REVIEW PAPER

Adriatic shellfish as reservoirs of zoonotic pathogens

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Abstract

Adriatic shellfish's biological and ecological characteristics influence their sanitary safety and their role as potential vectors of zoonotic pathogens. Filtration capacity of shellfish, although essential for their feeding, enables the accumulation of bacteria, viruses, and parasites present in the marine environment. The most important species in the Adriatic Sea mussels, oysters, and warty venus, represent a valuable food resource, but due to the frequent consumption of raw shellfish, pose a risk of zoonotic transmission to humans. Most common pathogens are bacteria (*Vibrio* spp., *Salmonella* spp., *Listeria monocytogenes*, *Campylobacter* spp., and *Escherichia coli*), viruses (norovirus, astrovirus, hepatitis A and E), and parasites (*Giardia duodenalis*, *Cryptosporidium* spp., *Toxoplasma gondii*, and *Sarcocystis* spp.). Factors influencing pathogen accumulation are temperature, salinity, pollution, and anthropogenic impacts. Measures for the prevention and control of zoonotic risks, include the classification of farming areas, depuration, monitoring, and laboratory diagnostics. Special emphasis is placed on the importance of the integrated "One Health" approach, which links environmental protection, food safety, and public health.

Keywords: Adriatic shellfish, zoonotic pathogens, food safety

Introduction

Shellfish, more precisely bivalves, have an important role in Adriatic Sea ecosystem representing an important food and economic resource. Due to their filtration diet, bivalves contribute to environmental purification, but at the same time they can bioaccumulate microorganisms and chemical contaminants present in water (Arapov et al., 2010; Ward and Shumway, 2004). This filtration mechanism makes them particularly susceptible to microbiological contamination and potential vectors of zoonotic pathogens.

Contamination of shellfish with pathogens mainly comes from faecal polluted coastal waters, where shellfish harbour bacteria such as *Vibrio* spp., *Salmonella* spp. and *Listeria monocytogenes*, enteric viruses such as norovirus and hepatitis A, and parasites such as *Giardia duodenalis* and *Cryptosporidium* spp. (Bellou et al., 2013; Čadež and Teskeredžić, 2005; Desdouits et al., 2023). The Adriatic Sea is particularly vulnerable to pollution due to its semi-enclosed nature, slower water exchange and high concentration of human activities along the coast. Intensive tourism, discharge of insufficiently treated wastewater and agricultural runoff

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contribute to the introduction of microbial pollutants into coastal areas, increasing the likelihood of pathogen bioaccumulation in shellfish (Bratoš Cetinić 2024; Roy et al., 2024). In addition, climate change, especially the increase in sea temperature, favours the development of thermophilic bacteria such as *Vibrio parahaemolyticus* and *Vibrio vulnificus*, the frequency of which increases significantly in the warmer part of the year (Brumfield et al., 2023; Masanja et al., 2023). The risk is further increased by the fact that microbiological contamination does not alter the organoleptic properties of shellfish, which is why products can appear completely fresh and sensory acceptable, despite the presence of infectious agents (Ferri et al. 2024).

Managing shellfish safety requires systematic monitoring of the marine environment, including regular microbiological classification of production areas, and strict compliance with European and national regulations governing the collection, depuration and placing on the market of live shellfish (EC, 2019; Ministry of Agriculture, Forestry and Fisheries, 2022; EC, 2017). In addition, it is important to have a detailed understanding of the biological processes of pathogen filtration and accumulation, the factors affecting their survival, as well as epidemiological trends in diseases associated with shellfish consumption.

