitative observation. The first reviews on parasites in sturgeons were published by Dogiel (1945) and later by Schulman (1954). The first detailed book on parasitic worms in sturgeons was published by Skrjabina (1974). By the nineteenth century, 15 species were recognized as specific to the family Acipenseridae; this list has since been expanded to a total of 27 species. There are a number of pioneering scientists who have contributed to the current knowledge of parasites in sturgeons, among them are Rudolphi (1809, 1819), Dujardin (1845), van Beneden (1871) and several Russian colleagues including Grimm (1870, 1871, 1875).

In this contribution the attempt is to provide an overview on the life cycles, distribution and epizootology of specific and most important parasites, mainly representatives of Protozoa. Coelenterata, Vermes and Crustaceans. The information provided on morphological aspects and distribution will be limited and refers mainly to the pertinent literature on the subject published in three volumes of the book, 'The Key to Parasites of Freshwater Fish of Fish of the USSR Fauna", edited by Bauer (1984. 1985, 1987).

Protozoa

This systematic group contributes mainly to the blood parasites (principally Kinetoplastida) which are found rather frequently in most sturgeons. Four species are specific to sturgeons: (i) *Trypanosoma anura* Winitschenko 1971 has been described in the blood of *Acipenser schrenckii* of the Amur River, (ii) two species of *Cryptobia* have been checked for their occurence in different Asipenseridae; of these, *C. acipenseris* (Joff, Lewashow, Boschenko 1926), has been reported to occur within the watersheds of the Don, Volga and Yenisei rivers, namely in *Huso huso, A. gueldenstaedtii, A. stellatus. A. nudiventris* and *A. ruthenus.* Most frequently affected by this parasite was *A. ruthenus;* (iii) *C. pseudoscaphirhynchi* (Ostroumow 1949) has been found in the blood of *Pseudoscaphirhynchus kaufmanni* of the River Amudaria (draining into the basin of the Aral Sea) with prevalences of about 50% (Osmanov, 1971). No data are available on the pathology of these infections and nothing has ever been published in this regard. According to available literature, sturgeons of North America are infected by only one species of protozoa, the *C. salmositica* Ratz 1951, found in the blood of *A. transmontanus* (see Hoffmann, 1998). This parasite is widely distributed in the freshwater fishes of North America and hence cannot be considered as specific for Acipenseridae.

A microsporidean *Pleistophora sulci* (Rashin, 1949) parasite in eggs of *A. ruthenus. A. gueldenstaedtii* and *A. baerii* was described for the first time in the Danube River (Czech Republic) from *A. ruthenus* (prevalence about 50%) (Rashin. 1949) and afterwards in the basins of the Volga River [10% prevalence, seven to 10 infected eggs per fish from the Volgograd reservoir (data from Ivanov, 1966)], the Kura River (in the Caucasus) (Schulman, 1954) and Ob River (Skripchenko et al., 1971). Immature fish *(A. baerii)* were infected (prevalence of 37.5%) with an average intensity of 23 eggs per sample. Whereas only 3% of the eggs were infected, the infection rate increased with the advancing age of the fish, reaching 100% in adults (Skripchenko et al., 1971). Infected eggs are white and rather large in comparison to healthy (uninfected) eggs. Pansporoblasts with mature spores are found in the centre of the infected eggs, while outside the centre of infected eggs are young spores. Pathogenicity of the parasite is not high, as in all described cases only a small percent of eggs were infected. Lorn and Dykova (1992) consider this parasite species to be within the collective group *Microsporidium* Balbiani 1884 (this group seems to be a depository for species with uncertain generic position). One unidentified microsporidean of the genus *Glugea* was found in the intestine, kidney and swimbladder of *A. baerii* from the Selenga River (Baikal Lake basin) (Pronin, 1977).

A sporozoan *Haemogregarina acipenseris* Nawrozky 1914. has been reported to infect the erythrocytes of *A. ruthenus* (Volga River). In most cases only one and rarely two parasites were noted in each of the blood cells of the infected fish. All of these sporozoan species are in need of further investigation of their morphology and life cycles as well as their ecological and economic consequences. The lack of sound morphological data useful for systematic species allocation still forces parasitologists to place several of these species into the category of 'dubious" (Lom and Dykova. 1992). One unidentified sporozoan of the genera *Eimeria* was found in the intestine wall of *A. baerii* of the Selenga River (Baikal Lake basin) (Pronin, 1977); little is known about the effect of this parasite on the physiology of the fish.

Infections with *Cnidosporidia* (= *Myxozoa),* which are found in acipenserids during both their freshwater and sea water phase, have been noted as being extremely rare. Only one species of this group has been described *(Zschokkella sturionis* Tripathi 1948). It was found in *A. sturio,* caught in the Channel La Manch. This parasite was also later found in the gall bladders of *A. gueldenstaedtii, A. stellatus* and *A. ruthenus* caught in the Azov and Caspian seas as well as the rivers Don and Volga. Data on its pathogenicity, however, are not available.

One species of flagellates (Polymastigota) *Hexamita truttae* was found in the gall bladders of *A. ruthenus* from the Ob River, as well as in *A. gueldenstaedtii, A. stellatus, A. ruthenus* and *H. huso* from the Volga River and the Caspian Sea. Prevalence varied from 3.4 to 12.1%) (Izumova, 1977).

Many species of ciliates were found on all sturgeons and their various hybrids, especially on young fish. These are representatives of the family *Epistylididae (Apiosoma)* and *Trichodinidae (Trichodina, Trichodinella, Paratrichodina, Tripartiella, Dipartiella)* which do not demonstrate strict specificity to the fish hosts. One species. *P. uralensis* Kaschkovsky and Lom 1979, was found once and described from *A. ruthenus* in the River Ob. Single specimens of *Ichthyophthirius multifiliis* were detected on *A. ruthenus* from the Volga River (Lubarskaya and Levrent'eva. 1985). Some ciliate species are well known as pathogenic for different fishes.

Coelenterata (Cnidaria)

There is only one representative of this group found in sturgeons, the *Polypodium hydriforme,* which infects eggs of acipenseriform fishes in Eurasia and North America. It was first described in 1870 by Owsjannikow (1871) and was recognized inside the eggs of the Volga sterlet, *A. ruthenus.* To date, *P. hydriforme* has been found in 12 species of the family *Acipenseridae* and in one species of the *Polyodontidae* of the Old and New World (Raikova, 1994). It was not found on

A. baerii from East Siberia (Pugachev, 1984). Long-term studies in Russia undertaken by Raikova have provided information on the morphological features, developmental stages and general biology and life style of this parasite. A review by Raikova (2002) on *P. hydriforme* and polypodiosis is presented in this volume, and the reader is referred to this publication for details.

Helminths

Parasitic worms infecting sturgeons are rather diverse. They are represented by all classes of helminths, clearly demonstrated in the aforementioned Skrjabina (1974) publication. Unfortunately this work has never been translated into English; thus, extensive use thereof is made in this review. Specific helminths and those which occur occasionally in sturgeons are described in detail according to their systematic category.

