



A global synthesis of ecosystem services provided and disrupted by freshwater bivalve molluscs

Alexandra Zieritz^{1,*} , Ronaldo Sousa² , David C. Aldridge³, Karel Douda⁴, Eduardo Esteves⁵, Noé Ferreira-Rodríguez⁶, Jon H. Mageroy⁷, Daniele Nizzoli⁸, Martin Osterling⁹, Joaquim Reis¹⁰, Nicoletta Riccardi¹¹, Daniel Dailly¹², Clemens Gumpinger¹² and Ana Sofia Vaz^{13,14,15}

¹*School of Geography, University of Nottingham, University Park, Sir Clive Granger Building, NG7 2RD, Nottingham, UK*

²*CBMA – Centre of Molecular and Environmental Biology, Department of Biology, University of Minho, Campus Gualtar, 4710-057, Braga, Portugal*

³*Department of Zoology, University of Cambridge, Downing Street, Cambridge, CB2 3EJ, UK*

⁴*Department of Zoology and Fisheries, Czech University of Life Sciences Prague, Kamýcká, 129, Prague, Czech Republic*

⁵*Departamento de Engenharia Alimentar, Instituto Superior de Engenharia and CCMAR Centre of Marine Sciences, Universidade do Algarve, Estr. da Penha, 8005-139, Faro, Portugal*

⁶*Departamento de Ecología e Biología Animal, Facultad de Biología, Universidade de Vigo, Campus As Lagoas – Marcosende, 36310, Vigo, Spain*

⁷*Norwegian Institute of Nature Research, Oslo, Sognsveien 68, 0855, Oslo, Norway*

⁸*Department of Chemistry, Life Sciences and Environmental Sustainability, University of Parma, Viale delle Scienze, 11/A, 43124, Parma, Italy*

⁹*Department of Environmental and Life Sciences – Biology, Karlstad University, Universitetsgatan 2, 651 88, Karlstad, Sweden*

¹⁰*Faculdade de Ciências da Universidade de Lisboa, MARE – Marine and Environmental Sciences Centre, Campo Grande, 1749-016, Lisbon, Portugal*

¹¹*CNR-IRSA Water Research Institute, Corso Tonolli, 50, 28922, Verbania Pallanza (VB), Italy*

¹²*blattfisch e.U. – Consultants in Aquatic Ecology and Engineering, Gabelsbergerstraße 7, 4600, Wels, Austria*

¹³*CIBIO, Centro de Investigação em Biodiversidade e Recursos Genéticos, InBIO Laboratório Associado, Campus de Vairão, Universidade do Porto, 4485-661, Vairão, Portugal*

¹⁴*Departamento de Biologia, Faculdade de Ciências, Universidade do Porto, 4099-002, Porto, Portugal*

¹⁵*BIOPOLIS Program in Genomics, Biodiversity and Land Planning, CIBIO, Campus de Vairão, 4485-661, Vairão, Portugal*

ABSTRACT

Identification of ecosystem services, i.e. the contributions that ecosystems make to human well-being, has proven instrumental in galvanising public and political support for safeguarding biodiversity and its benefits to people. Here we synthesise the global evidence on ecosystem services provided and disrupted by freshwater bivalves, a heterogeneous group of >1200 species, including some of the most threatened (in Unionida) and invasive (e.g. *Dreissena polymorpha*) taxa globally. Our systematic literature review resulted in a data set of 904 records from 69 countries relating to 24 classes of provisioning ($N = 189$), cultural ($N = 491$) and regulating ($N = 224$) services following the Common International Classification of Ecosystem Services (CICES). Prominent ecosystem services included (i) the provisioning of food, materials and medicinal products, (ii) knowledge acquisition (e.g. on water quality, past environments and historical societies), ornamental and other cultural contributions, and (iii) the filtration, sequestration, storage and/or transformation of biological and physico-chemical water properties. About 9% of records provided evidence for the disruption rather than provision of ecosystem services. Synergies and trade-offs of ecosystem services were observed. For instance, water filtration by freshwater bivalves can be beneficial for the cultural service ‘biomonitoring’, while negatively or positively affecting food

* Author for correspondence (Tel.: +44 (0)115 951 5559; E-mail: alexandra.zieritz@nottingham.ac.uk).

consumption or human recreation. Our evidence base spanned a total of 91 genera and 191 species, dominated by Unionida (55% of records, 76% of species), Veneroida (21 and 9%, respectively; mainly *Corbicula* spp.) and Myoida (20 and 4%, respectively; mainly *Dreissena* spp.). About one third of records, predominantly from Europe and the Americas, related to species that were non-native to the country of study. The majority of records originated from Asia (35%), with available evidence for 23 CICES classes, as well as Europe (29%) and North America (23%), where research was largely focused on ‘biomonitoring’. Whilst the earliest record (from 1949) originated from North America, since 2000, annual output of records has increased rapidly in Asia and Europe. Future research should focus on filling gaps in knowledge in lesser-studied regions, including Africa and South America, and should look to provide a quantitative valuation of the socio-economic costs and benefits of ecosystem services shaped by freshwater bivalves.

Key words: biofiltration, biomonitoring, *Corbicula*, cultural services, *Dreissena*, ecosystem services, freshwater mussels, provisioning services, regulating services, Unionida.

CONTENTS

I. Introduction	3
II. Literature search and review	4
(1) Data collection	4
(2) Data visualisation	4
III. General description of the data set	4
(1) Taxonomic trends	4
(2) Geographical trends	6
(3) Temporal trends	6
IV. Provisioning ecosystem services	7
(1) Nutrition	7
(a) Captured and cultivated food	7
(b) Food production	8
(2) Materials	9
(a) Material production	9
(b) Tools	9
(3) Medicinal	9
(4) Energy	9
V. Cultural ecosystem services	9
(1) Knowledge	9
(a) Biomonitoring	9
(b) Palaeoenvironment	10
(c) Archaeology	10
(d) Biomimicry	11
(e) Social education	11
(2) Attitudes and other interactions	11
(a) Spiritual, symbolic and religious	11
(b) Tradition	11
(3) Aesthetic experiences	11
(4) Physical interactions	11
VI. Regulating ecosystem services	11
(1) Regulation of organisms	12
(a) Algae	12
(b) Bacteria	12
(c) Diseases	12
(2) Mediation of human inputs	12
(a) Filtration and sequestration	12
(b) Transformation	13
(3) Physico-chemical regulation	13
(a) Storage and excretion	13
(b) Water clearance	13
VII. Discussion	14
(1) Temporal and geographic trends	14
(2) Synergies and trade-offs among FB ecosystem services	14

VIII. Conclusions	15
IX. Acknowledgements	15
X. References	15
XI. Supporting information	32

I. INTRODUCTION

The concept of Ecosystem Services (ESs), i.e. ‘the contributions that ecosystems make to human well-being’ (Haines-Young & Potschin, 2018, p. 9), has proven instrumental in galvanising public and political support for biodiversity conservation (MEA, 2005). Based on the latest *Common International Classification of Ecosystem Services* (CICES; Haines-Young & Potschin, 2018), ESs include the provisioning of material and energy needs (provisioning ESs), non-material characteristics of ecosystems that affect physical and mental states of people (cultural ESs), and regulation and maintenance of the environment for humans (regulating ESs). Although the importance of ESs extends beyond their economic value, estimates indicate an ESs worth of €171,521 million in the European Union for 2012 (Vysna *et al.*, 2021), at least US\$ 250 billion/year for pollination services globally (IPBES, 2019), and an expected worldwide loss of US\$ 9.87 trillion by 2050 due to environmental change (Roxburgh *et al.*, 2020). Even though much progress has been made (e.g. Green & ElMBERG, 2014; Rodrigues *et al.*, 2020; Brock, Cini & Sumner, 2021), understanding how different animal groups contribute to ESs is far from complete, particularly with respect to freshwater invertebrate taxa (Collier, Probert & Jeffries, 2016; IPBES, 2019).

Freshwater bivalves (FBs) are among the most abundant groups of invertebrates in freshwater ecosystems globally and can make up more than 90% of the benthic (i.e. bottom-dwelling) biomass (Okland, 1963; Sousa *et al.*, 2008). FBs comprise >1200 species spread across taxonomically and biologically distinct groups, with most species (72%) belonging to the strictly freshwater order Unionida (Lopes-Lima *et al.*, 2018). Due to their (semi)infaunal, suspension-feeding life habit and complex life cycle, involving a parasitic larval stage, Unionida are particularly sensitive to anthropogenic habitat degradation and represent one of the most threatened taxonomic groups. Forty species are already presumed extinct (Lopes-Lima *et al.*, 2018; IUCN, 2021), including eight species recently declared extinct by the U.S. Fish and Wildlife Service (The Center for Biological Diversity, 2021). By contrast, several notoriously invasive species are known within the Unionida (e.g. *Simanodonta woodiana*) and more commonly, non-unionid FB orders, including the Ponto-Caspian myoid zebra and quagga mussels (*Dreissena polymorpha*, *Dreissena bugensis*), the veneroid Asian clam (*Corbicula fluminea*) and the mytiloid golden mussel (*Limnoperna fortunei*), native to East and South-east Asia (Sousa *et al.*, 2014). These species often displace or replace native FB species in invaded regions, which has resulted in severe population losses of Unionida in, for

example, the Laurentian Great Lakes and large stretches of European mainland river basins (Strayer, 1999; Sousa *et al.*, 2014). Owing to their different life histories and ecology, invasive FBs often attain much greater biomass than native FBs and can cause severe ecological and economic damage (Strayer, 1999; Sousa *et al.*, 2014; Haubrock *et al.*, 2022).

Research and conservation of FBs is commonly justified by the important ecosystem functions and services that they provide (Lopes-Lima *et al.*, 2018). However, the available scientific evidence for FB–ES associations has never been comprehensively reviewed and systematised. Adopting the ES designations of the *Millennium Ecosystem Assessment* (2005), Vaughn (2018) identified three provisioning (i.e. food for humans, food for other species, products from shells), two cultural (i.e. cultural and existence value), one regulating (i.e. biofiltration) and four supporting ESs (i.e. nutrient cycling and storage, habitat/habitat modification, environmental monitoring, food webs) provided by FBs (see also Vaughn & Hoellein, 2018). Whilst these works represent an important first step towards assessing the ESs of FBs, they are not comprehensive, largely restricted to a single continent (North America) and taxonomic group (Unionida), and strongly focused on supporting services, which are not regarded as ESs *per se* by CICES (Haines-Young & Potschin, 2018). In addition, the available evidence on FBs disrupting rather than providing ESs has never been reviewed to date, although attempts have been made to quantify both ES provisions and disruptions, particularly of non-native FBs (Limburg *et al.*, 2010).

A comprehensive, systematic review of the global scientific evidence is needed not only to provide a more complete understanding of the ESs provided and disrupted by FBs, but also to understand temporal and geographic trends across specific ESs and taxa, and identify gaps in our current knowledge and areas of importance for future research. Considering the ongoing and predicted future spread of non-native FBs in many regions of the world (Gallardo *et al.*, 2018; Petsch *et al.*, 2021), a better understanding of the differences and similarities in ESs provided and disrupted by native and non-native species is therefore of particular urgency.

This study provides a systematic review of the available evidence for ESs associated with FBs. Its specific objectives were to (i) synthesise ESs that are associated with FBs; (ii) quantify the available evidence across temporal and geographic scales, taxonomic groups, native *versus* non-native species, and types of ESs; and, on that basis; (iii) derive novel insights into the importance of FBs to humans; and (iv) identify current shortcomings in our knowledge and recommend future directions for research.