Biological characteristics of Shellfish

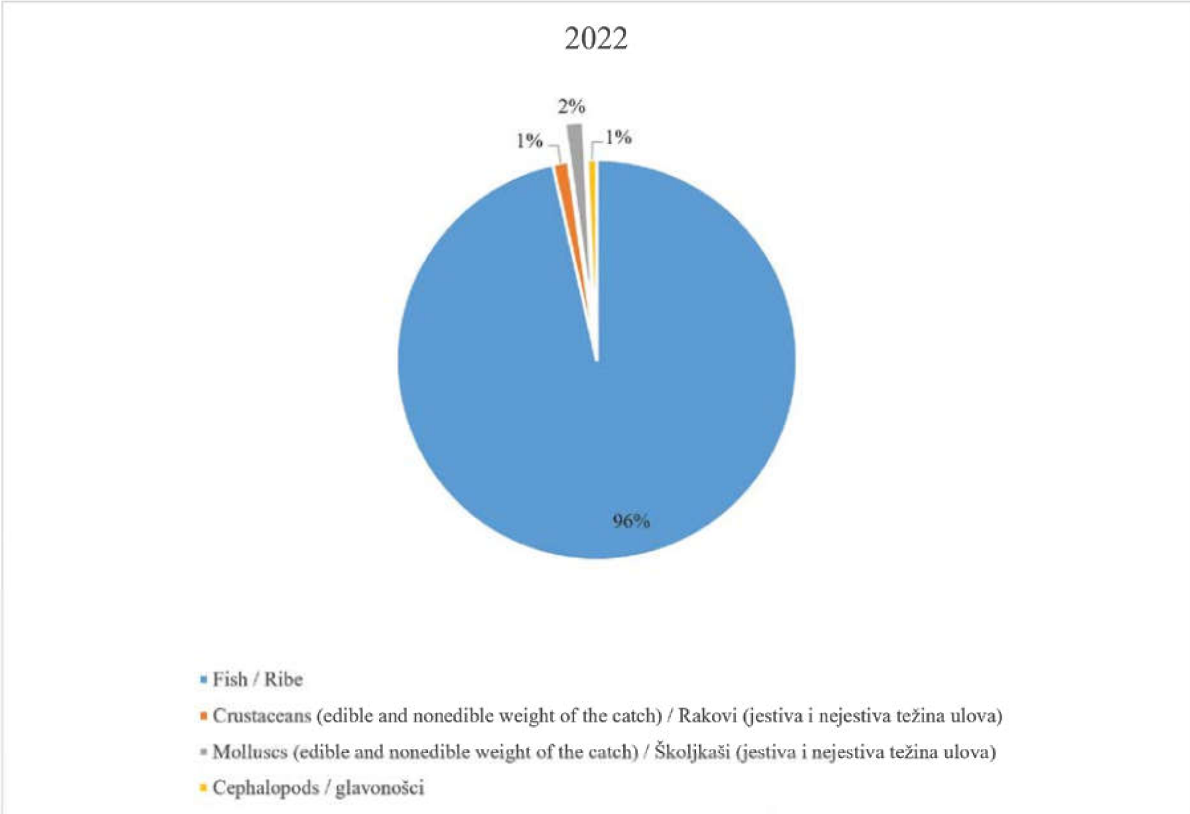
Bivalves are animals belonging to the phylum *Mollusca*, class *Bivalvia* counting around 9200 species. They share their phylum with gastropods, cephalopods and five other less numerous classes. Their Latin name means two shells, they are also sometimes called *pelecypoda*, Greek for hatchet foot, and *acephala*, Greek for headless, which are all their main distinguishing features from cephalopods and gastropods (Peharda Uljević et al., 2022). Bivalves are bilaterally symmetric having a left and right valve, distinguishing characteristic from similarly looking brachiopods that have a dorsal and ventral valve (Dorit et al., 1991). Main components of bivalve anatomy are left and right shells joined at the umbo that enclose soft tissue of the mantle that can have tentacles and eyes, for example in scallops. Bivalves can have one, monomyarian, or two, dimyarian, adductor muscles these muscles allow some bivalves to swim and propulse themselves and together with the foot make a life of an adult bivalve far less sessile that one would imagine it (Helm et al., 2004; Peharda Uljević et al., 2022). Bysal glands make byssus and bind the animal to the substrate, gills filter the water that is brought in and out by two siphons, maintaining both respiration and filtering food from the water which is then digested in the digestive system. Sexes of bivalves can be separate (dioecious) or hermaphroditic (monoecious), the same animal can be either sex depending on its age and size. Fertilisation in bivalves can happen in the open environment or in mantle chamber. Fertilised eggs live a planktonic life progressing through different larval stages. Metamorphosis is a critical time in the development of bivalves, during which the animal changes from a swimming, planktonic to a sedentary benthic existence (Helm et al., 2004).

Phytoplankton is bivalves' main food source; other sources can be fine particles of non-living organic material (detritus) along with associated bacteria and dissolved organic material. Bivalves can periodically reject some of the food as pseudofaeces expelling it from the mantle cavity, often by the vigorous "clapping" together of the shell valves (Helm et al., 2004).

Most significant species of shellfish in the Adriatic Sea

Adriatic Sea is home to 252 bivalve species (Peharda Uljević et al., 2022). While around 15 species of bivalves have been traditionally consumed locally, only the European flat oyster (*Ostrea edulis*) and the Mediterranean mussel (*Mytilus galloprovincialis*) are commercially interesting for farming (Bratoš Cetinić 2024). While scallops were also farmed for a short time in the late 1980s (Marguš 1994), their production isn't noted in official statistical data, despite that numerous objects still hold permits for their production in Aquaculture Permit Register (Ministry of Agriculture – Directorate of Fisheries 2026a). It is important to also mention two edible but protected species in the Adriatic: fan mussel (*Pinna nobilis*) critically endangered on the IUCN Red List of Threatened Species (Kersting et al., 2019), and date mussel (*Lithophaga lithophaga*) whose lifestyle makes harvesting them extremely destructive to the rocky habitats (Colletti et al., 2020; Ministry of Environmental Protection and Spatial Planning 2002).