Monogenea. Only three specific species of Monogenea infecting sturgeons are known in Russia and adjacent countries; a total of some 10 species is known world-wide. Of all the Monogenea worms, the genus *Nitzschia* Baer 1875 (family Capsalidae Baird 1853) is one of the best known. One species is *Nitzschia sturionis* Abildgaard 1794, which infects the gills of all sturgeons in Europe. Two other species *N. monticelli* Price 1939 from *A. sturio* in the Mediterranean and *N. superba* MacCallum 1924 from gills of sturgeons of North America are considered by Schulman (1954) and Bychowsky (1957) to be synonyms of *N. sturionis,* whereas Hoffman (1998) does not agree with this conclusion for N. *superba.*

Nitzschia sturionis is a rather large parasite, attaining a length of about 10 mm (Fig. la). Its distribution is rather broad in sturgeons occurring in both sea and brackish water systems. However, it perishes quickly in fresh waters where its hosts migrate for spawning and can therefore only be found during the early phase of the upstream migration. The parasite is often found on gills and palate of sturgeons of the Black, Azov and Caspian seas (Fig. 1b and c), but was absent on sturgeons of the Aral Sea (Dogiel and Bychowsky, 1934), including *A. nudiventris,* which is the only natural representative of Acipenseridae in the Aral Sea. In 1935-1936 a tragic event caused significant mortality of this sturgeon species; a quick population decline resulted (Dogiel and Lutta, 1937; Lutta 1937, 1941). Witnesses of this mortality reported that large, diseased fish jumped on to the beaches and perished. An investigation led to the discovery that in the year prior to this specific incident (in 1934), about 90 specimens of mature Caspian Sea *A. stellatus* had been transferred to the Aral Sea in an attempt to acclimate the species there. No prophylactic measures had been employed to prevent disease transfer although *N. sturionis* was known to be a common parasite of the species. It is therefore obvious that the parasite was

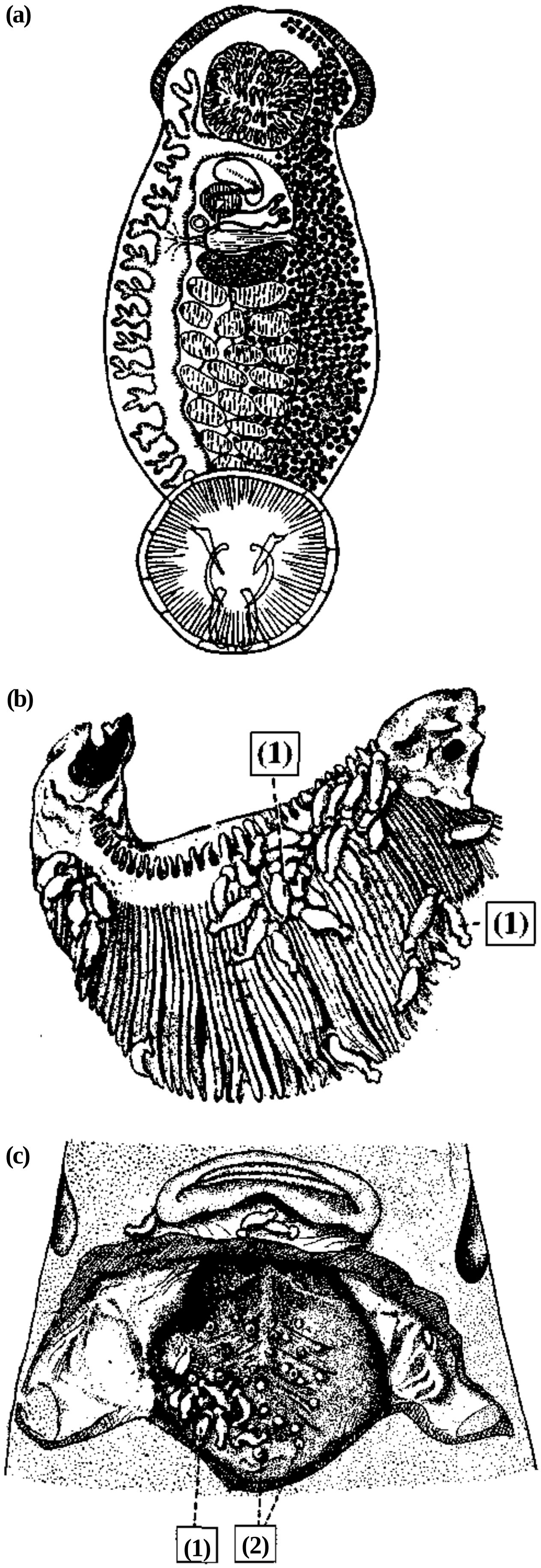

Fig. 1. *Nitzschia sturionis* (Abildgaard 1794): classical drawing of the habitus and anatomical features (a) after Bychowsky, following Lutta, 1937; (b) infestation of the gills of *Acipenser nudiventris* with *Nitzschia,* showing the clustering of this parasite along the base of the gill arch (1) with some specimens occurring near the apical ends of the gill lamellae (after Lutta, 1941). (c) Ventral view of the preferred locations of *N. sturionis* (1) along the dorsal end of the palate towards the oesophagus of *Acipenser nudiventris* and typical attack marks (2) (after Lutta, 1941)

introduced along with *A. stellatus* to the Aral Sea, severely infecting the local population of *A. nudiventris* because the native fish exhibited no immunity against this parasite. Because of this lack of immunity, the parasite population increased extremely rapidly, with the reported devastating effect. Lutta (1937) stated that 100-300 and sometimes even up to 600 specimens of *N. sturionis* were found on one single sturgeon specimen. They infested not only the gills but also the entire mouth cavity. It has been stated that if the infestation level reaches about 300-400 specimens per fish, that these parasites are capable of consuming about 150-200 cm^3 of fish blood in 1 day. Histological studies of infected gills have shown destruction of gill lamellae, with hyperplasia of primary lamellae and other changes in the gill tissues (Lutta, 1941).

The long-term dynamic of infection rate is shown in Fig. 2. The mortality of *A. nudiventris* was also observed in 1970 with a maximum number of 80 worms on one fish (Osmanov, 1975). Osmanov (1952) supposed that *N. sturionis* was on gills of *A, nudiventris* before its appearance on *A. stellatus* in the year 1934, and therefore assumed that the 1936 epizootic outbreak was partly enhanced by a periodic process connected to changes in hydrological conditions rather than to the transfer of infested fish alone. However, because of this parasite being a marine species, it could not have historically survived in the Aral Sea. Already 4000 years ago the sea was a large freshwater lake; about 1600 years ago it was a hyperhalinic waterbody with a salinity from 36 to 100 mg L⁻'. All salts dissolved in the water were of riverine origin as a result of high evaporation rates of river water (Aladin, 2000). These data support the idea of Dogiel and Lutta (1937) as well as the seawater aquaria trials which found high infection rates of Acipenserids in seawater. Some years ago, Gaevskaya and Tkachuk (1992) provided data on the infection of *H. huso* and *A. gueldenstaedtii* in the Sevastopol aquaria (Crimea, Ukraine), reporting that 532 specimens of *N. sturionis* had been detected on one deceased specimen of *H. huso.*

The second most representative group of the Monogenea found on the gills of sturgeons includes the species belonging to the family Diclybothriidae (Bychowsky et Gussew 1950). These species differ physiologically from those of the genus *Nitzschia* as they inhabit species occurring in freshwater bodies or, at the most, brackish estuaries. *Diclybothrium armatum* Leuckart 1835, is widely distributed among all sturgeons of Europe and Asia from western European rivers up to the rivers of Kolyma