II. LITERATURE SEARCH AND REVIEW

(1) Data collection

Data on published evidence of associations between FBs and ESs were derived from a scientific literature search conducted in *ISI Web of Science* (ISI WOS; <http://webofknowledge.com/>) and *Scopus* (<https://www.scopus.com/>) search engines in June 2020 and updated in March 2021, using an exhaustive compilation of search terms (Appendix S1). Search terms referring to FBs included common terms/names [e.g. ‘freshwater’ AND (‘mussel’ OR ‘clam’)], and scientific names of all known bivalve genera as well as species within predominantly marine genera that complete their life cycles in fresh water as provided by Graf & Cummings (2021). Search terms referring to ESs included general terms (e.g. ‘environment* function*’ OR ‘ecosystem service’) as well as terms referring to specific ESs that are potentially associated with FBs, including provisioning (e.g. ‘food’ OR ‘material’), regulating (e.g. ‘water quality’ OR ‘biological control’) and cultural (e.g. ‘ornamental’ OR ‘recreation’) ESs (Haines-Young & Potschin, 2018). The search string started with the most general terms on FBs and ESs, followed by step-by-step addition of new, more specific terms. If the new search resulted in a higher number of outputs, the new term was retained, otherwise it was removed. Studies written in English, German, French, Italian, Romanian, Portuguese, Spanish, Czech and Slovakian, and published up to and including 31 December 2020 were considered.

Published studies retrieved *via* ISI WOS and *Scopus* searches were combined, and duplicates removed. Relevant records (i.e. pieces of evidence for an association between FB(s) and a specific ES) were identified by applying the following inclusion and exclusion criteria. In general, only records that reported primary evidence for an association between FBs (i.e. species/genera that complete their life cycles in fresh water) and ESs were retained. Therefore, records based on secondary evidence (e.g. in literature reviews or meta-analyses) were excluded to avoid double-counting. Definition of ESs followed CICES (Haines-Young & Potschin, 2018) and thus, evidence for ecological functions of FBs without explicit implications on human well-being were excluded.

To allow reproducibility, ESs reported in the literature were classified following CICES (Haines-Young & Potschin, 2018) employing a three-level hierarchical system (Table 1). In addition, we extracted data on the geographic location (i.e. country/region and continent; Appendix S2) and taxonomic name(s) (i.e. order, genus and species) of FBs from each record where available. Based on that information, the FB taxon/taxa of each record was/were categorised as native or non-native to the country of study using information on native species distributions from Graf & Cummings (2021) and CABI (2021). Finally, information was extracted from each record on whether the FB(s) was/were reported by the authors as a provider and/or disruptor,

i.e. promoting and/or diminishing the quality or quantity of the respective ES.

(2) Data visualisation

The number of records per year of publication was plotted as smoothing curves (averages for 2-year time periods) between 1949 (the first case study reported in our data set) and 31 December 2020. Sankey diagrams were generated to illustrate the relative quantity of and linkage among records on different ES categories based on different continents of study, status (native *versus* non-native), effect (provider *versus* disrupter) and/or taxonomic order of study species using the R-package ‘d3Network’ (Gandrud, 2015).

III. GENERAL DESCRIPTION OF THE DATA SET

A total of 6745 published studies were retrieved using our search terms. After the application of exclusion and inclusion criteria, the final data set comprised 684 studies (see Appendix S3 for a full list of studies) and 904 records (i.e. pieces of evidence for association between FBs and specific ES classes as defined in Table 1). In total, we identified evidence for 24 CICES classes of provisioning, cultural and regulating ESs that are associated with FBs (Table 1). A total of 146 studies provided evidence for more than one ES class, with up to five records being extracted from a single publication. Cultural ESs were the most represented ($N = 491$), followed by regulating ($N = 224$) and provisioning services ($N = 189$) (Fig. 1A; Table 1). Evidence was strongly skewed towards FBs as providers (91%) rather than disrupters (9%), with evidence for disruption being largely restricted to provisioning (~5%) and regulating ESs (~4%; Fig. 1A).

(1) Taxonomic trends

Evidence came from a total of 91 genera and 191 species across seven bivalve orders, dominated by Unionida (76% of species), followed by Sphaerioida and Veneroida (each 9%), Myoida (4%), Cardioida, Myalinida and Mytiloida (each <1%). Whilst available evidence was also largely based on Unionida (55% of records), a considerable proportion of records related to Veneroida (21%) and Myoida (20%), respectively. At the genus and species levels, records were strongly skewed towards non-Unionida. Thus, 20% of records referred to each of the myoid genus *Dreissena* and the veneroid genus *Corbicula*, respectively, followed by the unionid genera *Unio* (11%) and *Sinohyriopsis* (4%). The most represented species in the data set were *D. polymorpha* and *C. fluminea* (18% of records each), followed by the unionid *Sinohyriopsis cumingii* (4%). Whilst almost two thirds (62%) of records referred to species that were native rather than non-native (38%) to the respective country of study, 60% of records on disrupting ESs were based on non-native species (Fig. 1A). Records pertaining to non-native species were

Table 1. Hierarchical classification and description of ecosystem services (following Haines-Young & Potschin (2018)) found to be associated with freshwater bivalves in the published literature.

Section	Group	Class (CICES code)	Description	% of records		
Provisioning	Energy	Energy production (1.1.4.3)	Bivalves used in the provision of energy for human use	<1		
		Materials	Material production (1.1.4.2; 1.1.6.2)	Bivalves or their parts used to support the production of other materials (excluding ornaments)	2	
	Medicinal		Tools (1.1.4.2; 1.1.6.2)	Bivalves or their parts used as tools (excluding ornaments)	2	
			Biophysical products (1.1.4.2; 1.1.6.2)	Use of biophysical products of bivalves (excluding genetic material) for medicinal or therapeutic purposes	2	
	Nutrition	Genetic/protein information (1.2.2.3)	Use of genetic or protein information from bivalves for medicinal or therapeutic purposes	3		
		Captured food (1.1.6.1)	Cultivated food (1.1.4.1)	Bivalves captured in the wild as food for direct human consumption	6	
			Food production (1.1.4.1; 1.1.6.1)	Bivalves cultivated as food for direct human consumption	2	
	Cultural	Aesthetic experiences	Ornamental (3.1.2.4)	Bivalves (captured or cultivated) influencing the production of other edible organisms supporting human diets	4	
			Spiritual, symbolic and religious (3.2.1.1; 3.2.1.2)	Ornamental (3.1.2.4)	Bivalves or their parts providing ornamental benefits to humans	3
				Tradition (3.1.2.3)	Bivalves or their parts providing symbolic, spiritual or religious meaning to society	1
Knowledge		Archaeology (3.1.2.1)	Characteristics of bivalves that are resonant in terms of cultural heritage and traditions of human communities	1		
		Biomimicry (3.1.2.1)	Bivalves enabling acquisition of knowledge about past human societies and communities	4		
		Biomonitoring (3.1.2.1)	Use of bivalve morphology, physiology and/or behaviour in the design and production of other materials	<1		
		Paleoenvironment (3.1.2.1)	Bivalves enabling acquisition of knowledge about water quality for human benefit	34		
Regulating		Physical interactions	Social education (3.1.2.1)	Bivalves enabling acquisition of knowledge about past environments	9	
			Recreation (3.1.1.1; 3.1.1.2)	Social education (3.1.2.1)	Bivalves contributing to social education and training	<1
				Recreation (3.1.1.1; 3.1.1.2)	Bivalves affecting human physical interactions with nature, including leisure and recreational activities	1
	Regulation of organisms	Algae (2.2.3.1)	Bivalves affecting prevalence and concentration levels of algae, including blue-green algae (cyanobacteria), that affect human health and amenity value of waterbodies	7		
		Bacteria (2.2.3.1)	Bivalves affecting prevalence and concentration levels of bacteria that affect human health and security	2		
		Diseases (2.2.3.2)	Bivalves affecting prevalence and concentration levels of human diseases (e.g. gastroenteritis) due to interactions with pathogenic organisms (e.g. viruses, protozoan parasites) that affect human health and security	1		
	Mediation of human inputs	Filtration and sequestration (2.1.1.2)	Bivalves filtering, sequestering, accumulating or storing harmful wastes of human origin	8		
		Transformation (2.1.1.1)	Bivalves transforming or decomposing harmful wastes of human origin	1		
		Physico-chemical regulation	Storage and excretion (2.2.5.1; 2.2.5.2)	Bivalves contributing to removal or addition of organic or inorganic substances (e.g. sediments and nutrients) with implications for recreational activities or human health	4	
	Water clearance (2.1.2.1; 2.1.2.3)		Bivalves changing the physical properties of water quality with implications for recreational activities and/or human health	3		

largely dominated by the genera *Dreissena* (62%) and *Corbicula* (28%), and additionally included *Sinanodonta* (5%, Unionida), *Limnoperna* (4%, Mytiloidea), *Amblema* (<1%, Unionida) and *Mytilopsis* (<1%, Myoidea). The vast majority of records on

Dreissena and *Limnoperna* originated from countries where these genera are not native (i.e. 95 and 88% of records, respectively), whilst this was true only for about half of the records on *Sinanodonta* (51%) and *Corbicula* (42%).

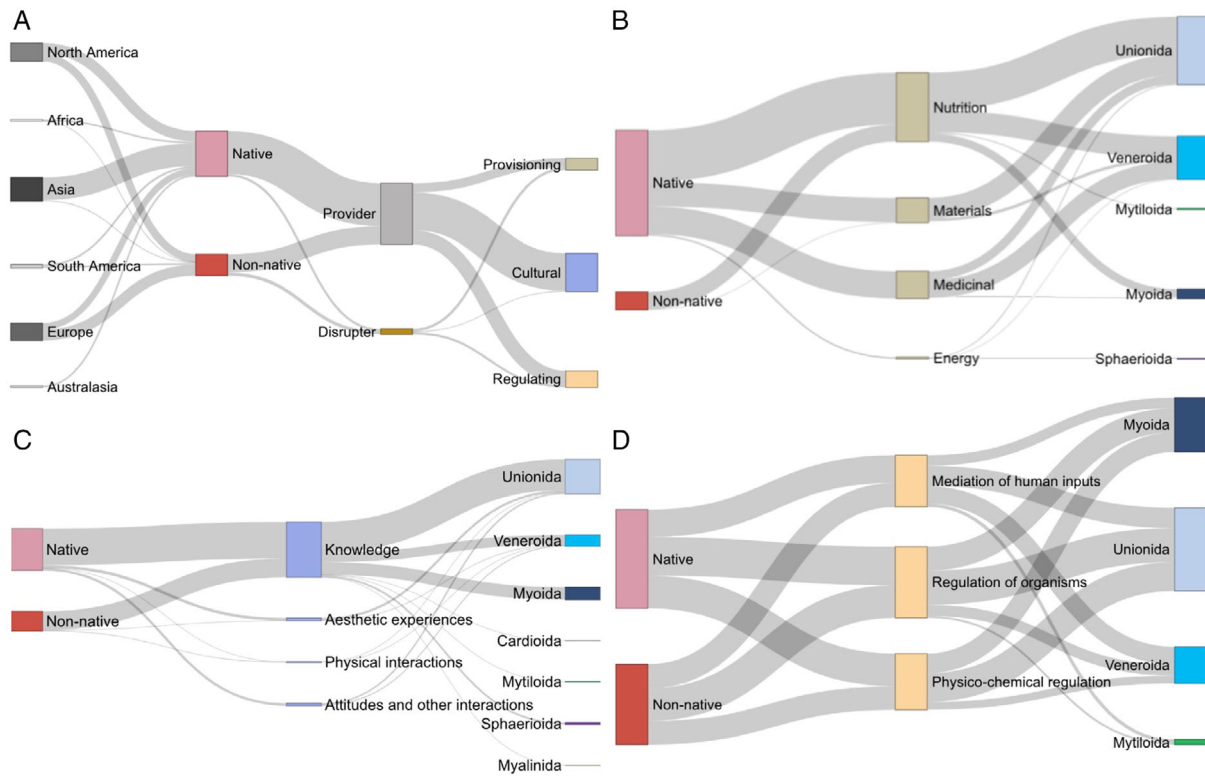


Fig. 1. Linkages among the relative quantity of published records providing primary evidence for an association between freshwater bivalves and specific sections and groups of ecosystem services (sensu Haines-Young & Potschin, 2018) based on different continents of study and/or status (native *versus* non-native), effect (provider *versus* disrupter) and/or taxonomic order of study species. (A) Linkages among continent of study, status and effect of species, and ecosystem service section across all 904 published records. (B–D) Linkages among status and taxonomic order of species, and ecosystem service-group of (B) provisioning ($N = 189$), (C) cultural ($N = 491$) and (D) regulating ($N = 224$) services.