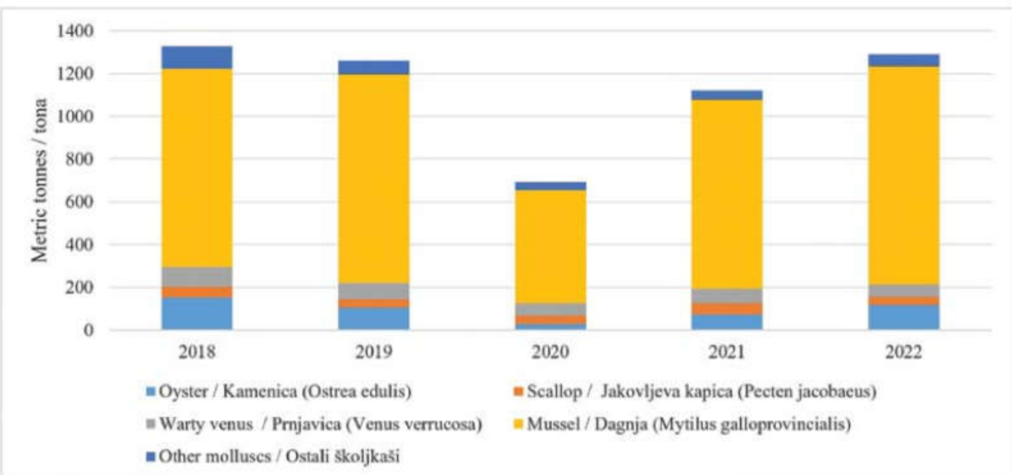
According to the last available data of Croatian Bureau of Statistics for 2022 molluscs made 2 % of total aquatic production (caught and farmed) graph 1.



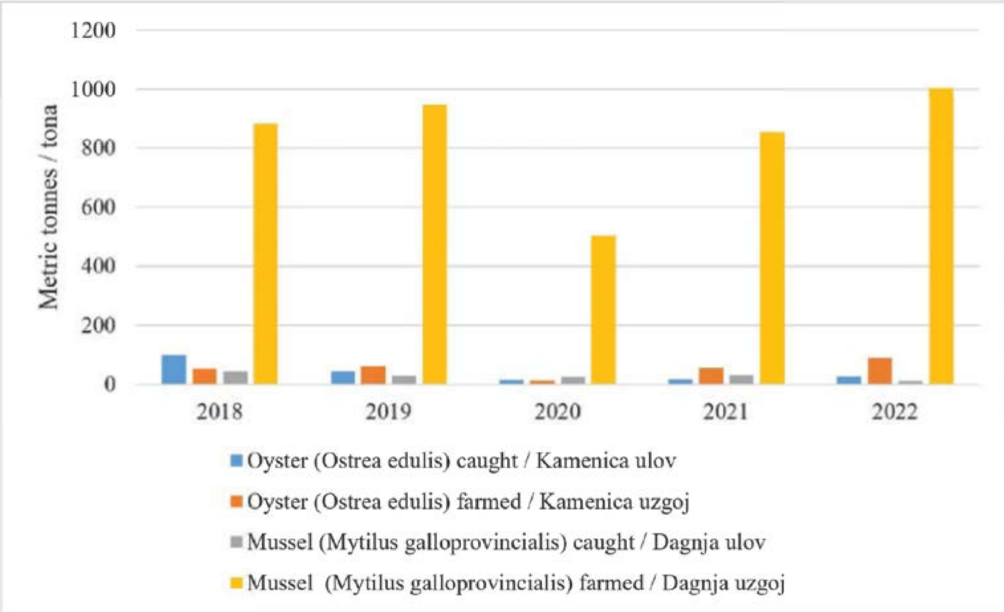
Graph 1. Shares in total aquatic production in Croatia in 2022 (Croatian Bureau of Statistics, 2023)

The biggest share in production was held by mussels (79 %), followed by the only other farmed species, oyster, at 9 %. Other significant species were warty venus at 5 %, scallop at 3 %, while the last 4 % was denominated as other molluscs (Croatian Bureau of Statistics, 2023). The category other molluscs includes these species: *Ruditapes decussatus* (Grooved carpet shell), *Callista chione* (Smooth callista), *Arca noae* (Noah's ark), *Pectinidae* (Scallops), *Chamelea gallina* (Striped venus), *Mimachlamys varia* (Variegated scallop), *Flexopecten glaber* (Smooth scallop) (Eurostat 2025; Ministry of Agriculture – Directorate of Fisheries 2026b).