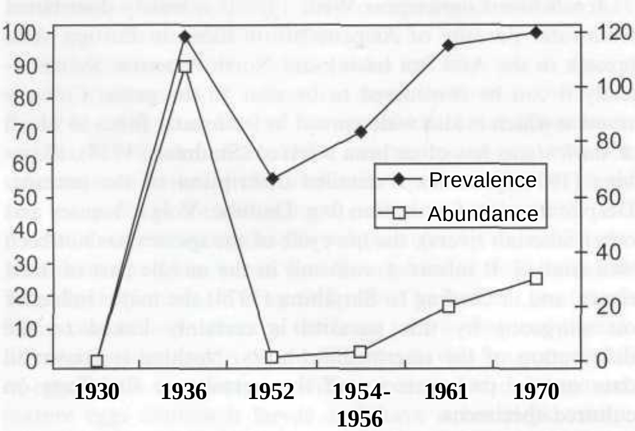

Fig. 2. Long-term data on infection of *A. nudiventris* by *N. sturionis* in the Aral Sea (data from Dogiel and Bychovsky, 1934; Lutta, 1941; Osmanov, 1952; Osmanov, 1962; Osmanov, 1975)

and the Amur basin in the eastern part of Russia (except in the Aral Sea basin). This species has also been found on sturgeons of North America (Hoffman, 1998). Choudry and Dick (1996) refer to previous records of *D. armatum* on sturgeons of North America as being identical with the new species *D. atriatum.* Here is an area of further systematic research as there is another species of this genus *D. hamulatum* Simer 1929, occurring on the gills of *A.fuhescens.*

The biology of *D. armatum* has been carefully studied in Russia using data gathered from *A. ruthenus* of the Volga River near the city of Satarow (Bauer, 1959). This study has shown that infestation of *A. ruthenus* (apparently also of other Acipenserids) takes place mostly during the autumn and winter periods when sturgeons gather at deeper places of the river (so-called winter pits). However, intensity of infestation declines during the over-wintering period. It has also been stated that young specimens of *A. ruthenus* experience a low infestation level. This can most likely be explained by the absence of contacts between young and older fish during summer. In experimental infection trials infestation took place when fishes were 1 or 2 months old. Optimal temperatures for infestations with *D. armatum* are in the range of 18-20°C. Further temperature increase is unfavourable for all developing stages of this parasite. A decrease in the water temperature is clearly associated with a lowered developmental speed of the parasite, thereby increasing the lifespan of the planktonic larval phase while at the same time their activity declines. Normal development of the early life cycle stages of this parasite take place only in fresh water and survival in brackish water is low. Therefore, this parasite can be considered to be a typical freshwater species. Epizootic significance of *D. armatum* is generally low. In one case it was reported that the number of parasites infesting an old fish did not exceed 90 specimens. Risk of serious outbreaks arise for non-infected areas only when infected fish are transferred from another area and released into the watershed so that the local vulnerable sturgeon populations previously free of *D. armatum* become infested.

Another species of Diclybothriidae is described as a representative of the new genus *Paradydibothrium* Bychowsky and Gussew 1950. *Paradydibothrium padficum* was found on the gills of *A. medirostris* from the Sakhalin Island. This genus differs from the genus *Diclybothrium* by a narrower part of the adhesive disk and by the size of hooks (Skrjabina, 1974). The life cycle of this species has not yet been satisfactorily studied. As it has been found on the gills of *A. medirostris* during the marine phase of its life, it can be proposed that this parasite affects sturgeons primarily at sea. One representative of the genus *Paradidybothrium* sp. was also found in North America (Hoffman, 1998).

Cestoda. About 20 cestode species were detected from acipenseriform fishes (Skrjabina, 1974). These endoparasites are of high relevance to aquaculture, especially those belonging to the order Amphilinidea. They are rather uncommon fiat worms (leaf-like in shape; 26-124 mm in length, **12-42** mm in width, white or brown in colour) which parasitize the body cavity of fishes and turtles. Among Russian taxonomists, Dubinina (1974) insisted in maintaining this group of parasites as an independent class called Amphilinida; however, this view is not shared by all taxonomists working in this field.

Amphilina foliacea (Rudolphi, 1819) is the most common representative of this group, parasitizing all Acipenseridae. Its life cycle includes different crustaceans of the family

Gammaridae as intermediate hosts. This was stated for the first time by Janicky (1928) who studied the life cycle of *Amphilina* at the Volga Biological Station near Saratow. Three gammarid species and one of the mysids were identified as intermediate hosts. In the Caspian Sea, Dubinina (1974) identified *Dikerogammarus caspius, D. haemobaphes, Pontogammarus crassus, P. obesus, P. robustoides* and *Gmelina coastata* as intermediate hosts of *A. foliacea.*

The infestation rates of sturgeons by *A. foliacea* can differ greatly within river systems. Bauer (1948) found that at the time from 20 up to 93% of all fish were infested in the Yenisei River, from Krasnoyarsk to Dudinca. This can partly be explained by the abundance of gammarids in the river as well as in the Baikal Lake. This parasite is absent in *A. baerii* from the Lena and Kolyma rivers (Pugachev, 1984) and in the Aral Sea. The infestation rate seems also to be age related, with 2+ and 3+ fish being the most affected (Skrjabina, 1974). High infestation rates are associated with physiological effects, with reduced liver glycogen being documented. In some cases, severe effects on gonads can be observed (Dubinin, 1952), with subsequent influence on reproductive success. Data on adult worms encapsulation in the liver and their migration into the body cavity of fish were obtained (Davydov and Kuperman, 1993).

The other species, *A. japonica* Goto et Ishii 1936, now occurs in sturgeons in the Amur River, Sakhalin Island and in Japan. *A. bipunctata* Riser 1948, from North American sturgeons is the synonym of the *A. japonica* (Dubinina, 1982).

Several species of the order Spathebothriidea have been found in sturgeons of Russia and adjacent countries, among them is *Bothriomonus fallax* Liihe 1900, which is documented from *H. huso, A. nudiventris, A. ruthenus, A. gueldenstaedtii, A. sturio* and *A. stellatus* in the basins of the Black, Azov and Caspian seas. This large cestode (up to 170 mm in length; length of plerocercoid up to 25 mm, 1 mm width) can infest all parts of the intestine. Intermediate hosts are not yet fully known but *Dikerogammarus haemobaphes* has been identified as one of them by Sudarikov and Kurochkin (1964). *Bothriomonus fallax* can be found in sturgeons only during their marine life phase, with older fish apparently showing higher infestation rates than younger fish in the northern part of the Caspian Sea (Markov et al., 1967). In contrast, only young specimens of *A. sturio* and *A. stellatus* seemed to have been affected in the Danube estuary during the 1970s (Skrjabina, 1974). In all cases, no pathological anamolies were associated with these infestations. Another species, *B. sturionis* Duvernoy 1842, has been described from sturgeons from the Atlantic watersheds; apparently this species seems not to be restricted to sturgeons as it has later been identified in other fish species (Burt and Sandeman, 1969). *Cyathocephalus truncatus* (Pallas, 1781a,b), a typical parasite of salmonid fishes, was found in *A. sturio* from Ladoga Lake as well as in *A. ruthenus* and *A. baerii* from the Yenisey and Lena rivers (Skrjabina, 1974).

Eubothrium acipenserinum Cholodkovsky 1918 was found only in sturgeons from the Black and Caspian seas. This species belongs to the order Pseudophyllidae, mainly affecting species with an anadromous life style. However, the species has not yet been found in *A. ruthenus.* When infested fish enter freshwater habitats, the parasite will hot survive. Infestation rates have been reported to be usually higher in the southern than in the northern part of the Caspian Sea. *A. stellatus* Saidov (1956) identified up to 100 specimens of helminths in individual fish in the south-western part of the Caspian Sea. The life cycle of this parasite is still not fully understood but it can be assumed that copepods are certainly among the intermediate hosts of the species.