(2) Geographical trends

Evidence was collected from a total of 69 countries, with 18% of records originating from the USA, followed by China (13%), France and Canada (each 5%). On the continent level, most records originated from Asia (35%), Europe (29%) and North America (23%), whilst records from Africa (2%), Australasia (3%) and South America (6%) were scarce (with 2% of records not providing this information; Figs 1A and 2A). Research has been strongly focused towards cultural ESs in Africa, Europe, North America, South America and Australasia (48–89% of overall records), whilst in Asia, provisioning, regulating and cultural ESs contributed to records in almost equal amounts (Fig. 2A). Asia also provided the widest range of evidence, with available evidence for 23 of the 24 CICES classes (i.e. all except ‘Social education’; Table 1) compared with lower coverage from Europe (19), North America (16), South America (14), Australasia (9) and Africa (7). Records from Asia, Africa and Australasia were almost exclusively focused on native species (>95%), whilst a considerable proportion of records from Europe, North America and South America related to non-native species (<52% natives) (Fig. 1A).

(3) Temporal trends

Annual publication of studies reporting FB–ES associations generally increased through the years, with the earliest found paper published in 1949 (Fig. 2B,C). The first evidence for non-native species was published in 1980 (Fig. 2C). The rate of acquisition of evidence for non-native species increased markedly in the early 1990s and has been increasing relatively steadily since (Fig. 2C). The rate of record publication on native species and Unionida increased considerably in the mid 2000s (Fig. 2C). Since the turn of the century, annual record output remained relatively stable for the Myoidea (dominated by usually non-native *Dreissena* spp.) and Sphaeroidea, but increased notably for Veneroidea (largely dominated by *Corbicula* spp.; Fig. 2C).

Whilst the first record from North America dates from 1949, first records from the other continents are more recent, spanning from 1977 (Asia) to 1982 (Europe), 1983 (Africa), 1989 (Australasia) and 1995 (South America) (Fig. 2B). Annual publication of ES records from North America has been relatively constant for the past 20+ years, while records from Europe have increased over the same period, particularly with regard to cultural ESs (Fig. 2B). Rate of publication

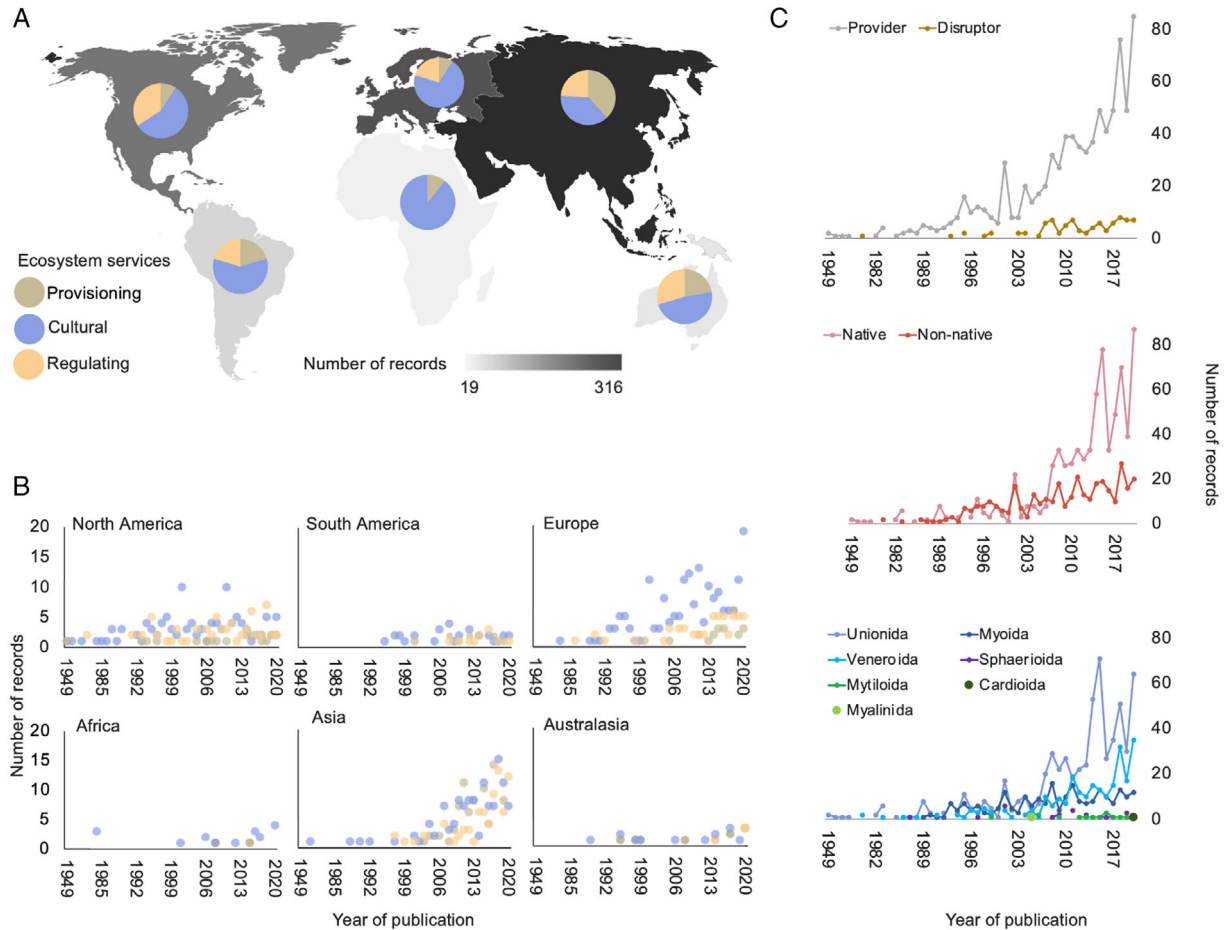


Fig. 2. Geographic and temporal patterns of published records providing primary evidence of an association between freshwater bivalves and specific sections of ecosystem services (*sensu* Haines-Young & Potschin, 2018). (A) Heatmap of total number of records per continent with pie charts showing the relative proportions of the three ecosystem service sections. (B,C) Number of records per year of publication (B) per continent grouped by ecosystem service sections, and (C) grouped based on whether freshwater bivalves acted as ecosystem service providers or disruptors (top panel), bivalve status (native or non-native; middle panel), and taxonomic order (bottom panel). Values from 1949 to 1985 are condensed along the *x*-axes relative to those from 1985 to 2020 for ease of visualisation.

for Asia has been increasing rapidly for the past ten years across all three ES sections (Fig. 2B).

IV. PROVISIONING ECOSYSTEM SERVICES

Based on our database, FBs are associated with four groups of provisioning ESs (PESs), i.e. Nutrition (56% of PES records), Medicinal (24%), Materials (19%) and Energy (1%) (Table 1, Fig. 1B). Records on PESs are disproportionately associated with native rather than non-native species, and better represented by Veneroidea (*Corbicula*) and Unionida rather than Myoidea (*Dreissena*), Mytiloidea and Sphaeroidea (compare Fig. 1B with Fig. 1A,C,D). With respect to PES groups, native species were disproportionately associated with Materials and Medicinal PESs, whilst non-native species were disproportionately associated with Nutrition

(Fig. 1B) and disruption of PESs (Fig. 1A). Trends were also apparent across taxa, e.g. Veneroidea (*Corbicula*) was disproportionately associated with nutritional and medicinal PESs, Unionida with Nutrition and Materials, and Myoidea (*Dreissena*) with Nutrition (Fig. 1B).

(1) Nutrition

Nutritional PESs fulfilled by FBs include the direct use of FBs captured in the wild (30%) or cultivated (8%) as a food source for humans, and the association of FBs with the production of other edible organisms supporting human diets (18%) (Table 1).

(a) Captured and cultivated food

Captured and, in some cases, cultivated veneroid and unionid species provide an important food source for – often

vulnerable – communities across large parts of Asia, including Cambodia (Ngor *et al.*, 2018), China (Zeng *et al.*, 2019; Fig. 3A), India (Sonowal & Kardong, 2020), Indonesia (Lukman *et al.*, 2019), Japan (Horikoshi, 2020) and Malaysia (Zieritz *et al.*, 2018a; Rak *et al.*, 2020a), as well as, for example, Western Africa (Akélé *et al.*, 2015). On other continents, records on FBs as a source of food are often historical, referring to, for example, ancient/indigenous communities in North America (Theler & Hill, 2019), Australia (Garvey, 2017) and Europe (Nicodemus, 2011). However, due to high bioaccumulation rates in FBs, consumption of FBs from polluted sites can also have adverse effects on

human health due to, for example, elevated persistent organic pollutant levels (Takabe *et al.*, 2012), and heavy metal (Ghosh *et al.*, 2020b) and radionuclide poisoning (Martin *et al.*, 1998) (Fig. 1A).

(b) Food production

The effect of FBs on other edible organisms or other food can be beneficial as well as disruptive for human well-being. Examples for beneficial ES effects include the use of FBs, including non-native species, as chicken feeds (McLaughlan, Rose & Aldridge, 2014; Bayerle *et al.*, 2017),