Overpowering share of mussels and oysters, which are only molluscs farmed in Croatia, is a reoccurring trend as can be seen in graph 2.



Graph 2. Shares in molluscs production in Croatia 2018-2022 (metric tonnes) (Croatian Bureau of Statistics, 2023)



Graph 3. Shares of farmed and wild caught mussels and oysters in Croatia 2018-2022 (Croatian Bureau of Statistics, 2023)

While mussels and oyster farming dominates the industry there is still a place for wild caught oysters and mussels on the market, as can be seen in graph 3.

Zoonotic pathogens of significance in shellfish

The three main categories of zoonotic pathogens present in shellfish are bacteria, viruses and parasites. Bacteria are the most abundant and usually originate from faecal contamination associated with agricultural runoff or urban wastewater. They can survive in conditions of increased salinity and accumulate in shellfish tissues, retaining their potential to cause disease (Chazal et al., 2024). Their occurrence depends on environmental factors such as temperature, precipitation and nitrogen levels, and is generally higher after heavy rains, storms or increased inflow of river and stormwater that carry pollutants from land. The increase in antibiotic-resistant bacteria in the marine environment in recent years is of further concern, as it makes it difficult to treat infections and demonstrates that antimicrobial pollution has wider ecological consequences (Desdouits et al., 2023). Viruses are an important group of zoonotic organisms associated with shellfish, although they cannot reproduce in shellfish, they effectively persist and can spread infection for long periods of time. The main source of viral contamination is wastewater discharges (Dimitrijević et al., 2023). Many enteric viruses are highly contagious, even minor exposure causing disease. Viral presence in seawater is prolonged during the colder months, making the risk higher at this time of year (Desdouits et al., 2023).

Parasites, although less common than bacteria and viruses, also pose a potential risk. Various stages of parasites, including cysts and oocysts, can be passively transmitted by shellfish and enter the marine environment through wastewater or runoff from coastal areas. They can be retained by shellfish during the filtration process, allowing them to survive in seawater for long periods (Huss et al., 2004). Although there are not yet many documented cases of diseases caused by parasites in Adriatic Sea mussels, environmental changes and increasing human pressure on coastal ecosystems increase the likelihood of their occurrence in the future. Detailed overview of bacterial, viral and parasitic zoonotic pathogens present in shellfish can be seen in Tables 1-3.

Sources of contamination and impact of the environment

Certain pathogens present in the water can enter shellfish during filtration. They can persist and accumulate there due to a combination of environmental, physiological and biological factors. Numerous bacteria, viruses and parasites can bind to the surfaces of shellfish tissues, especially the gills and digestive gland, where they are protected from elimi-

Table 1 Bacterial pathogens

Pathogen	Morphology	Toxin/enzyme	Sickness in humans	Resistance to environmental factors
Vibrio spp. (V. parahaemolyticus, V. vulnificus, V. cholerae)	Gram negative curved rod	Thermostable direct hemolysin, thermostable direct hemolysin-related hemolysin, enterotoxin, cholera toxin	Gastroenteritis (*V. parahaemolyticus*), sepsis and wound infections (*V. vulnificus*)	Abundance increases with warmer seas and lower salinity, especially in summer and after rains/floods
Salmonella spp.	Gram negative rod	Lipopolysaccharide endotoxin, invasins, proteases	Salmonellosis	Typically, of faecal origin, it multiplies better at higher temperatures, while cold storage and freezing reduce survival.
Escherichia coli (STEC)	Gram negative rod	Shiga toxin, hemolysin, adhesin	Diarrhoea, haemolytic uremic syndrome	It adapts well to organically rich and humid environments, sensitive to high temperatures.
Listeria monocytogenes	Gram positive rod	Listeriolysin O, phospholipase	Listeriosis (meningitis, septicaemia, miscarriage)	It can grow at temperatures from approximately -0.4 °C to 45 °C, tolerates high salt concentrations and a wide pH range.
Campylobacter spp.	Gram negative curved rod	Cytotoxic distending toxin (CDT)	Gastroenteritis	Sensitive to high O_2 content and desiccation, survives briefly at low temperatures