A number of cestode species from different orders not yet mentioned were also detected in acipenseriforms. *Proteocephalus osculatus* Goeze 1782, [syn. *P. skorikowi* (Linstow 1904)] - a typical parasite of silurid fishes - is among them as well as *Bothriocephalus opsariichthydis* Yamaguti 1934 and *Silurotaenia siluri* Batsch 1786. Several species of the orders Tetraphyllidea and Cyclophyllidea also occur in sturgeons, mainly during their larval stages (Skrjabina, 1974).

Aspidogastrea. One species of these worms, *Aspidogaster limacoides* Diesing 1835 - a typical parasite of cyprinid fishes, was found in *A. nudiventris* from the Aral Sea (prevalence 55%, average abundance 310 specimens per fish (Osmanov, 1971).

Trematoda. About 28 trematode species have been found in Acipenserid fish occurring in many regions of Russia (Skrjabina, 1974). However, while most of them occur on a wide range of fish species, only five of them are specific to sturgeons. One has to realize that sturgeons are in principle seldom infected by Metacercaria compared with many other fish species (particularly in freshwater).

Rhipidocotyle kovalae Ivanov 1967, has been reported from *H. huso* and *A. gueldenstaedtii* of the Volga River and the northern part of the Caspian Sea. This parasite occurs mainly in the rear section of the intestine. The life cycle of the parasite is to date not well understood. It seems, however, that *R. kovalae* mainly occurs in sturgeons during their marine phase of life and it is mainly found in fish returning from the sea during their spawning migration. This feature differs from other species of this genus and from those of the genus *Bucephalus* which use the freshwater mollusc *Anodonta* as the first intermediate host. Several freshwater fishes are known to act as the second intermediate host (Taskinen et al., 1997). There is a noticeable knowledge gap as there are no data on the pathogenicity of these parasites on sturgeon populations while also little data have been published on any other representatives of the genus *Rhipidocotyle* in sturgeons. There are also data on the occurrence in sturgeons of *R. illense* (Danube and Amudarya rivers), *B. polymorphus* (Volga and Ural rivers) and *B. skrjabini* (Amur River) (Skrjabina, 1974). This interesting group of trematodes is certainly in need of further investigation.

Acrolichanus auriculatus Wedl 1857 is a widely distributed freshwater parasite of Acipenseriform fishes in Europe, Asia (except in the Aral Sea basin) and North America. Systematically it can be considered to be near to the genus *Crepidostomum* which is also wide-spread in freshwater fishes to which *A. auriculatus* has often been referred (Shulman, 1954). Skrjabina (1974) provides a detailed description of the parasite. Despite its wide distribution (e.g. Danube, Volga, Yenisey and other Siberian rivers), the life cycle of the species has not been well studied. It infests *A. ruthenus* in the middle part of these rivers, and, according to Skrjabina (1974) the major influence on sturgeons by this parasite is certainly linked to the distribution of the intermediate hosts. Nothing is known to date on the pathogenicity of the parasite or its effects on cultured specimens.

The Trematode family Deropristidae Skrjabin, 1958 consists of four genera; representatives of all of these genera infest acipenseriform fishes. *Deropristis hispida* (Rudolphi, 1819) is a parasite typically found in sturgeons of Europe (e.g. North Sea, Mediterranean, Black and Azov seas) in the marine phase of their life cycle. The major hosts of this trematode are *A. stellatus* (most often affected), *H. huso, A. sturio,* and *A. gueldenstaedtii.* This rather large parasite (up to 10 mm in length) occurs in all parts of the intestine, beginning with the oesophagus. Its body is covered with small aciculae. The highest infestation level has been found in *A. stellatus* that reach up to 1000 individuals per fish. All age groups have been found to be infested by this trematode (Skrjabina, 1974). Data on occurrence of *Deropristis* sp. in sturgeons in the Amur River was reported by Jukhimenko (1985).

Skrjabinopsolus semiarmatus (Molin 1858) is another relatively large trematode, reaching about 5.5 mm total length. It has been found to infest all anadromous sturgeons in the Mediterranean, Black and Caspian seas. In *A. ruthenus* it appears also in slightly brackish to freshwater during the time the species spends in estuaries. Skrjabina (1974) has shown that the intensity of infestation declines between April and September. Unfortunately, the life cycle of the species as well as the potential pathological effects in the intestine of the fish have not yet been adequately studied. Another species of this genus *S. manteri* (Cable 1952) has been described from North America. It has been found in the spiral valve of freshwater sturgeons *A. fulvescens* and *Scaphirhynchus platorhynchus* of the Mississippi River. The life cycle is not studied nor is its pathogenicity. Choudhury and Dick (1998) recognized this species as a subspecies of *S. semiarmatus.* Furthermore, these authors consider the genus *Cestrahelmins* with *C. rivularis* Becker, 1971 from *A. transmontanus* not to be a member of this family. Another species of this family, *Pristicola sturionis* Cobbold 1858, was found only in North American acipenseriforms (Skrjabina, 1974). There are no data showing that trematodes specific to Acipenseridae are pathogenic even when the infection rate is rather high.

Nematoda. About 30 nematode species including larval forms were recorded from acipenseriforms. One species of the family Capillariidae (*Piscicapillaria tuberculata* Linstow 1914) has been found in sturgeons from the basins of the Caspian, Black and Azov seas (Skrjabina, 1974). This freshwater parasite is frequently brought by migratory fishes from rivers (Volga, Danube) into the sea. Perhaps, similarly to other capillariids, its development involves some oligochaetes (Moravec, 1994). The parasite mostly infects *A. ruthenus* and sometimes young anadromous fishes of other sturgeon species in which it may cause gut inflammation (Dubinin, 1952).

The monotype family Cystoopsidae has one species that is specific to sturgeons: *Cystoopsis acipenseris* Wagner 1867. It is found in many sturgeons of Europe, in the Amur River basin and in North America. These worms penetrate into the subcutaneous layer of the abdominal part of the fish body and a capsule is formed around each two worms (male and female). It can be recognized in preparations by the naked eye. Its diameter is up to 9 mm. Sex dimorphism is well expressed. The length of the male is up to 2 mm. The body of the female forms two sections whereby the front part is long and thread-like and the hind part is round. Females have a long uterus full of eggs which are always at different stages of development; mature eggs contain a larvae and have a barrel-like shape (Skrjabina, 1974). The life cycle of *Cystoopsis* was first studied by Janicky and Rashin (1928). These authors stated that after dissipation of the capsule, released eggs enter the free water and are ingested by different gammarids *(Gammarus pulex, G. platycheir, Dikerogammarus haemobaphes* and others); the larvae hatch in their stomachs and migrate to different parts of the crustacean body, mostly to the extremities, where they encapsulate themselves. Two to three weeks later (depending on water temperature) they mature to reach an infective stage. *Cystoopsis* is an euryhaline parasite mostly infecting *A. ruthenus* and, rarely, young fish of other anadromous sturgeon species which have not yet migrated downstream toward the sea. Mortality of young fish can occur when the infestation rate is high (Ivanov, 1966).

Cystoopsis acipenseris has also been reported from North America in *A. transmontanus* of the Columbia River (Chitwood and Macintosh, 1950).