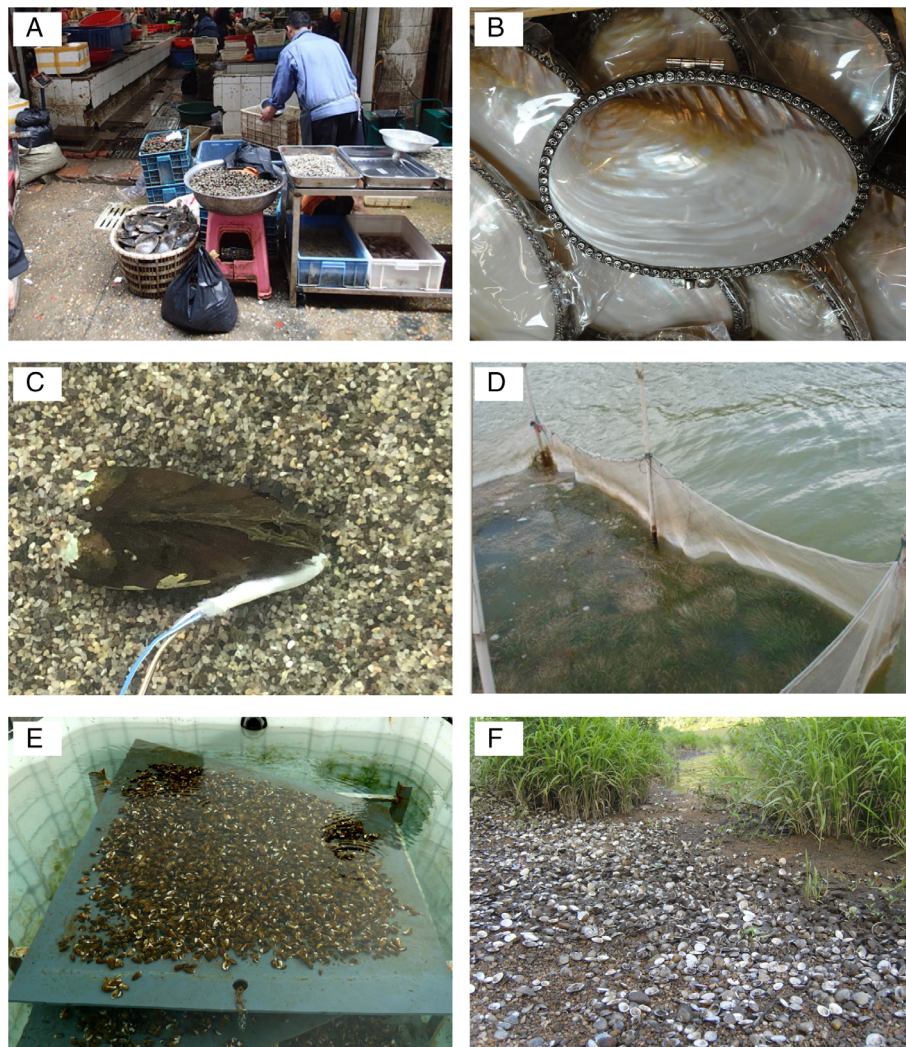


Fig. 3. Examples of freshwater bivalves providing (A–E) and disrupting (F) ecosystem services. (A) Freshwater bivalves from Poyang Lake, China, being sold as a food source (credit: K. Douda). (B) Ornamental purse made of the nacreous layer of *Cristaria* sp. for sale at Chatuchak Market, Bangkok, Thailand (credit: U. Kovitvadih & S. Kovitvadih). (C) *Unio elongatulus* equipped with valvometer used for biomonitoring of water quality (credit: N. Riccardi). (D) Effect of *Sinadondonta woodiana* on water clarity in Lake Dianchi, China. Mussels were placed into the enclosure and their filtration improved water clarity to the extent that bottom-rooting macrophytes could establish from the seed bank on the lake bed (credit D.C. Aldridge). (E) Non-native *Dreissena polymorpha* attached on acrylic glass panels, which were inserted in a pilot-plant in Milan, Italy, resulting in the removal of pharmaceuticals, drugs of abuse and heavy metals from civil wastewaters (credit: A. Binelli). (F) Disruption of the recreational value of the beach of the Minho River, Portugal, by dense aggregations of non-native *Corbicula fluminea* shells after a massive die-off event (credit: R. Sousa).

as diffusers of antibiotic resistance in trout aquaculture (Sicuro *et al.*, 2020), and – in the form of shell powder – as antimicrobial agents in soybean curd preservation (Yang *et al.*, 2019). Disruptive effects in this respect mostly refer to non-native FBs, including the observed decrease of commercially harvested fish following introduction of *Dreissena* spp. to habitats in North America (Fera, Rennie & Dunlop, 2017; Hansen *et al.*, 2020) and reduced productivity of shrimp farms in Colombia due to the invasive myoid *Mytilopsis trautwineana* (Aldridge *et al.*, 2008).

(2) Materials

Records refer to the use of FBs or their parts in the production of other materials (11%) or tools (7%) without explicit or exclusive ornamental value (Table 1).

(a) Material production

Notable examples include studies investigating the potential application of FB shells or their derivatives as filling material in construction (Li *et al.*, 2013b; Chakraborty *et al.*, 2020), as adsorbents of dyestuffs (Figueiredo, Loureiro & Boaventura, 2005) or purifiers of peat water (i.e. *via* hydroxyapatite synthesised from *Corbicula molhikiana* shells; Alif, Aprillia & Arief, 2018). Evidence for actual use of FBs in material production is relatively scarce, with the use of nacre in button production arguably being the most significant, particularly with respect to historical communities (Haag, 2012; Strack, 2015; Sakalauskaite *et al.*, 2019) but also including contemporary societies, such as fishermen in the Tocantins River, Brazil (Beasley, 2001).

(b) Tools

Evidence for the use of FBs as tools is completely restricted to historical communities, pertaining to the use of shells and pearls as, for example, knives, scrapers (e.g. to skin animal hides, scaling of fish, scraping plant material for string/fishnet production) and tools for shaping pottery vessels during the Pleistocene and pre-historic times across all continents (Leechman, 1949; Jackson & Jackson, 2008; Romanus *et al.*, 2008; Debryne, 2010; Weston, Szabó & Stern, 2017; Mărgărit, Mirea & Radu, 2018).

(3) Medicinal

Records pertaining to the use of FBs for medicinal purposes refer to genetic/protein information (15%) and biophysical products (10%) (Table 1), and originate almost exclusively (89%) from Asia. A large number of studies in this category are based on *C. fluminea* from Eastern Asia (China, Taiwan, Japan), where this species has been used in Traditional Chinese Medicine and has been shown to exhibit anti-inflammatory (Yeh *et al.*, 2017), neuroprotective (Hsieh *et al.*, 2017), hypotensive (i.e. reducing blood pressure; Tsai *et al.*, 2006), hepato-protective and antioxidant effects (Bai *et al.*, 2020), and the ability to reduce cholesterol levels (Chijimatsu *et al.*, 2011) and improve wound healing

(Peng *et al.*, 2017). Some notable examples of medicinal ESs of other FB species include therapeutic effects of *Pisidium corneum* and *Lamellidens marginalis* on bone diseases (osteoporosis and arthritis, respectively) (Chakraborty *et al.*, 2010; Choi *et al.*, 2019), and properties of *S. cumingii* concerned with wound repair (Dai *et al.*, 2010) and immunoenhancement (Qiao *et al.*, 2016). An example for the medicinal use of a biophysical FB product is the use of shells or their derivatives in dental implants (Wang *et al.*, 2006; Zhu *et al.*, 2011).

(4) Energy

Finally, two studies from Asia provided evidence for the potential use of FBs in energy provision, including the suitability of *S. woodiana* shells as an economic catalyst for biodiesel (Chinese tallow oil) production (Hu, Wang & Han, 2011).

V. CULTURAL ECOSYSTEM SERVICES

The vast majority of records for cultural ESs (CESs) are concerned with the acquisition of knowledge from FBs (using FBs as instruments rather than objects of research; 88%), whilst evidence for their relevance to aesthetics (6%), people's attitudes and other interactions (5%), and physical interactions (1%) is comparatively scarce (Fig. 1C, Table 1). Representation of non-native species was largely confined to knowledge acquisition, whilst evidence for FBs providing benefits in terms of attitudes, aesthetics and other interactions was almost exclusively based on native species (Fig. 1C).

(1) Knowledge

Within this group of studies, most records were associated with the use of FBs for the acquisition of knowledge about current water quality (i.e. CICES class 'biomonitoring'; 63%), but also on palaeoenvironments (16%), past human societies and communities ('archaeology'; 8%), optimisation of production of other materials ('biomimicry'; 1%) and social education (<1%) (Table 1).

(a) Biomonitoring

Due to their high filtration capacity and consequently, bioaccumulation rates, coupled with often high population densities that facilitate the collection of adequate replicate samples (Vaughn, 2018), FBs are popular organisms in biomonitoring studies that assess spatial and temporal patterns of water quality, including the location of pollution sources and quantification of the effects of remedial (e.g. establishment of a water treatment plant) or destructive actions (e.g. pesticide spill). Non-native species, in particular, *D. polymorpha*, *D. bugensis* and *C. fluminea* in Europe and North America, are commonly used in this context due to their ability to survive in poor water quality habitats (Sousa *et al.*, 2014).

Many of these records are based on the quantification of concentrations in mussel tissues and/or shells of, for example,

heavy metals (Johns, 2001; Lukashev, 2008; Reis *et al.*, 2014; Labuschagne *et al.*, 2020), organic/chemical compounds (e.g. insecticides, pesticides, organotins, persistent organic compounds, organic halogens, polycyclic aromatic hydrocarbons, hormones) (Hayer, Wagner & Pihan, 1996; Regoli *et al.*, 2001; Richman & Somers, 2010; Khazri *et al.*, 2016; Bai & Acharya, 2019; Lécivain *et al.*, 2020), microplastics (Su *et al.*, 2018) and radionuclides (Bollhöfer, 2012). In other studies, authors provide information about water quality by quantifying biomarkers that are proxies for physiological stress, including glutathione S-transferase, glutathione reductase activity or DNA damage (de Lafontaine *et al.*, 2000; Binelli *et al.*, 2006; Contardo-Jara & Wiegand, 2008; Michel *et al.*, 2013; Klimova *et al.*, 2017; Bonnail *et al.*, 2018; Bonnail, Macías & Osta, 2019a). Behavioural and physiological indicators, such as valve movement and heart rate recovery time, have become increasingly popular tools for early detection and real-time monitoring of water quality (Fig. 3C; Mouabad *et al.*, 2001; Tran *et al.*, 2007; Chen *et al.*, 2010; Jou *et al.*, 2016; Zarykhta *et al.*, 2019), and are commercially available (de Zwart, Kramer & Jenner, 1995). FBs have also been suggested as early warning systems for the presence of (neuro)toxins [e.g. those produced by phytoplankton (Wood *et al.*, 2006; Lepoutre *et al.*, 2020b)], and human pathogens and diseases, such as microsporidia (Lucy *et al.*, 2008), *Escherichia coli* (Selegan *et al.*, 2001), and other bacteria (Graczyk *et al.*, 2001) and protozoa (Géba *et al.*, 2020a). Other, more scarcely applied indicators used in FB biomonitoring of water quality include simple presence/absence of (indicator) species (Chazanah *et al.*, 2020), morphological condition indices, including growth rates (Cataldo *et al.*, 2001a; Thitiphuree *et al.*, 2013), and Na:Cl ratios in shells as indicator of road salt pollution (O'Neil & Gillikin, 2014). In some cases, long-term monitoring programs utilising one or more of the indicators described above (e.g. concentrations in tissue/shells, valve movement) have been put in place using caged FBs, e.g. in pulp and paper mill recipient watercourses of Finland (1984–1998 using *Anodonta anatina*; Herve, Paasivirta & Heinonen, 2001), in Lake Maggiore, Italy (1996–2008 using *D. polymorpha*; Riva *et al.*, 2010), and in the Niagara River, North America (1983–2009 using *Elliptio complanata*; Richman *et al.*, 2011).

(b) Palaeoenvironment

Due to their calcareous shells, FBs can also be used as archives of past environmental conditions (Vaughn, 2018). In their simplest form, these palaeoenvironmental reconstructions are based on data on the presence or relative abundances of FB species, which are used to infer the prevalent climatic, hydrological or other environmental conditions at the time and site. Many of these records refer to relatively recent, i.e. Holocene (0.01–0 Mya) and Pleistocene (2.6–0.01 Mya), deposits, including those from Turkey (Kuzucuoğlu *et al.*, 1997), Lithuania and Belarus (Sanko, Gaigalas & Yelovicheva, 2011), the Arabian Peninsula

(Matter *et al.*, 2015) and China (Noda *et al.*, 2007). Other records refer to older strata, starting from the Pliocene [5–2.6 Mya; e.g. Omo-Turkana Basin, Kenya (Van Bocxlaer, 2020)], to the Miocene [23–5 Mya; e.g. Austria (Harzhauser & Tempfer, 2004) and the Andes (Cadena & Casado-Ferrer, 2019)], and as far back as the Oligocene (34–23 Mya), Eocene (56–34 Mya), Cretaceous (145–66 Mya) and Jurassic (201–145 Mya) of e.g. North America (Pierce & Constenius, 2001; Good, 2004; Montgomery & Barnes, 2012) and the British Isles (Andrews & Walton, 1990). In a few cases, authors have used intraspecific variation in morphological characteristics, such as the shape of the shell (Eagar, 1948) or relative growth rate (Black *et al.*, 2010), to reconstruct palaeoenvironments. However, considering the incomplete understanding of how shell shape, size and sculpture is related to specific environmental conditions and functions in and across contemporary species (Zieritz & Aldridge, 2009; Levine, Hansen & Gerald, 2014), the value of fossilised specimens in this respect is currently restricted.