Table 2 Virus pathogens

Virus	Sickness in humans	Methods of detection	Resistance to environmental factors	Remark
Hepatitis A virus (HAV) *(Picornaviridae, Hepatovirus)*	Hepatitis A	RT-PCR in concordance with ISO 15216 1, serology	Survives for weeks in seawater, depuration often does not remove HAV	The most common shellfish virus, frequent epidemic cases in the Mediterranean
Norovirus (GI, GII) *(Caliciviridae, Norovirus)*	Acute gastroenteritis	RT-qPCR in concordance with ISO 15216 1, sequencing	Very high - resistant to temperatures up to 60 °C and resistant to depuration	Main cause of shellfish-associated gastroenteritis, high infectivity
Hepatitis E virus (HEV) (*Hepeviridae, Orthohepevirus A*)	Hepatitis E	RT-PCR, sequencing	Moderate to high - especially stable at lower temperatures	Zoonotic potential of genotypes 3 and 4, HEV 3 is predominant in Europe, often associated with pig farming and runoff
Astrovirus *(Astroviridae, Mamastrovirus)*	Acute gastroenteritis	RT-PCR	It persists in fresh and seawater for weeks, with greater stability at low temperatures	Occasionally detected in shellfish, more important as an indicator of faecal pollution

nation from the body. Surface structures of pathogens, such as fimbriae or capsid proteins, often bind to specific receptors or components of the mussel mucus, thereby promoting their adherence (Maalouf et al., 2011; Zannella et al., 2017). Despite the natural immune response of mussels, some microbes can integrate into the tissues or haemolymph after adherence, providing them with a protected environment that allows them to survive for long periods of time (Provost et al., 2011). The accumulation of pathogens and their resistance significantly depend on environmental factors. The survival of pathogens and the efficiency of their retention within shellfish depend on water temperature, salinity, pH and organic matter concentration (EFSA, 2012). Larger quantities of pathogens from terrestrial sources can be introduced by seasonal fluctuations, such as increased rainfall or runoff, and the concentration of zoonotic microorganisms in coastal waters is further increased by pollution from agricultural or human activities. Stressors affecting shellfish, such as exposure to pollution, overcrowding or changes

Table 3 Parasite pathogens

Parasite	Taxonomic group	Route of transmission to humans	Sickness in humans	Remark
Toxoplasma gondii	Protozoa (sporozoan)	Oocysts from cat faeces in water filtered by shellfish	Toxoplasmosis (mild to severe, dangerous for pregnant women)	Oocysts remain infectious for a long time in seawater and can persist in shell-fish tissues for weeks to months.
Giardia duodenalis	Protozoa (flagellates)	Cysts filtered from faecal contaminated water	Giardiasis (diarrhoea, bloat-ing, cramps)	Cyst viability in salt water and/or within shellfish is lower than in Toxoplasma and Cryptosporidium
Cryptosporidium spp.	Protozoa (coccidia)	Oocysts filtered from faecal contaminated water	Cryptosporidiosis (diar-rhoea, abdominal pain)	Oocysts survive for a long time, high risk for immuno-compromised individuals
Sarcocystis spp.	Protozoa (coccidia)	Sporocysts from carnivore faeces filtered by shells	Intestinal sarcocystosis (diarrhoea, cramps)	Primarily a meat-related zoonosis, shellfish can be mechanical vectors, rarely causing disease

in water quality, can weaken their immune systems, facilitating the retention of pathogens (Le Guyader et al., 2012). Some infections are particularly resistant to shellfish defence mechanisms. Parasites such as *Cryptosporidium*, viruses such as norovirus and hepatitis A, and zoonotic bacteria such as *Salmonella* and *Vibrio* species can withstand enzymatic degradation and continue to spread through tissues (Le Guyader et al., 2012). The combination of a protected environment in the tissue, specific pathogen survival strategies, and environmental conditions results in a high probability of accumulation. Such accumulation can pose a serious public health problem when contaminated shellfish are consumed raw or undercooked (Campbell et al., 2022).