Three species of the family Anisakidae belonging to the genus *Hysterothylaceum* (= *Contracaecum)* were detected in acipenseriform fishes. Two of them, *Hysterothylaceum aduncum* Rudolphi 1802 and *H. gadi* Miiller 1776, occur in a wide range of marine and anadrome fishes. *H. aduncum* rarely infests sturgeons but *H. gadi* is rather common in specimens from the Black Sea. These species can use fish as their paratenic or definitive hosts (Moravec, 1994). *Hysterothylaceum bidentatum* Linstow 1899 seems to be specific to sturgeons; it occurs in the Black and Caspian sea basins (Danube, Dnieper, Volga and Kura rivers), less frequently also in the coastal zones of the seas with lower salinity (Skrjabina, 1974). First intermediate hosts are gammarids and possibly simuliids and chironomids (Levashov, 1925; Geller and Babich, 1953). Fertilized eggs pass their first developmental stages in the female uterus and hatch once released into the water while also undergoing two moultings. The third moulting takes place in the intermediate hosts, which are the gammarids. The last moulting and sex differentiation takes place in the stomach of the final host.

Dubinin (1952) describes inflammatory processes in the intestine walls and sometimes a perforation of the swimbladder in heavily infested fishes. There are some histological changes in the tissue structure of the intestine (Ivanov and Golovin, 1966). Attempts to acclimate *A. ruthenus* in the Chu River (Kazakhstan) were undertaken in the 1950s. Being aware of the problem and trying to minimize the risk associated with the transfer of the *H. bidentatum,* all fish were treated with an antihelminthic Santonin (0.04 g per specimen). The treatment was thought to be sufficient to prevent the transfer of this parasite. It was reported that within 10-12 h all parasites had been killed (Agapova, 1956).

One endemic parasite of the Caspian seal is known to belong to the genus *Anisakis {A. schupakowi* Mozgovoy 1951) and was found in inner organs of *A. gueldenstaedtii* during larval life cycle stages (prevalence 6.6%) (Saidov, 1956). The present systematic identity of the species seems to be valid (D'Amelio et al., 2000). There is general information on the following species occurring in larvae of sturgeons: *Anisakis simplex, Raphidascaris acus, Contracaecum microcephalum* and *Porrocaecum reticulatum* (Skrjabina, 1974).

Three species of the genus *Cucullanus* (family Cucullanidae) occur in sturgeons. C. *sphaerocephalus* (Rudolphi, 1809) infects the stomach and intestine of all European sturgeons species. C. *lebedevi* Skrjabina 1966 infests Siberian and Pacific sturgeon species. The first species differs from the second by a shorter male spicula (length up to 0.44 mm). The spicule length of the second species is more than twice as long (up to 1.11 mm).

Both species are euryhaline as they are found both in freshwater and anadromous sturgeons. The third species of this genus, C. *clitellaris* Ward et Magath 1917, has been described from American freshwater acipenserids. Choudhury (1997) considers C. *lebedevi* as a synonym of *C. clitellaris.* Life cycles of all these species are not yet fully known. Also, the potential effects of these parasites on their hosts is poorly understood.

Three species from the family Camallanidae were detected in sturgeons in Russia. All of them *Camallanus fotedari* (= C. *cotti)* from *H. dauricus* (Amur River), *Camallanus truncatus* have been described from *A. nudiventris,* while *P. kaufmanni* (Aral Sea), *Procamallanus fulvidraconis* from *A. nudiventris* and *P. kaufmanni* (Aral Sea basin) were noted to occur in a wide range of fishes, including sturgeons in which they are very rare except for *P. fulvidraconis,* known to infect sturgeons from the Aral Sea regularly (Skrjabina, 1974).

About 10 species of the genus *Rhabdochona* (family Rhabdochonidae) occur in acipenseriforms but all of them are rare or considered as accidentally occurring parasites (Skrjabina, 1974).

Six species of the family Cystidicolidae occur in sturgeons. Some of them are accidental parasites *(Cystidicoloides ephemeridarum* in *A. ruthenus* from the Ob River, *Spinitectus gracilis* in *A. fulvescens* from North America) (Skrjabina, 1974; McDonald and Margolis, 1995). Two species of the genus *Capillospirura* have been found in the intestine of Russian sturgeons: C. *ovotrichuria* Skriabin 1924 and C. *argumentosa* Skrjabina 1966, which differ from each other by the length of the male spicule and by their egg filaments. Eggs of the first species have filaments on both poles whereas the second species has filaments on only one pole. It seems that both species are euryhaline. In most cases infestation rate is low. Mature fishes are infected with more parasites than are young fishes (Skrjabina, 1974). The life cycle is as yet not completely known. Data is not available on the pathogenicity of the species.

Cyclozone acipenserina Dogiel 1932 is a specific parasite of sturgeons in the Black and Caspian sea basins. This nematode had been systematically re-assigned several times (Skrjabina, 1974). *Cyclozone acipenserina* is a species that is hosted by sturgeons while thriving in marine systems. The life cycle is unknown. Data on pathogenicity are absent. An additional nematode called *Physaloptera inexpectata* was described by Dogiel and Bychowsky (1934) and identified in anadromous specimens of Caspian Sea sturgeons. Several years later the same species was described by Sobolev (1949) as apparently a new genus named *Dogielina.* Unfortunately, the systematics and biology of this species are still unclear as only two specimens have so far been reported. *Dogielina inexpectata* (Dogiel and Bychowsky, 1934) seems to be the species *D. inquirenda* (Moravec, 1994). One specific parasite of sturgeons *Spinitectus acipenseris* was described in North America (McDonald and Margolis, 1995).

Acanthocephala. Twelve species of these worms were detected in acipenseriforms (Skrjabina, 1974). Most of them are rare or accidental parasites of sturgeons. Some of them are usual for sturgeons but have a wide range of fish hosts: *Pseudoechinirhynchus clavula* Dujardin 1845 in sturgeons from Volga and Yenisey rivers and Baikal Lake, and *Pomphorhynchus laevis* Müller 1776 in sturgeons from the Volga River. Only one species, *Leptorhynchoides plagicephalus* Westrumb 1821, is specific to sturgeons. It occurs in all species of the European sturgeons from the Baltic, Mediterranean, Black and Caspian sea basins. The intermediate host is *Gammarus pulex.* It can infect sterlet as well as other migrating sturgeons during freshwater and marine periods of their lives. This species causes gut inflammation (Ivanov and Golovin, 1966).

Hirudinea. Six species were found on sturgeons. Leeches in general can be responsible for sturgeon infection with kinetoplastids. Five species, *Limnotrachelobdella turkestanica, L. okae, Piscicola geometra, Caspiobdella fadejewi* and *Hemiclepsis marginata,* have a wide range of fish hosts. Typical anaemia caused by *P. geometra* in experiments was revealed in young sturgeons (Syrovatka, 1985). Only one species, *Acipenserobdella volgensis* Zykoff 1903, seems to be specific for sturgeons. It was found on *A. nudiventris, A. ruthenus,* and *A. baerii* from the Volga, Angara and Selenga rivers. The life cycle has not been studied and data on pathogenicity are absent.