A rather widespread approach is the use of stable isotope ratios (mostly of oxygen and/or carbon) in (sub)fossil FB shells to reconstruct palaeoenvironmental (mostly palaeoclimatic) conditions. These usually refer to the Holocene, e.g. from Egypt (Hassan *et al.*, 2012), Hungary (Schöll-Barna *et al.*, 2012), Italy (Baroni *et al.*, 2001), Argentina (Pérez *et al.*, 2020) and the USA (Tevész *et al.*, 1997; Yu *et al.*, 2008), and less frequently, to earlier epochs (e.g. Eocene USA; Buskirk *et al.*, 2016). The regularity of annual shell formation of FBs in non-tropical regions, leading to the formation of visible annual shell rings, further provides the opportunity to evaluate changes in e.g. isotope composition at high temporal (i.e. annual or even intra-annual seasonal) resolution. Such a 'sclerochronological' approach has been applied on (sub)fossil shells, e.g. from Holocene Syria (Çakırlar & Şeşen, 2013), Holocene Turkey (Lewis *et al.*, 2017) and Miocene Amazon (Kaandorp, Wesselingh & Vonhof, 2006), but also on contemporary specimens, such as *Margaritifera margaritifera*, which can attain lifespans of >200 years (Schöne *et al.*, 2020). In a combined sclerochronological analysis of archaeological, recent and contemporary FB shells (*Amblema plicata* and *Quadrula quadrula*), Fritts *et al.* (2017) constructed an environmental archive of the Illinois River, USA, spanning the past 1000 years.

Evidence of the use of FBs in palaeoenvironmental reconstructions *via* other indicators includes the reconstruction of past metal concentrations (Binkowski *et al.*, 2019), and the reconstruction of palaeobasins through phylogeographical analyses (Hewitt *et al.*, 2018).

(c) Archaeology

Evidence for FBs providing information on historical human societies and communities is based on the presence, abundance or isotopic signature of species/specimens. Several studies provide evidence for the historic use of FBs as food, tools, ornaments and/or objects of spiritual, symbolic or

religious meaning [e.g. *Nodularia douglasiae* from Neolithic China (Li *et al.*, 2013a); *Unio* sp. in Eneolithic Romania (Mărgărit, 2020)]. In other cases, information on other aspects of past human societies are provided through FBs. For example, the isotopic signature (carbon and oxygen) of ornamental disc beads made from *Unio* shells from several Neolithic burials in Poland revealed that these originated from both riverine and lacustrine environments, which suggests changes in the shell source over time and thereby provided evidence for the existence of a regional exchange network (Apolinarska & Kurzawska, 2020). In Burleigh (1983), an Egyptian tomb was dated to ~5000 ya using radiocarbon data from an *Etheria elliptica* shell found in the tomb. Finally, a number of studies utilise palaeoenvironmental and palaeoclimatic information reconstructed through stable isotope data from FBs to infer information on ancient human ecologies. An example is the study by Çakırlar & Şeşen (2013), who used sclerochronological isotope data from archaeological *Unio* sp. shells to show that continuous perennial flow of the Jaghjagh River, Syria, throughout the transition from the third to the second millennium BC was responsible for the continuous occupation of the Tell Mozan.

(d) Biomimicry

Records providing evidence for the use of FBs in biomimicry (see Table 1 for a description of the term) were scarce, restricted to Asia and focused on improving understanding of the mechanical behaviour of nacre for the design of nacre-inspired synthetic materials (Jiao *et al.*, 2019; Liu *et al.*, 2020).

(e) Social education

Evidence for the value of FBs in social education in our database is confined to only two records, including a collaborative FB translocation initiative between the Mataranga Maori tribe (New Zealand) and western scientists, which aimed not only to renature this freshwater ecosystem but also to reconnect this indigenous tribe with their land and water (Michel *et al.*, 2019).

(2) Attitudes and other interactions

Records relate to a symbolic, spiritual or religious meaning of FBs (3%) and their importance for the cultural heritage or traditions of human communities (2%).

(a) Spiritual, symbolic and religious

The majority of these records relate to FB shells and pearls, mostly from the order Unionida, as burial objects used by ancient human communities in e.g. Egypt (Burleigh, 1983), Mongolia (Kiryushin *et al.*, 2011), Russia (Korolev *et al.*, 2018) and Argentina (Fabra, Gordillo & Piovano, 2012). More recently, from the 18th to the early 20th centuries, harvested freshwater pearls, particularly from *M. margaritifera*, have been used as decoration on various objects of religious significance (Strack, 2015).

(b) Tradition

Evidence on the relevance of FBs to cultural heritage and traditions in our database are restricted mainly to their use in traditional foods and particularly that of *Corbicula* spp. in traditional Asian cuisine, including soups [e.g. in China and Japan (Ke *et al.*, 2011; Horikoshi, 2020)] or as smoked *etok salai* in Malaysia (Rak *et al.*, 2020a). FBs are also considered traditional ('first') foods of indigenous tribes in North America, Australia and New Zealand (Brim Box *et al.*, 2006; Noble *et al.*, 2016).

(3) Aesthetic experiences

Evidence for FBs providing aesthetic experiences to humans is restricted to the ornamental use of living FBs, their shells or pearls (Fig. 3B). Many of these records refer to archaeological FBs (Burleigh, 1983; Apolinarska & Kurzawska, 2020; Mărgărit, 2020). In North America and Europe, intense 'pearl fishing' over the past century has led to a steep decline and even extirpations of unionid populations but is now largely banned (Bauer, 1988; Anthony & Downing, 2001; Strack, 2015). Freshwater pearl culture for ornamental purposes is an important economy especially in China and other parts of Asia (Janakiram, 2003; Fiske & Shepherd, 2007), with considerable ongoing research efforts aimed at optimising the culture of high-quality pearls and nacre (Wang *et al.*, 2020). Finally, live FBs are commonly used in the ornamental pet trade (Erdoğan & Erdoğan, 2015; Ng *et al.*, 2016).

(4) Physical interactions

Evidence for FBs affecting human physical interactions is restricted to leisure and recreational activities. Most of these records refer to the effects of non-native species, showing both their roles as providers (e.g. *D. polymorpha* increasing the recreational value of an English lake by improving water clarity; Mansfield *et al.*, 2014) as well as disrupters of these ESs (e.g. *C. fluminea* shells after massive die-off events reducing the recreational value of beaches; Fig. 3F; Ilarri *et al.*, 2011).

VI. REGULATING ECOSYSTEM SERVICES

Evidence for associations between FBs and regulating ESs (RESs) concerns the regulation of organisms, i.e. algae, bacteria and/or diseases (39% of RES records), mediation of human inputs, such as sequestration or decomposition of harmful wastes of human origin (34%), and physico-chemical regulation, including water clearance (27%). RES records were disproportionately commonly associated with non-native species (compare Fig. 1D with Fig. 1A–C), particularly *D. polymorpha* and *D. bugensis* in North America and Europe, and *L. fortunei* in South America. Evidence for disruption of RESs was predominantly based on non-native rather than native species (81 versus 19% of records). Different taxonomic orders contributed evidence to each of the three CICES

groups unequally, with Myoida and Unionida contributing particularly to biological and physico-chemical regulation, and Veneroida and Unionida to the mediation of human inputs (Fig. 1D).

(1) Regulation of organisms

Records relate mostly to FBs affecting the prevalence and concentration levels of algae in the water (28%; Fig. 3D) and, to a lesser extent, those of bacteria (8%) and diseases (4%), thereby affecting human health, security and/or amenity value of the respective waterbodies. Evidence for an effect on humans of regulation of organisms by FBs is available from all continents apart from Africa, and is based on both native and non-native species.

(a) Algae

Evidence is exclusively based on the effects of (selective) biofiltration by FBs of phytoplankton, which is often accompanied by an effect on water clarity (Fig. 3D). Many of these studies are based on laboratory experiments that investigate the ability and rate at which FBs can ingest (and, in some studies digest) and thus, remove (certain compartments of) phytoplankton from the water column, including harmful derivatives, such as hepatotoxic microcystins and nodularins (Pham *et al.*, 2016; Buelow & Waltham, 2020; Silva *et al.*, 2020). A number of studies provide evidence for these mechanisms *in situ*, often through mesocosm experiments. Notable examples on the provision of this ES by native species include the alleviation of the negative effects of cyanobacterial blooms on submerged macrophyte growth by the unionid *S. cumingii* in Lake Taihu, China (He *et al.*, 2014), and effective bioaccumulation of microcystins and/or nodularins by unionid species in Japanese and Latvian lakes (Park, Yokoyama & Okino, 2001; Barda *et al.*, 2015). Much of the respective literature from Europe and North America is focused on non-native, invasive *Dreissena* species, which have caused reductions and, in some cases, extirpation of local, native unionid populations (Strayer, 1999; Sousa *et al.*, 2014). The prevailing evidence indicates that this shift in FB species composition results in a reduction of overall phytoplankton biomass, which is, however often accompanied by an increase in nuisance algae, such as the green alga *Cladophora glomerata* (e.g. Lake Ontario, Canada; Ozersky *et al.*, 2009), and/or harmful cyanobacteria, such as *Microcystis* spp. (e.g. Laurentian Great Lakes; Vanderploeg *et al.*, 2001). The negative knock-on effects on human health have been illustrated by Jones (2019), who showed that a steep drop in microcystin levels caused by a sudden, massive die-off of *D. polymorpha* in Gull Lake, Michigan, USA, led to improved infant health (measured as e.g. instances of low birth weight, length of gestation). That said, the effects of dreissenid invasions appear to depend on the prevailing conditions, including phosphorus concentrations, at the site (Raikow *et al.*, 2004). For example, data from Lake Michigan, USA, indicate that invasion by *D. polymorpha* has led not only

to an increase of cyanobacteria but also to increased overall phytoplankton density (De Stasio *et al.*, 2008). On the other hand, *D. bugensis* has been shown to control phytoplankton, including cyanobacteria, in urban ponds in the Netherlands (Waajen *et al.*, 2016).

(b) Bacteria

Scientific interest in the potential use of FBs as a bioremediation tool for bacterial contamination of water bodies has gained traction only relatively recently. One of the first studies providing strong evidence for FBs significantly reducing concentrations of bacteria of human importance is that by Bianchi *et al.* (2014), showing that the unionid *Diplodon chilensis* can reduce bacterial loads in sewage water from a Patagonian lake. *In situ* experiments by Ismail *et al.* (2015, 2016) revealed the ability of the native unionid *Anodonta californiensis* and non-native veneroid *C. fluminea* to reduce concentrations of *Escherichia coli* in human-impacted lakes and rivers in California, USA. Laboratory experiments in Italy provided similar results for the non-native *D. polymorpha*, which almost completely removed *E. coli* from the water (Mezzanotte *et al.*, 2016). Also in Italy, mesocosm experiments showed that integration of the non-native unionid *S. woodiana* can reduce the environmental impacts of inland trout farming in terms of reducing total bacterial concentrations by up to 72% (Sicuro *et al.*, 2020).

(c) Diseases

Evidence for FBs as potential bioremediation tools for human pathogenic viruses and bacteria and their vectors originated mainly from Asia and Europe. Laboratory experiments in Italy showed that non-native *D. polymorpha* can significantly reduce concentrations of rota- and polioviruses in water (Mezzanotte *et al.*, 2016). In Japan, the native, pearl-producing unionid *Sinohyriopsis schlegelii* was found effectively to deplete oocysts of gastroenteritis-inducing *Cryptosporidium parvum* in the final settling pond of a sewage plant (Izumi *et al.*, 2012). A study from Indonesia showed that FB shell powder can be used as an environmentally friendly alternative to organophosphate pesticides in controlling larvae of *Anopheles* and *Aedes aegypti* mosquitos, which are vectors of malaria and dengue fever (Sorontou & Agussalim., 2016).