Prevention and control of shellfish contamination

One of the most fertile areas for shellfish farming in the Mediterranean is the Adriatic Sea, providing an important source of income and food for coastal cities (Bratoš Cetinić 2024). In line with the principles of the "One Health" concept, the prevention of zoonotic risks requires a comprehensive and integrated approach that includes environmental protection, responsible aquaculture management, high standards of hygiene in food processing, effective surveillance systems and public awareness raising. Effective prevention starts with the management of the aquatic environment in which shellfish are farmed. Human activities, in particular the discharge of untreated wastewater and runoff from agricultural areas, are often a source of pollution of coastal and lagoon waters of the Adriatic. Coastal management plans should include strict control of wastewater discharges, regular maintenance of treatment plants and the application of advanced disinfection technologies, such as UV treatment or chlorination, to reduce the input of contaminants. In agricultural areas near shellfish farms, vegetation protection zones should be established to retain runoff with fecal bacteria (Bass et al., 2025; Bobanović-Ćolić et al., 2021). The sanitary condition of production areas is assessed by regular analyses of seawater and shellfish for the presence of indicator organisms, primarily *E. coli.* According to European regulations, only shellfish from waters of acceptable microbiological quality, according to the sanitary classification of the collection zones, may be placed on the market. Shellfish from class A zones can be consumed immediately, while those from classes B and C must undergo a purification (depuration) or relaying process before being placed on the market (EC, 2019). Considering new research demonstrating species-specific purification rate heterogeneity in bivalves, a shift towards species-specific purification strategies for bivalves from classes B and C zones is warranted to ensure food safety sustainability (Vuoso et al., 2026). Live shellfish may only be placed on the market through an approved dispatch center, where the prescribed conditions for hygienic processing and transport must be respected (Ministry of Agriculture, Forestry and Fisheries, 2022). The application of good aquaculture practices is essential to prevent the introduction and spread of pathogens in farming (Bratoš Cetinić, 2024). When selecting a location, preference should be given to areas with good water circulation and low impact from land-based sources of pollution. Rotation of farming areas and control of stocking density help to preserve water quality and reduce the accumulation of organic matter that is conducive to the survival of microorganisms (Piria et al., 2025). Strict hygiene measures must be observed during collection and transport. Traceability systems that link each batch to its collection point are essential to prevent epidemics and ensure accountability in the supply chain (Desdouits et al., 2023). The procedures that follow collection ensure greater microbiological safety of the product. The most common method used is depuration, which involves keeping live shellfish in sterile, disinfected seawater under strictly controlled conditions. This procedure is effective in reducing bacterial contamination but is not particularly effective against viruses (Campbell et al., 2022). In industrial plants, it is essential to implement a HACCP system to identify and control potential contamination risks. In accordance with ISO 22000 standards and national food safety regulations, this includes checking water sources, maintaining equipment cleanliness, and regular microbiological testing of finished products (FAO and WHO, 2024; ISO, 2018). Surveillance and monitoring systems are essential for effective prevention. Preventive measures are based on the regulatory framework established by the World Health Organization (WHO), the Food and Agriculture Organization of the United Nations (FAO), and the European Union (EU).

Laboratory procedures for sampling and diagnostics of zoonotic agents in Adriatic shellfish are essential for ensuring food safety and protecting public health. Since shellfish are filter feeders, they can bioaccumulate a wide range of microorganisms, including bacteria, viruses and parasites from the marine environment, which requires the use of precise and reliable diagnostic methods. The first step in the diagnostic process is proper sampling of shellfish from production areas. Samples must be collected sterilely and transported under controlled temperature conditions to prevent contamination or degradation before laboratory analysis (Ministry of Agriculture, Forestry and Fisheries, 2022). Standard microbiological methods based on cultivation are used to identify bacterial agents such as *Salmonella* spp., *Vibrio* spp., *Listeria monocytogenes*, *Campylobacter* spp. and *Escherichia coli*. ISO-standardized isolation procedures include incubation in selective broths and plating on differential media, for example modified carbon-cefoperazone-deoxycholate (mCCD) agar for *Campylobacter*, Xylose-Lysine-Deoxycholate (XLD) agar for *Salmonella*, and Thiosulfate-Citrate-Bile-Sucrose (TCS) agar for *Vibrio* species (Desdouits et al., 2023; Popovic et al., 2010). Additional biochemical and serological tests, such as the API 20E system and oxidase tests, are used to confirm the identity of the isolate (Džafić et al., 2025).

The identification of viral agents, especially norovirus and hepatitis A (HAV) and E (HEV), is based on molecular techniques (Bellou et al., 2013). After sample homogenization and nucleic acid extraction, reverse transcription PCR (RT-PCR) and real-time quantitative PCR (RT-qPCR) are applied. These methods enable highly sensitive and specific detection and quantification of viral contamination (Atmar et al., 1995). Quantitative results are important for infection risk assessment and decision-making in the public health system. Consistency and comparability of data are ensured by the application of standardized protocols within the networks of reference laboratories of the European Union, in accordance with Commission Implementing Regulation (EU) 2019/627 of March 15, 2019 (EC, 2019). Molecular and immunological methods such as PCR, ELISA tests and immunofluorescence microscopy are used to detect parasitic and difficult-to-cultivate pathogens. In parallel, environmental parameters such as sea temperature, salinity, turbidity and concentration of nutrients are monitored, as they significantly affect the survival and accumulation of pathogens in shellfish (Hohweyer et al., 2013). A multidisciplinary approach, combining environmental science, microbiology, molecular biology and analytical chemistry, is necessary for a comprehensive assessment of the risks that shellfish-borne zoonoses pose to public health (Desdouits et al., 2023).