Copepoda parasitica. Nine species were detected on sturgeons. Six of them *(Ergasilus sieboldi, Paraergasilus rylovi, Lernaea cyprinacea, L. elegans, Caligus lacustris, Argulus foliaceus)* occur on different fishes and are well known as pathogenic to fishes in aquaculture. Three species are specific to sturgeons. One of them, *Pseudotracheliastes stellatus,* is pathogenic. A rather high infection of *A. stellatus* and *A. gueldenstaedtii* by *P. stellatus* (family Lernaeopodidae) was noted in the Azov Sea during the 1980s. Infection prevalence was up to 100%. Intensity was rather high and resulted in quantitative and qualitative changes in white and red blood cells. Diseased fish had anaemia-denoted impairment of their physiological state (Shestakovskaya and Syrovatka, 1988; Kazarnikova et al., 1998). Data gathered in the 1990s have shown that such infections have decreased from 100 to 65% for *A. ruthenus* and to 33% for *A. stellatus.* The decrease can presumably be explained by the reduced size of sturgeon populations in the Azov Sea thereby limiting the probability for massive transfers between individuals. The other specific copepod of this genus, *P. soldatovi,* is not considered to have pathogenic effects and occurs in the Amur River on sturgeons only. Another representative of Copepoda parasitica is certainly specific for acipenserids and this is *Dichelesthium oblongum* Abildgaard 1794, of the family Dichelesthiidae which is systematically close to the family Caligidae. This is a true marine parasite infecting gills of Acipenserids of Europe and North America during the marine period of their lives. In Russia it has been found only in the Black Sea (Gusev, 1987). However, Kabata and Khodarevski (1977) have described a larva of this species from the skin of *H. huso* of the Caspian Sea. Therefore, it has to be noted that this species infects sturgeons in the Caspian Sea, probably at an extremely low rate.

Diseases of reared sturgeons in Russia and adjoining countries

As mentioned, the first step of rearing sturgeons was to culture young fishes (0 +, 1 +) in artificial conditions and put them into natural water bodies. In the latter half of the twentieth century rearing sturgeons to maturity had been started in Russia. During the first steps different diseases were described that had been caused by different pathogens.

Viral, bacterial and fungal diseases. *Viral diseases.* Four different viruses have been described in North American reared sturgeons (Adkinson et al., 1998), among them the white sturgeon Irido virus (WSIV). This virus preferably infests epithelia of the gills and skin. Two viruses have been found in the Netherlands and Belgium (Adkinson et al., 1998). Rosenthal and Gessner (1990) reported the transfer of sturgeons from North America to Europe which were potentially infected by this virus and urged quarantine measures because an *Adenovirus* infection had caused health problems in *A. transmontanus* transferred to Italy (Ghittino and Ghittino, 1985). So far, no viruses have been found in Russia, although the first investigation has only been recently undertaken (Shchelkunov, 2000). There is no reason to believe that these disease agents do not occur in Russia; it seems to be simply a matter of time before their presence is discovered through more systematic sampling and improved detection methods. Rosenthal and Gessner (1990) also stated at the time that it was difficult to culture these viruses and therefore methodologies used to detect them were still of questionable certainty.

Bacterial diseases are rather widely distributed in Russia. An example is the Flexibacter [cytophaga-like (FCL) infection (Voronin, 1998)]. Special bacteriological investigations made in the Konakov centrum of sturgeon culture (Middle Russia) have shown that the pathogen of the disease is *Flavobacterium johnsonae* - lie bacteria. Outbreak of the disease takes place in spring when the water temperature is less than 16°C. Young sturgeons of 3-4 g weight are especially vulnerable. Oytetracycline and chloramine were used to control this infection (Guseva et al., 1998). It is extremely important to continue the study of bacterial diseases of reared sturgeons in Russia.

Fungal diseases caused by Saprolegniaceae are of great importance, especially during incubation of sturgeon eggs. Mortality of eggs during this period sometimes reaches 70-90%. Thirteen species of pathogens have been found, including *Saprolegnia* (seven species), *Achlia* (two species), *Aphanomyces* (one species), *Dactyunus* (two species) and *Zeptolognia* (one species). Most common are *S. parasitica*, ***S. ferax*** and ***Dictyudius monosporus*** (Ivanova et al., 1993). There are many methods to control this group of diseases.

Protozoan diseases. Most common diseases of this group are those in reared young sturgeons caused by ciliates of the genus *Trichodina* and other genera of the family Urceolariidae. Six species of these have been found in Russia. The infection rate in most cases, however, is not very high and losses are seldom (Ivanova et al., 1993). Rarer are those infections of reared sturgeons caused by such Protozoans as *Ichthyophthirius* ***multifilis, Chilodonella cyprini*** and other dangerous pathogens through the rearing of carp and other pond fishes.

Helmintological diseases of reared sturgeons are very rare in fish farms, although representatives of several species of Monogenea, Trematodes, Cestodes and Nematodes are sometimes found in reared sturgeons but in very low quantity. For example, eye flukes of the genus *Diplostomum* are rather often found in sturgeons farms of the Caspian and Azov sea basins, but in small numbers (Ivanova et al., 1993).

Crustacean infestations. Little is known on parasitic crustaceans attacking cultured sturgeon species. One species that can be considered to have significant effects in farms is the carp louse *Argulus foliaceus,* having reportedly caused mortality of one-summer-old sturgeons in farms of the Azov River basin (Ivanova et al., 1993). The reported case infestations reached up to 15 parasites per specimen with the consequencial changes in several blood parameters of the fish. Other crustaceans such as *Ergasilus sieboldi* are rather rare as parasites on cultured young sturgeons but there is no reason to assume that under given circumstances, no harm to the production output and/or quality of the fish will occur. As reported earlier, other parasitic crustacean species do naturally occur on sturgeons (Kazarnikova et al., 1998) and these may have simply been overlooked or may have not been involved in mass mortality on farms.

Conclusions

Although far from being complete, the knowledge on the diversity of parasitic species occurring on and in sturgeons in Russia is extensive. However, little is known about their ecology, range of distribution and prevalence. Other than a number of extensive studies on the subject, most of which were entirely dependent on the interest and research activities of the individual scientist, there has been little incentive to organize these studies more systematically. It is recommended that national and international organizations and societies encourage and facilitate more structured research programmes. These should be designed to enable trend analyses in changes of the parasitic fauna of fish such as sturgeons in the face of environmental changes also affecting biodiversity in general.

Further, in aquaculture, diseases will continue to play an important role in the economic performance of the industry. It is surprising that so little science is currently directed toward the understanding of the biology and ecology of potentially harmful parasites. It is highly recommended that such studies be supported and systematically organized to assist in preventing loss of cultured stock while also preventing aquaculture becoming a potential reservoir for parasites and disease agents affecting natural stocks.

References

Adkinson, M. A.; Cambre, A.; Hedrick, M., 1998: Identification of an iridovirus in Russian sturgeon *(Acipenser guldentstaedtii)* from northern Europe. Bull. European Assoc. Fish Pathol. 18, 29-32.

Agapova, A. J., 1956: Parasites of fishes of West Kazakhstan water bodies. Proc. Zool. Institute of the Kzahkhstan Acad. Sci. 5, 5-60 [In Russian].

Aladin, N. V., 2000: Water and environmental health - historic evolution of the Aral Sea system. Water security - opportunity for development and cooperation in the Aral Sea area. SIWI Proceedings. Report 9, 35-49.

Bauer, O. N., 1948: Parasites of fishes of the River Yenisey. Proc. All-union Res. Inst. Of Lake and River Fisheries 27, 97-156 [In Russian].

Bauer, O. N., 1959: Biology of *Diclybothrium armatum* Leucart (Monogenea) - parasitic of sturgeon fishes. Problems in Ecology. Kiev. 3, 142-153 [In Russian].

Bauer, O. N., (ed.) 1984: Key of freshwater fish parasites of the USSR fauna. Vol 1, 1-431 [In Russian].

Bauer, O. N., (ed.) 1985: Key of freshwater fish parasites of the USSR fauna. Vol 2, 1-425 [In Russian].

Bauer, O. N., (ed.) 1987: Key of freshwater fish parasites of the USSR fauna. Vol 3, 1-583 [In Russian],

van Beneden, P. J., 1871: Les poissons des côtes de Belgique, Leurs parasites in leurs commenseaux. Mem. Acad. Roy. Soc. Belg. 38, 1-100.