(2) Mediation of human inputs

In the vast majority of records on FBs acting as remediators of harmful organic or inorganic substances of human origin, evidence relates to filtration and/or sequestration of these substances (32%), whilst evidence for (subsequent) transformation or decomposition into less harmful substances is rare (2%).

(a) Filtration and sequestration

Some of the earliest records are focused on the remediation of heavy metal contamination of water through FB biofiltration. This topic has received particular attention in India, usually focusing on Cadmium (Cd) and using the native unionid

L. marginalis, which was shown to significantly alleviate Cd-contamination in waters receiving industrial effluents (Jana & Das, 1997; Das & Jana, 2003). As FBs are also readily eaten in this region and thus can pose a health hazard, the findings of Cd-biosorptive properties of FB shells (Ismail, Aris & Latif, 2014a; Hossain, Bhattacharyya & Aditya, 2015) and applied by Ghosh *et al.* (2020b) are particularly promising.

In Europe, North America and South America, research on the potential application of FBs as bioremediation tools for anthropogenic pollution of fresh waters is largely focused on non-native species. In the USA, a flow-through mussel filter designed by Diggins *et al.* (2002) using *D. polymorpha* and *D. bugensis* was found to clear up to 96% of suspended particles (to which many pollutants readily adsorb) from effluents before discharge. A similar design with ~40,000 *D. polymorpha* individuals was piloted in the largest wastewater treatment plant of Milan, Italy, resulting in the efficient removal of various heavy metals as well as pharmaceuticals and drugs of abuse (Fig. 3E; Binelli *et al.*, 2014; Magni *et al.*, 2015). In Portugal, *C. fluminea* was shown to be able to assist in the remediation of acid mine drainage, as well as olive oil mill and winery wastewaters (Rosa *et al.*, 2014; Pipolo *et al.*, 2017; Ferreira *et al.*, 2018; Domingues *et al.*, 2020). One of the few such records on native unionid species from outside Asia is that of *D. chilensis* alleviating environmental effects of a fish aquaculture in Chile by removing nutrients and organic matter from the water (Parada *et al.*, 2008).

(b) Transformation

Evidence for the ability of FBs to transform substances of human origin is scarce and comes mainly from *L. fortunei*. In its native China, laboratory experiments showed that both living specimens and, to a lesser extent, shells, can reduce the concentrations of the plant growth regulator forchlorfenuron in a process involving bacteria-associated nitrification and denitrification reactions (Zhang, Cui & Huang, 2015). In laboratory experiments in Argentina, where *L. fortunei* is invasive, herbicide (including glyphosate) and pesticide concentrations in the water decreased by 40% under live *L. fortunei* presence and by 25% in empty shell treatments, again involving transformation due to mineralisation by microbial communities (Di Fiori *et al.*, 2012).

(3) Physico-chemical regulation

Evidence is available from all continents except South America for FBs decreasing or increasing concentrations of organic or inorganic substances (of non-human origin) (17%) as well as affecting the physical properties of water quality (11%) with implications for human health and/or recreation.

(a) Storage and excretion

Particularly in China, there has been growing interest in using native unionid FBs in the restoration of freshwater ecosystems. L. Wang *et al.* (2017) showed that when combined with

stocking of planktivorous fish and replanting submerged macrophytes, *S. cumingii* can effectively remove nutrients from eutrophicated waterbodies (as well as suppress phytoplankton growth). Similarly, *Lamprotula leai* in combination with the annelid *Tubifex tubifex* has been demonstrated to be effective in promoting plant growth and nutrient absorption within 'Constructed Wetlands', an ecological engineering solution for removing and transforming pollutants from wastewater (Kang *et al.*, 2018). In North America and Europe, evidence comes almost exclusively from non-native species and predominantly *D. polymorpha* and *D. bugensis*. Research has focussed mainly on their effects on nutrient cycling (especially of phosphorus and nitrogen), which are complex and not uniform across ecosystems, rendering these invaders both providers and disruptors of this RES. In North America, a considerable body of research has been conducted on this topic in the Laurentian Great Lakes. In Lake Huron, it was shown that sequestration of phosphorus by *D. polymorpha* and *D. bugensis* led to reduced primary productivity with knock-on effects on secondary producers and fish (Cha *et al.*, 2011). In Lake Erie, modelling showed that the invasion of these FBs decreased ecosystem resistance to eutrophication, necessitating increased phosphorus management to preserve lake ESs (Roy *et al.*, 2010). In Lake Simcoe, dreissenid FBs have been shown to remineralise and thus increase bioavailability of phosphorus and nitrogen, whilst their shells represent a long-term sink for phosphorus, nitrogen and calcium (Ozersky, Evans & Ginn, 2015). On the other hand, decline in primary production and increase in water clarity caused by a dreissenid invasion has resulted in the Great Lakes becoming a significant CO₂ net emitter (>7.7 Tg-C annually) (Lin & Guo, 2016). Despite their disruptive effects on RESs, cultivation of *D. polymorpha* has been suggested as a tool for managing nutrient-enriched reservoirs in the UK (McLaughlan & Aldridge, 2013) and has successfully reduced nutrient exports from the Szczecin/Oder Lagoon to the open Baltic by up to 3500 t N and 420 t P per year (Schernewski, Stybel & Neumann, 2012; Friedland *et al.*, 2019).

(b) Water clearance

Evidence for FBs improving clarity and other physical properties of water quality with implications for humans (e.g. in terms of health or recreational activities) is mostly associated with the regulation of organisms, e.g. phytoplankton, sequestration and/or transformation of substances of human origin, and/or removal of naturally occurring substances (Holland, 1993; Schernewski *et al.*, 2012; Waajen *et al.*, 2016; L. Wang *et al.*, 2017). Many of these studies concern non-native dreissenids in North America and Europe, and whilst their effects on increased water clarity are generally regarded as an ES provision, they have also been shown to disrupt ESs provided by the physical properties of water, e.g. by causing unpleasant odour and taste due to increased cyanobacterial growth in the St. Lawrence River, Canada (Watson & Ridal, 2004).

VII. DISCUSSION

(1) Temporal and geographic trends

Our systematic review of ESs provided and disrupted by FBs has identified a number of patterns over time and space. Our data set suggests that occasional scientific interest on FB–ES associations from the late 1940s to the 1980s was followed by an exponential increase in attention. This trend coincides with increased global interest in ecology and biodiversity conservation since the 1980s (Stork & Astrin, 2014), with particular interest focussed on non-native species since the 1990s (Vaz *et al.*, 2017). The rapidly increasing rate of annual record publication on FB–ESs in the 2000s may be explained by the popularisation of the ES concept, especially following publication of the *Millennium Ecosystem Assessment* (MEA, 2005) and subsequent initiatives, such as The Economics of Ecosystems and Biodiversity, the Ecosystem Services Partnership and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.

Despite the general increase in publications over time, the rate and amount of evidence published has not been homogeneous across geographical areas. Asia stands out in our data set as the current epicentre of FB–ES research in terms of the quantity of available evidence (35% of records originate from Asia), breadth of research (23 of 24 CICES-classes) and increase in annual evidence output in recent years. Four CICES classes were based exclusively on evidence from Asia, i.e. the use of genetic or protein information for medicinal purposes, use in the provision of energy, use in the design and production of other materials, and relevance to cultural heritage and traditions (although evidence for latter class also exists at least for North America and Australasia; Noble *et al.*, 2016). Other CICES classes and groups were strongly dominated by evidence from Asia, and particularly East Asia, including the use of FBs or their products for food and material production, and the restoration of freshwater ecosystems. If anything, this dominance of Asia is likely under-represented in our data set due to our exclusion of publications written in Asian languages. The prevalence of records on FB–ES associations from Asia may reflect the continent's size (29% of land area and 60% of global population; UN, 2021), social and biogeographical heterogeneity, and diverse FB fauna, particularly in the Indotropics (Lopes-Lima *et al.*, 2018; Zieritz *et al.*, 2018b). However, research into other aspects of FB biology and ecology in Asia is considerably lagging behind that in North America and Europe, despite numerous conservation issues (Lopes-Lima *et al.*, 2018; Zieritz *et al.*, 2018b).

Long-term protection of global FB diversity and functionality will require a good understanding of both their ecology and their ESs. For example, in China, where FB products ('commodities'), such as ornamental pearls or medicines, are particularly popular, knowledge gaps on species diversity and conservation status should be urgently addressed to avoid unsustainable exploitation of rare and/or threatened species. By contrast, in North America and Europe, ES

research has so far strongly focused on the use of FBs in bio-monitoring, with other potential ESs having been largely ignored. In North America particularly, significant resources have also been dedicated to generate a better understanding of the functional roles of FBs within their ecosystems (Vaughn & Hakenkamp, 2001; Vaughn, 2018), but the majority of these studies lack a clear relevance to humans. FB conservation in these regions would benefit from more explicitly recognising the contributions that FBs make to human well-being. That said, there is evidence for this acquired knowledge on FB–ESs already pushing conservation initiatives in these regions, including the Mussels for Clean Water Initiative, which aims to restore native FB populations in the Delaware and other northwestern US river basins 'to promote cleaner water and healthier aquatic ecosystems' (The Partnership for the Delaware Estuary, 2017). Finally, in the southern hemisphere, all aspects of FB research, including ecology, conservation and ESs, are notoriously understudied.

Some avenues of ES research that are popular in one region may not be attractive in other regions due to differences in socio-economic conditions and/or characteristics of the FB fauna, but efforts should be made to identify the complete range of (potential) ESs of FBs globally. For example, whilst in the western world, FBs are rarely eaten any more, their potential as a bioremediation tool for disturbed ecosystems appears to be severely underexplored. In Africa, research into the use of FBs as a source of food and biomonitoring tool may be of particular relevance (Akélé *et al.*, 2015; Labuschagne *et al.*, 2020). Future research would benefit greatly from international collaborations to facilitate exchange of knowledge, know-how and technologies. Ultimately, this should be accompanied by quantification and economic valuation of ESs over space and time (Strayer, 2017), including data from unpublished and grey literature, as well as cost–benefit analyses under alternative management and environmental change scenarios.

(2) Synergies and trade-offs among FB ecosystem services

From our database, 146 studies provided evidence for multiple FB–ES associations, indicating that the provision/disruption of one ES coincided with the provision/disruption of one or more other ESs (synergistic and trade-off effects; Turkelboom *et al.*, 2016). Common examples for ES synergies in our database referred to knowledge acquisition (e.g. biomonitoring), regulation of organisms (e.g. algae), mediation of human inputs (e.g. heavy metals) and/or physico-chemical regulation (e.g. through water clearance). All of these ESs, which provide benefits to human health and improved amenity value of waterbodies, derive from the considerable filtration and bioaccumulation capacity of FBs (Vaughn, 2018). The same traits are also responsible for FBs providing nutritious food (Ke *et al.*, 2011; Horikoshi, 2020), and supporting the production of (shell)fish

for food and the ornamental pet trade (Erdoğan & Erdoğan, 2015; Sicuro *et al.*, 2020).

The effect of a particular FB on one or more ESs is often context specific, which can result in trade-offs among the provision and disruption of specific ESs. For example, the remediation of polluted water by FB filtration may be offset by the adverse effects on human health when these FBs are consumed. Based on our data set, non-native FBs appear to act more commonly as disrupters of ESs than native FBs, e.g. by reducing the recreational value of waterbodies by causing cyanobacterial blooms (Vanderploeg *et al.*, 2001; Jones, 2019). Furthermore, invasive FBs are known to cause a range of other ecological and economic impacts, including the complete alteration of ecosystem structure and functioning, and the fouling of industrial intakes and boats (Strayer, 1999; Sousa, Gutiérrez & Aldridge, 2009; Sousa *et al.*, 2014), with massive economic costs (63.8 billion US\$ between 1980 and 2020 according to Haubrock *et al.*, 2022). On the other hand, there is evidence for invasive FBs providing ESs, most notably through biomonitoring and nutrient removal in eutrophicated ecosystems (Richman & Somers, 2010; McLaughlan & Aldridge, 2013). Future research should aim to provide a more complete understanding and quantification of how the provisioning of one ES may reduce the provisioning of another or result in additional ecological and/or economic costs, particularly with regard to native *versus* non-native species.