In the Adriatic region, coastal states, including Italy, Slovenia, Croatia, Montenegro, and Albania, are systematically improving their capacities to respond to threats and coordinating their surveillance and control systems through joint cross-border programs, including the European Union Strategy for the Adriatic and Ionian Region (EC, 2020). However, prevention does not end at the point of production. Consumers have a key role in reducing zoonotic risk. Educational programs should emphasize the importance of proper handling, storage and heat treatment of shellfish. Consumption of raw shellfish carries certain risks, although it is part of the cultural tradition in some parts of the Adriatic. Increasing awareness of the importance of proper preparation can significantly reduce the incidence of foodborne diseases (Lattos et al., 2021).

Conclusions

The shellfish of the Adriatic Sea have exceptional nutritional and economic importance. Ability of shellfish to filter large quantities of seawater leads to the bioaccumulation of various zoonotic pathogens, namely bacteria, viruses and parasites. Shellfish are potential vectors of diseases that are transmitted to humans, especially through the consumption of raw or insufficiently thermally processed shellfish. The risks are further enhanced by the specific environmental conditions of the Adriatic Sea, which is semi-enclosed, with limited water exchange and intense anthropogenic impacts such as pollution by wastewater and agricultural runoff. Climate change and rising temperatures further favour the development of thermophilic pathogens and increase the likelihood of infections. Continuous monitoring of seawater quality, precise microbiological classification of production areas and the implementation of depuration represent fundamental measures for the prevention of zoonotic risks, along with the necessary thermal processing of shellfish. The importance of proper hygiene practices during the collection, transport and preparation of shellfish is highlighted, since microbiological contamination does not affect their organoleptic properties and contaminated products may appear safe. Raising awareness among consumers and all participants in the food chain about the safe handling of shellfish further contributes to reducing the risk of infections. The "One Health" concept provides an integrated approach that links environmental protection, food safety and public health, and encourages multidisciplinary work to reduce zoonotic threats. Sustainable management of the marine environment, the application of high sanitary standards and strict enforcement of regulations are key to preserving the safety of shellfish as a valuable natural and food resource in the Adriatic.

Remark: This paper is an excerpt from the graduation thesis Lemić, K. (2025): Adriatic shellfish as vectors of zoonotic pathogens, Faculty of Veterinary Medicine, University of Zagreb, Zagreb.

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Školjkaši Jadrana kao vektori zoonotskih patogena

Sažetak

Jadranske školjke posjeduju biološke i ekološke karakteristike koje utječu na njihovu sanitarnu sigurnost i ulogu potencijalnih vektora zoonotskih patogena. Kapacitet filtracije školjkaša, iako je bitan za njihovu prehranu, omogućuje nakupljanje bakterija, virusa i parazita prisutnih u morskom okolišu. Najvažnije vrste u Jadranu, dagnje, kamenice i brbavice, predstavljaju vrijedan izvor hrane, ali zbog česte konzumacije sirovih školjkaša predstavljaju rizik od prijenosa zoonoza na ljude. Najčešći patogeni su bakterije (*Vibrio* spp., *Salmonella* spp., *Listeria monocytogenes*, *Campylobacter* spp. i *Escherichia coli*), virusi (norovirus, astrovirus, hepatitis A i E) i paraziti (*Giardia duodenalis*, *Cryptosporidium* spp., *Toxoplasma gondii* i *Sarcocystis* spp.). Čimbenici koji utječu na nakupljanje patogena su temperatura, slanost, onečišćenje i antropogeni utjecaji. Mjere za sprječavanje i kontrolu zoonotskih rizika uključuju klasifikaciju uzgojnih područja, pročišćavanje, praćenje i laboratorijsku dijagnostiku. Poseban naglasak stavlja se na važnost integriranog pristupa „Jedno zdravlje“ koji povezuje zaštitu okoliša, sigurnost hrane i javno zdravstvo.