Berg, L. S., 1948: Freshwater fishes of the USSR and adjacent countries. Vol 1, 1-466 [In Russian].

Burt, M. D., Sandeman, Y. M., 1969: Biology of *Botrhimonus (Diplocotyle) sturionis.* J. Fish. Res. Board Can. 26, 975-996.
Bychowsky, B. E., 1957: Monogenea, their system and phylogeny. M.-L.: pp. 1-509 [In Russian].
Chitwood, M. B.; Macintosh, A., 1950: American host record for the Russian sturgeon nematode *Cytoopsis acipenseris* Wagner, 1868. J. Parasitol. 36, 29.
Choudhury, A., 1997: A dissertation abstracts international. Part B: Science and Engineering. University Microfilms International 58, 5837.
Choudhury, A.; Dick, T. A., 1996: *Diclybothrium atriatum* n. sp. (Monogenea: Diclybothriidae) from North American acipenserid fishes with observations on *Diclybothrium armatum* and *Diclybothrium hamulatum.* J. Parasitol. 82, 965-976.
Choudhury, A.; Dick, T. A., 1998: Systematics of the Deropristiidae Cable & Hunninen, 1942 (Trematoda) and biogeographical associations with sturgeons (Osteichthyes: Acipenseridae). Syst. Parasitol. 41, 21-39.
D'Amelio, S.; Mathiopoulos, K. D.; Portes Santos, C; Pugachev, O.; Webb, S. C; Paggi, L., 2000: Genetic markers in ribosomal DNA for the identification of members of the genus *Anisakis* (Nematoda: Ascaridoidea) defined by PCR-based RFLP. Internat. J. Parasitol. 30, 223-226.
Davydov, V. G.; Kuperman, B. I., 1993: The ultrastructure of the tegument and the peculiarities of the biology of *Amphilina foliacea* (Plathelminthes, Amphilinidea). Folia Parasitol. 40, 13-22.
Dogiel, V. A., 1945: Sturgeon's parasite fauna analysis and estimation of its pathogenic significance. Trans. Ac. Sci. KazSSR, Ser. Zool. 4, 9-19 [In Russian].
Dogiel, V. A.; Bychovsky, B. E., 1934: Fauna of fish parasites of the Aral Sea. Parasitol. Sbornik 4, 241-346. [In Russian].
Dogiel, V. A.; Lutta, A. S., 1937: On the mortality of *Acipenser nudiventris* of the Aral Sea in 1936. J. Rybnoje Chozuaystvo 12, 25-27 [In Russian].
Dogiel, V. A.; Bychovsky, B. E., 1939: Fish parasites of the Caspian Sea. Proc. Complex Res. of the Caspian Sea 7, 1-150 [In Russian].
Dubinin, V. B., 1952: Parasitic fauna of young sturgeons of the lower Volga. Scientific papers of the University of Leningrad 45: Biol. Series 28, 238-251 [In Russian].
Dubinina, M. N., 1974: Development of *Amphilina foliacea* (Rud.) on all stages of the life cycle and situation of Amphilinea in the system of Platodes. Parasitol. Sbornik 26, 9-38 [In Russian].
Dubinina, M. N., 1982: Parasitic worms of the class Amphilinida (Plathelminthes). Nauka, L. 1-143 [In Russian].
Dujardin, F., 1845: Histoire Naturelle des Helminthes ou vers Intestinaux. Paris. 1-654 [In French].
Geller, E. R.; Babich, L. A., 1953: On the biology of *Contracaecum bidentatum.* Papers of Helminthology, 75th Anniversary of the Academia K. Y. Skriabin, Moscow. Publishing house of the USSR Acad. Sci. 133-138 [In Russian].
Gaevskaya, A. V.; Tkachuk, L. P., 1992: A case of fish disease caused by *N. sturionis* in Sevastopol aquaria. Rybnoe khozyaistvo. 7/8, 53-54 [In Russian].
Ghittino, P.; Ghittino, C, 1985: Adenovirosis-like disease in young white sturgeon *(Acipenser transmontanus)* farmed in Italy. Revista Ital. Piscicult. Ittiopatol. 20, 137-139 [In Italian].
Grimm, O. A., 1870: New cases of modification of some helminths. Paper of St Peterburg Soc. Nat. Hist. 1, 25-34 [In Russian].
Grimm, O. A., 1871: Data on the helminth fauna of the St Petersburg region. Papers of the St Peterburg Soc. Nat. Hist. 2, 499-504 [In Russian].
Grimm, O. A., 1875: Nachtrag zum Artikel des Herrn Salensku ueber den Bau und die Entwicklung der *Amphilina.* Z. Wiss. Zool. 25, 214 -216 [In German].
Gusev, A. V. 1987. Type Arthropoda. Key of freshwater fish parasites of the USSR fauna. Nauka. L. 3, 378-523 [In Russian].
Guseva, M.; Golovin, P. P.; Golovina, N. A., 1998: Infection of young sturgeons caused by *Flavobacterium johnstonae*-like bacterium. Fish. Manage. Ser. Aquacult. 2, 1-8 [In Russian].
Hoffman, G. L., 1998: Parasites of North American Freshwater Fish. 2nd edn. Cornell University Press, Ithaca, NY, pp. 1-539.
Ivanov, V. P., 1966: Helminth fauna of young sturgeons in the River Volga and the Volgograd Reservoir. In: Problems of ecology and parasitology of animals. Saratov University Press pp. 18—28 [In Russian].
Ivanov, V. P.; Golovin, N. F., 1966, Histopathology in some Helminthoses of acipenserids. Mater. XXI nauchn. konf. Volgogradsk. ped. inst. Volgograd, pp. 56-62 [In Russian].
Ivanova, N. S.; Golovina, V. A.; Golovin, P. P., 1993: Parasites and diseases of sturgeons artificially reared in the Volga-Caspian and Azov basins. Fish. Manage., Ser. Aquacult. 2, 1-34 (Saratov University Press) [In Russian].
Izumova, N. A., 1977: Fish parasite fauna of the USSR reservoirs and its formation paths. Nauka, L. 1-283 [In Russian].
Janicky, C, 1928: Development cycle of *Amphilina foliacea* parasite of *Acipenser ruthenus.* Observations and experiments. Papers of the Volga Biological Station 10, 97-134 [In Russian].
Janicky, C; Rashin, K., 1928: Die experimentelle Bestimmung des Zwischenwirtes von *Cystoopsis acipenseris* Volga - Sterlets. Naturwiss. 16, 1-37 [In German].
Jukhimenko, S. S., 1985: Parasites of *Acipenser schrenkii* and *Huso dauricus* from Amur River downstream. VIII Vsesoyuzn. sovestch. po parasitam i boleznjam ryb. Nauka. L.: 161-162 [In Russian].
Kabata, Z. P.; Khodarevski, O. A., 1977: Copepodit stages of *Dichelestium oblungum* (Abildgaard, 1794), a *Copepoda parasitica* of sturgeons. Parasitologia 11, 236-240 [In Russian].
Kazarnikova, A. V.; Shestakovskaya, H. V.; Katycheva, L. Y., 1998: Infection of the Azov Sea sturgeons by parasitic *Crustacea Pseudotracheliastes stellatus* L. under conditions of anthropogenic pollution. 9th Internat. Conf. 'Diseases of Fish and shellfish', Rhodes., Abstract, p. 113.
Koelreuther, I. T., 1771: Descriptio *Cyprini rutili,* quern Galowel russi vocant, historico-anatomica. Novi Commentarii Acad. Sci. Imp. Petropolitanae. 15, 494-503.
La Patra, S. E.; Subasinghe, R. P.; Schlotfeldt, H.-J., 1999: Present and future outlook on the ecology of wild sturgeons and fish health challenges associated with the management of these species. Bull. European Assoc. Fish Pathol. 19, 289.
Levashov, M. M., 1925: On the biology of the parasitic worms of sterlet. I. *Contracaecum bidentatum* Lin. Rab. Volzshsk. biol. st. 8, 1-3 [In Russian].
Lorn, J.; Dykova, I., 1992: Protozoan parasites of fishes. Elsevier Publishers, The Netherlands. 1-315.
Lubarskaya, O. D.; Lavrent'eva, Y. I., 1985: Formation features of parasite fauna formation of starlet from Kuybyschevsk reservoir. Proc. Vsesouznogo sovestchaniya po parasitam i boleznjam ryb. Nauka. L. 8, 88-89 [In Russian].
Luk'yanenko, V. I.; Vasil'ev, A. S.; Luk'yanenko, V. V.; Khabarov, M. V., 1999: On the increasing threat of extermination of the unique Caspian sturgeon populations and the urgent measures required to save them. J. Appl. Ichthyol. 15, 99-102.
Lutta, A. S., 1937: Influence of fish acclimatization on their parasite fauna. Priroda 5, 5-8 [In Russian].
Lutta, A. S., 1941: Inflammation of *Acipenser nudivetris* gills caused by *Mongenea Nitzschia sturionis* Abild. Zool. J. 20, 189-196 [In Russian].
Markov, G. S.; Trusov, V. Z.; Ivanov, V. P., 1967: Distribution of some acipenserid parasites in Northern Caspian. Sbornik nauchn. rabot Volgogradskogo ped. in-ta. 2, 180-182 [In Russian].
McDonald, T. E.; Margolis, L., 1995: Synopsis of the parasites of fishes of Canada: Suppl. (1978-1993). Ottawa. 1-265.
Moravec, F., 1994: Parasitic nematodes of freshwater fishes of Europe. Academia. Prague. 1-473.
Osmanov, S. O., 1952: Acipenseriforms helminth fauna in the Amudarya delta. Izvestiya AN UzSSR. 6, 50-55 [In Russian].
Osmanov, S. O., 1962: Parasites of *A. nudiventris* in the Aral Sea and problem with renewal of its fishery. Uzbeksky bilogichesky zhurnal 5, 35-38 [In Russian].
Osmanov, S. O., 1971: Fish parasites of Uzbekistan. Tashkent. 531 pp [In Russian].
Osmanov, S. O., 1975: Problems in parasitology of the Aral Sea. Tashkent. 200 pp [In Russian].
Owsjannikow, Ph., 1871: Ueber einen neuen Parasiten in den Eiern des Sterlets. Melanges Biologiques Titles du Bulletin de l'Academie des Sciences de Saint-Petersbourg 8, 334-338 [In French].
Pallas, P. S., 1775: *Lacerta apoda* descripta. Novi Commentarii Acad. Sci. Imp. Petropolitanae. 19, 435-454.
Pallas, P. S., 1781a: Bemerkungen ueber die Bandwurmer in Menschen und Tieren. Neue nordische Beitrage zur physikalischen und geographischer Erd- und Völkerbeschreibung, Naturgeschichte und Ökonomie. St Petersburg-Leipzig. 1, 39-112.
Pallas, P. S., 1781b: On the best ways for liberation from helminthes. Mesjazeslov s nastavlenijami na 1781. St Petersburg, 31-68 [In Russian].