VIII. CONCLUSIONS

- (1) Our systematic review of 684 published studies identified 904 records providing evidence for an association between FBs and 24 specific ES classes. Records originated predominantly from Asia, Europe and North America, with poor representation of countries from the southern hemisphere. About one in ten records referred to a disruption rather than provision of ESs.
- (2) Temporal trends in the publication of FB–ES associations reflected increased interest in ecology and conservation since the 1980s, increased attention on non-native species since the 1990s and popularisation of the ES concept since the 2000s.
- (3) Evidence on provisioning ESs, and particularly the provisioning of food, materials and medicines by *Corbicula* spp. and unionids, was prominent in Asian countries, yet this is a region where species diversity, distribution and ecology remain understudied.
- (4) In North America and Europe, evidence was primarily focused on cultural ESs, and predominantly the use of native and non-native FBs for biomonitoring. Other cultural CICES groups referred to the ornamental use of FBs, their religious, spiritual or traditional meaning, and their effects on physical interactions.
- (5) Regulating ESs comprised the regulation of organisms, including (harmful) algae and bacteria, the regulation of substances and physico-chemical water properties, and the

mediation of harmful substances of human origin. Records were commonly based on non-native species (mainly *Dreissena* spp.).

(6) Multiple FB–ES associations within single studies were often associated with the biofiltration and bioaccumulation capacity of FBs, linking various provisioning (e.g. source of micronutrients), cultural (e.g. biomonitoring) and regulating (e.g. of algae) ESs. Trade-offs among ESs provided and disrupted by FBs were particularly commonly observed for non-native FBs.

(7) As the global community of FB researchers grows, we recommend that future efforts are directed towards the continued documentation of FB–ESs, particularly in less well-studied geographic regions, such as Africa and South America. Attention should be given to ESs and FBs beyond those commonly reported. Progress should be made in the economic quantification of FB–ESs, so that trade-offs can be properly enumerated and informed decisions can be made about effective ecosystem management, conservation and restoration programs.

IX. ACKNOWLEDGEMENTS

This study resulted from discussions facilitated by the EU-COST Action CA18239. A.Z. was supported by an Anne McLaren Fellowship by the University of Nottingham. A.S.V. acknowledges support from FCT – Portuguese Foundation for Science and Technology through the program Stimulus for Scientific Employment – Individual Support [contract reference 2020.01175.CEECIND] and Ministerio de Ciencia, Innovación y Universidades (Spain) through the 2018 Juan de la Cierva-Formación program [contract reference FJC2018-038131-I]. D.C.A. was supported by a Dawson Fellowship from St. Catharine's College, Cambridge. E.E. was supported by Portuguese national funds from FCT - Foundation for Science and Technology through projects UIDB/04326/2020, UIDP/04326/2020 and LA/P/0101/2020. [Corrections added on 22 July 2022, after first online publication: Funder details for Eduardo Esteves have been added in this version.]

X. REFERENCES

- References identified with an asterisk (*) are used only in the supporting information.
- *ABAYCHI, J. K. & MUSTAFA, Y. Z. (1988). The asiatic clam, *Corbicula fluminea*: an indicator of trace metal pollution in the Shatt al-Arab River, Iraq. *Environmental Pollution* **54**, 109–122.
- *ADAMS, S. M. & SHOREY, C. D. (1998). Energy dispersive spectroscopy of granular concretions in the mantle of the freshwater mussel *Hyridella depressa* from Lake Burragorang as a technique to monitor metals in aquatic systems. *Aquatic Toxicology* **44**, 93102.
- *AGUIRRE-MARTÍNEZ, G. V., DEL VALLS, A. T. & LAURA MARTÍN-DÍAZ, M. (2015). Yes, caffeine, ibuprofen, carbamazepine, novobiocin and tamoxifen have an effect on *Corbicula fluminea* (Müller, 1774). *Ecotoxicology and Environmental Safety* **120**, 142–154.
- *AHMED, M. K., BHOWMIK, A. C., RAHMAN, S. & HAQUE, M. R. (2010). Heavy metal concentration in water, sediments, freshwater mussels and fishes of the River Shitalakhya, Bangladesh. *Asian Journal of Water, Environment and Pollution* **7**, 77–90.

- *AKARTE, S. R. & BAHADURE, R. B. (2015). Evaluation of minerals as manure value of faecal matter of chicks fed with molluscan supplementary diet. *International Journal of Pharma and Bio Sciences* **6**, B1342–B1346.
- AKÉLÉ, G., AGADJIHOUEË, H., MENSAH, G. & LALÉYÉ, P. (2015). Population dynamics of freshwater oyster *Etheria elliptica* (Bivalvia: Etheriidae) in the Pendjari River (Benin-Western Africa). *Knowledge and Management of Aquatic Ecosystems* **416**, 6.
- *ARSOY, A., DAS, Y. K., YAVUZ, O., GUVENC, D., ATMACA, E. & AGAOLGU, S. (2011). Organochlorine pesticide and polychlorinated biphenyls levels in fish and mussel in Van Region, Turkey. *Bulletin of Environmental Contamination and Toxicology* **87**, 65–69.
- *AKSU, O., YABANLI, M., CAN, E., KUTLUYER, F., KEHAYIAS, G., CAN, S. S., KOCABAŞ, M. & DEMIR, V. (2012). Comparison of heavy metals bioaccumulation by *Dreissena polymorpha* (Pallas, 1771) and *Unio elongatulus eucirrus* (Bourguignat, 1860) from Keban Dam Lake, Turkey. *Fresenius Environmental Bulletin* **21**, 1942–1947.
- *AL-AASM, I. S., CLARKE, J. D. & FRYER, B. J. (1998). Stable isotopes and heavy metal distribution in *Dreissena polymorpha* (Zebra Mussels) from western basin of Lake Erie, Canada. *Environmental Geology* **33**, 122–129.
- *ALCARAZ, C., CAIOLA, N. & IBÁÑEZ, C. (2011). Bioaccumulation of pollutants in the zebra mussel from hazardous industrial waste and evaluation of spatial distribution using GAMs. *Science of the Total Environment* **409**, 898–904.
- *ALDRIDGE, D. C. & HORNE, D. C. (1998). Fossil glochidia (Bivalvia, Unionidae): identification and value in palaeoenvironmental reconstructions. *Journal of Micropalaeontology* **17**, 179–182.
- ALDRIDGE, D. C., SALAZAR, M., SERNA, A. & COCK, J. (2008). Density-dependent effects of a new invasive false mussel, *Mytilopsis trautwimiana* (Tryon 1866), on shrimp, *Litopenaeus vannamei* (Boone 1931), aquaculture in Colombia. *Aquaculture* **281**, 34–42.
- *ALGAN, O., ÇAĞATAY, N., TÇHEPALYGA, A., ONGAN, D., EASTOE, C. & GÖKŞAN, E. (2001). Stratigraphy of the sediment infill in Bosphorus Strait: water exchange between the Black and Mediterranean Seas during the last glacial holocene. *Geo-Marine Letters* **20**, 209–218.
- ALIF, M. F., APRILLIA, W. & ARIEF, S. (2018). Peat water purification by hydroxyapatite (HAp) synthesized from waste pensil (*Corbicula molitkiana*) shells. *IOP Conference Series: Materials Science and Engineering* **299**, 12002.
- *ALLEN, H. J., DICKSON, K. L., MARTIN, H., THUESEN, K. A. & WALLER, W. T. (2002). Monitoring watersheds: biomonitors and other measures. *Journal of Urban Technology* **9**, 1–19.
- *AL-MASRI, M. S., BYRAKDAR, M. E., MAMISH, S. & AL-HALEEM, M. A. (2004). Determination of natural radioactivity in Euphrates river. *Journal of Radioanalytical and Nuclear Chemistry* **261**, 349–355.
- *AL-MUDAFFAR, N., FAWZI, I. N. O. & AL-EDANEE, T. (1990). Hydrocarbons in surface sediments and bivalves from Shatt Al-Arab and its rivers, Southern Iraq. *Oil and Chemical Pollution* **7**, 17–28.
- *AL-TAHER, Q. M., AKBAR, M. M. & AL-QAROONI, I. H. (2020). Estimation of heavy metals in water, sediments and bioaccumulation in two species of Mollusca: Clam *Pseudodontopsis euphraticus* and snail *Bellamya bengalensis* in Euphrates River in Al-Nasiriyah City, south of Iraq. *Plant Archives* **20**, 1454–1460.
- *AMRAOUI, I., KHALLOUFI, N. & TOUAYLIA, S. (2018). Effects to perfluorooctane sulfonate (PFOS) on the mollusk *Unio ravoisieri* under laboratory exposure. *Chemistry and Ecology* **34**, 324–339.
- *ANDRÉS, S., BAUDRIMONT, M., LAPAQUELLERIE, Y., RIBREYRE, F., MAILLET, N., LATOUCHE, C. & BOUDOU, A. (1999). Field transplantation of the freshwater bivalve *Corbicula fluminea* along a polymetallic contamination gradient (River Lot, France): I. Geochemical characteristics of the sampling sites and cadmium and zinc bioaccumulation kinetics. *Environmental Toxicology and Chemistry* **18**, 2462–2471.
- ANDREWS, J. E. & WALTON, W. (1990). Depositional environments within Middle Jurassic oyster-dominated lagoons: an integrated litho-, bio- and palynofacies study of the Duntulm Formation (Great Estuarine Group, Inner Hebrides). *Transactions of the Royal Society of Edinburgh: Earth Sciences* **81**, 1–22.
- ANTHONY, J. L. & DOWNING, J. A. (2001). Exploitation trajectory of a declining fauna: a century of freshwater mussel fisheries in North America. *Canadian Journal of Fisheries and Aquatic Sciences* **58**, 2071–2090.
- *ANTUNES, F., HINZMANN, M., LOPES-LIMA, M., MACHADO, J. & DA COSTA, P. M. (2010). Association between environmental microbiota and indigenous bacteria found in hemolymph, extrapallial fluid and mucus of *Anodonta cygnea* (Linnaeus, 1758). *Microbial Ecology* **60**, 304–309.
- *ANZANO, J., LASHERAS, R.-J., BONILLA, B., BONILLA, A., LANAJA, J., PERIBANEZ, M. A., GRACIA-SALINAS, M.-J., ANWAR, J. & SHAFIQUE, U. (2011). Determination of trace metals by voltamperometry in zebra mussel (*Dreissena polymorpha*) employed as environmental bio-indicator. *Green Chemistry Letters and Reviews* **4**, 261–267.
- *APOLINARSKA, K. (2009). delta O-18 and delta C-13 isotope investigation of the Late Glacial and early Holocene biogenic carbonates from the Lake Lednica sediments, western Poland. *Acta Geologica Polonica* **59**, 111–121.
- *APOLINARSKA, K. (2013). Stable isotope compositions of recent *Dreissena polymorpha* (Pallas) shells: Palaeoenvironmental implications. *Journal of Paleolimnology* **50**, 353–364.
- *APOLINARSKA, K. & HAMMARLUND, D. (2009). Multi-component stable isotope records from Late Weichselian and early Holocene lake sediments at Imiolki, Poland: palaeoclimatic and methodological implications. *Journal of Quaternary Science* **24**, 948–959.
- APOLINARSKA, K. & KURZAWSKA, A. (2020). Can stable isotopes of carbon and oxygen be used to determine the origin of freshwater shells used in Neolithic ornaments from Central Europe? *Archaeological and Anthropological Sciences* **12**, 15.
- *AREEKIJSEREE, M., ENKAGUL, A., KOVITVADHI, U., THONGPAN, A., MINGMUANG, M., PAKKONG, P. & RUNGRUANGSAK-TORRISSEN, K. (2004). Temperature and pH characteristics of amylase and proteinase of adult freshwater pearl mussel, *Hyriopsis (Hyriopsis) bialatus* Simpson 1900. *Aquaculture* **234**, 575–587.
- *ARFIATI, D., PUTRA, C. D. G., TULLAH, A. H., PERMANASARI, S. W. A. & PUSPITASARI, A. W. (2019). The dynamics of total organic matter (tom) on sangkuriang catfish (*Clarias gariepinus*) farming at upt ptpbp2kp and the effectiveness of freshwater bivalve (*Anodonta woodiana*) in reducing the total organic matter with varying density. *IOP Conference Series: Earth and Environmental Science* **236**, 012022.
- *ARINI, A., BAUDRIMONT, M., FEURTET-MAZEL, A., COYNEL, A., BLANG, G., COSTE, M. & DELMAS, F. (2011). Comparison of periphytic biofilm and filter-feeding bivalve metal bioaccumulation (Cd and Zn) to monitor hydrosystem restoration after industrial remediation: a year of biomonitoring. *Journal of Environmental Monitoring* **13**, 3386–3398.
- *ARINI, A., DAFFE, G., GONZALEZ, P., FEURTET-MAZEL, A. & BAUDRIMONT, M. (2014). What are the outcomes of an industrial remediation on a metal-impacted hydrosystem? A 2-year field biomonitoring of the filter-feeding bivalve *Corbicula fluminea*. *Chemosphere* **108**, 214–224.
- *ARRIBERE, M. A., CAMPBELL, L. M., RIZZO, A. P., ARCAGNI, M., REVENGA, J. & GUEVARA, S. R. (2010). Trace elements in plankton, benthic organisms, and forage fish of Lake Moreno, Northern Patagonia, Argentina. *Water, Air, and Soil Pollution* **212**, 167–182.
- *ARUMUGAM, A., LI, J., KRISHNAMURTHY, P., JIA, Z. X., LENG, Z., RAMASAMY, N. & DU, D. (2020). Investigation of toxic elements in *Carassius gibelio* and *Sinanodonta woodiana* and its health risk to humans. *Environmental Science and Pollution Research* **27**, 19955–19969.
- *ASOKAN, R. & HAMEED, P. S. (1992). Distribution of natural radionuclide-40K in biotic and abiotic components of the Cauvery river system, Tiruchirapalli, India. *Journal of Biosciences* **17**, 491–497.
- *ATKINSON, C. L., CHRISTIAN, A. D., SPOONER, D. E. & VAUGHN, C. C. (2014). Long-lived organisms provide an integrative footprint of agricultural land use. *Ecological Applications* **24**, 375–384.
- *BABAR, A. G., JAYAWANT, M. S. & PAWAR, S. P. (2017). Nutritional profile of the freshwater edible Bivalve *Lamellidens corrianus* (Lea 1834) and its relation to water quality in the Bhatsa River, India. *Asian Fisheries Science* **30**, 52–69.
- *BACCETTA, R. & MANTECCA, P. (2009). DDT polluted meltwater affects reproduction in the mussel *Dreissena polymorpha*. *Chemosphere* **76**, 1380–1385.
- *BAHTIAR ANADI, L., NURGAYAH, W. & DAN EMIYARTI, H. (2018). Population dynamics of Pokea Clam *Batissa violacea* var. *celebensis* von Martens 1897 at Lasolo Estuary of Southeast Sulawesi. *Jurnal Ilmu dan Teknologi Kelautan Tropis* **10**, 301–315.
- BAI, J., CHEN, Y., NING, Z., LIU, S., XU, C. & YAN, J.-K. (2020). Proteoglycan isolated from *Corbicula fluminea* exerts hepato-protective effects against alcohol-induced liver injury in mice. *International Journal of Biological Macromolecules* **142**, 1–10.
- BAI, X. & ACHARYA, K. (2019). Uptake of endocrine-disrupting chemicals by quagga mussels (*Dreissena bugensis*) in an urban-impacted aquatic ecosystem. *Environmental Science and Pollution Research* **26**, 250–258.
- *BAI, Z., LI, Q., HAN, X. & LI, J. (2017). Estimates of genetic parameters and genotype by environment interactions for shell nacre color and growth traits in the purple freshwater pearl mussel *Hyriopsis cumingii*. *Aquaculture International* **25**, 2079–2090.
- *BALDWIN, A. K., SPANJER, A. R., ROSEN, M. R. & THOM, T. (2020). Microplastics in Lake Mead National Recreation Area, USA: occurrence and biological uptake. *PLoS One* **15**, e0228896.
- *BAQAR, M., SADEF, Y., AHMAD, S. R., MAHMOOD, A., LI, J. & ZHANG, G. (2018). Organochlorine contaminants in freshwater mussels; occurrence, bioaccumulation pattern, spatio-temporal distribution and human health risk assessment from the tributaries of River Ravi, Pakistan. *Human and Ecological Risk Assessment* **24**, 1268–1290.
- BARDA, I., KANKAANPÄÄ, H., PURINA, I., BALODE, M., SJÖVALL, O. & MERILUOTO, J. (2015). Bioaccumulation of hepatotoxins—a considerable risk in the Latvian environment. *Environmental Pollution* **196**, 313–320.
- BARONI, C., BRUSCHI, G., VERONESE, L. & ZANCETTA, G. (2001). Younger Dryas to Early Holocene palaeoenvironmental evolution of the Lake Terlago (Southern Alps, Italy). *Supplementi di Geografia Fisica e Dinamica Quaternaria* **24**, 13–24.
- *BAR-YOSEF MAYER, D. E., LENG, M. J., ALDRIDGE, D. C., ARROWSMITH, C., GÜMÜŞ, B. A. & SLOANE, H. J. (2012). Modern and early-middle Holocene shells of the freshwater mollusc *Unio*, from Çatalhöyük in the Konya Basin, Turkey: preliminary palaeoclimatic implications from molluscan isotope data. *Journal of Archaeological Science* **39**, 76–83.
- *BASACK, S. B., ONETO, M. L., FUCHS, J. S., WOOD, E. J. & KESTEN, E. M. (1998). Esterases of *Corbicula fluminea* as biomarkers of exposure to organophosphorus pesticides. *Bulletin of Environmental Contamination and Toxicology* **61**, 569–576.