Ključne riječi: Jadranski školjkaši, zoonotski patogeni, sigurnost hrane

Schalentiere aus der Adria als Überträger zoonotischer Krankheitserreger

Zusammenfassung

Die biologischen und ökologischen Eigenschaften der Schalentiere aus der Adria beeinflussen ihre Lebensmittelsicherheit und ihre Rolle als potenzielle Überträger zoonotischer Krankheitserreger. Die Filterfähigkeit der Schalentiere ist zwar für ihre Nahrungsaufnahme unerlässlich, ermöglicht jedoch die Anreicherung von Bakterien, Viren und Parasiten, die in der Meeresumwelt vorkommen. Die wichtigsten Arten in der Adria – Miesmuscheln, Austern und Warzenmuscheln – stellen eine wertvolle Nahrungsquelle dar, bergen jedoch aufgrund des häufigen Verzehrs roher Schalentiere ein Risiko der Übertragung von Zoonosen auf den Menschen. Die häufigsten Krankheitserreger sind Bakterien (*Vibrio* spp., *Salmonella* spp., *Listeria monocytogenes*, *Campylobacter* spp. und *Escherichia coli*), Viren (Norovirus, Astrovirus, Hepatitis A und E) sowie Parasiten (*Giardia duodenalis*, *Cryptosporidium* spp., *Toxoplasma gondii* und *Sarcocystis* spp.). Faktoren, die die Anreicherung von Krankheitserregern beeinflussen, sind Temperatur, Salzgehalt, Umweltverschmutzung und anthropogene Einflüsse. Zu den Maßnahmen zur Prävention und Bekämpfung zoonotischer Risiken zählen die Klassifizierung von Zuchtgebieten, die Depuration, die Überwachung und die Labordiagnostik. Besonderes Augenmerk wird auf die Bedeutung des integrierten „One-Health"-Ansatzes gelegt, der Umweltschutz, Lebensmittelsicherheit und öffentliche Gesundheit miteinander verknüpft.

Schlüsselwörter: Schalentiere aus der Adria, zoonotische Krankheitserreger, Lebensmittelsicherheit

Los moluscos del mar Adriático como reservorios de patógenos zoonóticos

Resumen

Las características biológicas y ecológicas de los moluscos del mar Adriático influyen en su inocuidad sanitaria y en su papel como posibles vectores de patógenos zoonóticos. La capacidad de filtración de los moluscos, aunque esencial para su alimentación, favorece la acumulación de bacterias, virus y parásitos presentes en el medio marino. Las principales especies del mar Adriático, los mejillones, las ostras y la almeja verrugosa, constituyen un valioso recurso alimentario; sin embargo, debido al frecuente consumo de estos moluscos en estado crudo, representan un riesgo de transmisión zoonótica al ser humano. Los patógenos más frecuentes son bacterias (*Vibrio* spp., *Salmonella* spp., *Listeria monocytogenes*, *Campylobacter* spp. y *Escherichia coli*), virus (norovirus, astrovirus y los virus de la hepatitis A y E) y parásitos (*Giardia duodenalis*, *Cryptosporidium* spp., *Toxoplasma gondii* y *Sarcocystis* spp.). Los principales factores que influyen en la acumulación de patógenos son la temperatura, la salinidad, la contaminación y los impactos antropogénicos. Las medidas de prevención y control de los riesgos zoonóticos incluyen la clasificación de las zonas de producción, la depuración, la vigilancia y el diagnóstico de laboratorio. Se hace especial hincapié en la importancia del enfoque integrado «Una Sola Salud» (One Health), que vincula la protección del medio ambiente, la inocuidad de los alimentos y la salud pública.

Palabras claves: moluscos del mar Adriático, patógenos zoonóticos, inocuidad alimentaria

I molluschi bivalvi dell'Adriatico come vettori di patogeni zoonotici

Riassunto

I molluschi bivalvi dell'Adriatico possiedono caratteristiche biologiche ed ecologiche che influenzano la loro sicurezza igienico-sanitaria e il loro ruolo di potenziali vettori di patogeni zoonotici. La capacità filtrante dei molluschi bivalvi, sebbene essenziale per la loro alimentazione, consente l'accumulo di batteri, virus e parassiti presenti nell'ambiente marino. Le principali specie presenti nell'Adriatico, ossia cozze, ostriche e tartufi di mare, rappresentano una preziosa fonte alimentare, ma, a causa del frequente consumo di molluschi crudi, costituiscono anche un rischio di trasmissione di zoonosi all'uomo. I patogeni più comuni sono batteri (*Vibrio* spp., *Salmonella* spp., *Listeria monocytogenes*, *Campylobacter* spp. ed *Escherichia coli*), virus (norovirus, astrovirus, virus dell'epatite A ed E) e parassiti (*Giardia duodenalis*, *Cryptosporidium* spp., *Toxoplasma gondii* e *Sarcocystis* spp.). I fattori che influenzano l'accumulo dei patogeni comprendono la temperatura, la salinità, l'inquinamento e gli impatti antropici. Le misure per la prevenzione e il controllo dei rischi zoonotici comprendono la classificazione delle aree di allevamento, la depurazione, il monitoraggio e la diagnostica di laboratorio. Particolare enfasi è posta sull'importanza dell'approccio integrato "One Health" (Un'unica salute), che collega la tutela dell'ambiente, la sicurezza alimentare e la salute pubblica.

Parole chiave: molluschi bivalvi dell'Adriatico, patogeni zoonotici, sicurezza alimentare.