Pronin, N. M., 1977: Parasites of the Selenga stock of the Baikal sturgeons. Trudy Buryatskogo Inst. Estestvennych nauk BF SO AN SSSR. 13, 58-61 [In Russian].

Pugachev, O. N., 1984: Freshwater fish parasites from North-Eastern Asia. L. pp. 154 [In Russian].

Raikova, E. V., 1994: Life cycle, cytology and morphology of *Polypodium hydriforme*, a coelenterate parasite of the eggs of Acipenseriform fishes. J. Parasitol. 80, 1-22.

Raikova, E. V., 2002: *Polypodium hydriforme* infection in the eggs of Acipenseriform fishes. J. Appl. Ichthyol. (this volume).

Rashin, K., 1949: *Cocconema sulci* n.sp. (Microsporidia) cizopasnik vajicek jesetera maleho *(Acipenser ruthenus* L.). Vest. Cesk. Spol. Zool. 13, 295-298.

Rosenthal, H.; Gessner J., 1990: Ist die Einfuhrung von *Acipenser transmontanus* in die Bundesrepublik ohne Risiko? Fischer und Teichwirt 10, 295-296.

Rudolphi, C. A., 1809: Entozoorum sive vermium intestinalium historia naturalis, Vol. 2. Part 1, Amsteraedami. 1-575 pp.

Rudolphi, C. A., 1819: Entozoorum sinopsis cui auedunt mantissa duplex et indices locupletissimi. Berolini. pp. 340-342.

Saidov, Y. S., 1956: Helminth fauna of sturgeons of Dagestan. Trans. Inst. Animal Husbandry of Dagestan Dept. of the USSR Acad. Sci. 4, 54-79 [In Russian].

Schulman, S. S., 1954: Survey of parasite fauna of the USSR sturgeons. Trans. Leningrad Soc. Naturalists 72, 190-255 [In Russian].

Shchelkunov, I. S., 2000: Virus diseases of sturgeons. Fishery management. Series: Diseases of hydrobionts in aquaculture. Moscow 1, 3-16 [In Russian].

Shestakovskaya, E. V.; Syrovatka, N. I., 1988: Pseudotracheliastosis of Acipenseridae in the Azov Sea. Bolezny i parasity v teplovodnom rybnom khozjastve. Dushanbe 182-184 [In Russian].

Skripchenko, E. G.; Sous, S. M.; Nikulina, V. N., 1971: Little known fish parasite species of waterbodies of forest-steppe and steppe regions of the Siberia. Novye I maloizvestnye vidy fauny Sibiri. Novosibirsk, pp. 121-128 [In Russian].

Skrjabina, E. S., 1974: Helminths of sturgeons. Publishing house 'Nauka' M: 1-168 [In Russian].

Sobolev, A. A., 1949: Spirurata. Opredelitel parasiticheskich nematode. Nauka. M. 1. pp. 519 [In Russian].

Sokolov, L. I., 2002. Order Acipenseriformes. Atlas presnovodnych ryb Rossii. Vol. 1. Publishing house 'Nauka'. M: 36-59 [In Russian].

Sudarikov, M. E.; Kurochkin, Yu. V., 1964: Finds of cetode larvae in sturgeons. *Bothrimonus fallax* Lüke, 1900 in Amphipodes of the Caspian Sea. Trans. Astrakhan Reserve 9, 24-31 [In Russian].

Syrovatka, N. I., 1985: Parasites and diseases of sturgeons of the Azov Sea basin. PhD Thesis. Alma-Ata, 24 [In Russian].

Taskinen, J.; Maekelae, T.; Valtonen, E. T., 1997: Exploitation of *Anodonta piscinalis* (Bivalvia) by trematodes: parasite tactics and host longevity. Ann. Zool. Fenn. 34, 37-46.

Voronin, V. N., 1998: A flexibacter-like infection of fish in Russia: Epizootiology and treatment. Proc. 3rd Internat. Symp., Baltimore, MD, p. 115.

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