- BAUER, G. (1988). Threats to the freshwater pearl mussel *Margaritifera margaritifera* L. in Central Europe. *Biological Conservation* **45**, 239–253.
- BAYERLE, D. F., NUNES, R. V., JUNIOR, A. C. G., WACHHOLZ, L., SCHERER, C., DA SILVA, I. M., DE OLIVEIRA-BRUXEL, T. M. & DE VARGAS JUNIOR, J. G. (2017). Golden mussel (*Limnoperna fortunei*) in feed for broiler chicks using tannin as a sequestrant of toxic metals. *Semina: Ciências Agrárias* **38**, 843–854.
- *BAYERLE, D. F., NUNES, R. V., WACHHOLZ, L., DE OLIVEIRA BRUXEL, T. M., DE VARGAS, J. G. JR., SANGALLI, G., GIRON, T. V. & SCHONE, R. A. (2019). Use of golden mussel and wattle tannin in the supply of cut chickens. *Semina: Ciências Agrárias* **40**, 1951–1964.
- BEASLEY, C. R. (2001). The impact of exploitation on freshwater mussels (Bivalvia: Hyriidae) in the Tocantins River, Brazil. *Studies on Neotropical Fauna and Environment* **36**, 159–165.
- *BEAVER, J. R., CRISMAN, T. L. & BROCK, R. J. (1991). Grazing effects of an exotic bivalve (*Corbicula fluminea*) on hypereutrophic lake water. *Lake and Reservoir Management* **7**, 45–51.
- *BECKER-VAN SLOOTEN, K. & TARRADELLAS, J. (1995). Organotin in Swiss lakes after their ban: assessment of water, sediment, and *Dreissena polymorpha* contamination over a four-year period. *Archives of Environmental Contamination and Toxicology* **29**, 384–392.
- *BELANGER, S. E., CHERRY, D. S. & CAIRNS, J. JR. (1986). Seasonal, behavioral and growth changes of juvenile *Corbicula fluminea* exposed to chrysotile asbestos. *Water Research* **20**, 1243–1250.
- *BELANGER, S. E., CHERRY, D. S., CAIRNS, J. JR. & MCGUIRE, M. J. (1987). Using Asiatic clams as a biomonitor for chrysotile asbestos in public water supplies. *Journal American Water Works Association* **79**, 69–74.
- *BENITO, M., MOSTEO, R., RUBIO, E., LAPLANTE, D., ORMAD, M. P. & GOÑI, P. (2017). Bioaccumulation of inorganic elements in *Dreissena polymorpha* from the Ebro River, Spain: could zebra mussels be used as a bioindicator of the impact of human activities? *River Research and Applications* **33**, 718–728.
- *BENNET-CHAMBERS, M., DAVIES, P. & KNOTT, B. (1999). Cadmium in aquatic ecosystems in Western Australia: a legacy of nutrient-deficient soils. *Journal of Environmental Management* **57**, 283–295.
- *BERNY, P., LACHAUX, O., BURONFOSSE, T., MAZALLON, M. & GILLET, C. (2002). Zebra mussels (*Dreissena polymorpha*) as indicators of freshwater contamination with lindane. *Environmental Research* **90**, 142–151.
- *BERTIN, L. (2015). Exploitation of mother of pearl in the Middle Ages, Clos d'Ugnac archaeological site (Pennauiet, Aude, France): Malacological study, consumption, exploitation and utilization of the naire. *Quaternary International* **375**, 145–152.
- *BERVOETS, L., VOETS, J., CHU, S., COVACI, A., SCHEPENS, P. & BLUST, R. (2004). Comparison of accumulation of micropollutants between indigenous and transplanted zebra mussels (*Dreissena polymorpha*). *Environmental Toxicology and Chemistry* **23**, 1973–1983.
- *BERVOETS, L., VOETS, J., COVACI, A., CHU, S., QADAH, D., SMOLDERS, R., SCHEPENS, P. & BLUST, R. (2005a). Use of transplanted zebra mussels (*Dreissena polymorpha*) to assess the bioavailability of microcontaminants in Flemish surface waters. *Environmental Science and Technology* **39**, 1492–1505.
- *BERVOETS, L., VOETS, J., SMOLDERS, R. & BLUST, R. (2005b). Metal accumulation and condition of transplanted zebra mussel (*Dreissena polymorpha*) in metal polluted rivers. *Aquatic Ecosystem Health and Management* **8**, 451–460.
- *BETTINETTI, R., QUADRONI, S., GALASSI, S., BACCHETTA, R., BONARDI, L. & VAILATI, G. (2008). Is meltwater from Alpine glaciers a secondary DDT source for lakes? *Chemosphere* **73**, 1027–1031.
- *BHAKTA, J. N. & MUNKEGGE, Y. (2008). Role of ecosystem components in Cd removal process of aquatic ecosystem. *Ecological Engineering* **32**(274), 280.
- *BHALCHANDRA, W. & RAHANE, B. (2015). Biomonitoring of heavy metals (cadmium, zinc, copper, and lead) from Gangapur reservoir using three freshwater bivalve species. *Pollution Research* **34**, 125–132.
- *BIAN, X., LIU, H., GAN, J., LI, R. & YANG, J. (2009). HCH and DDT residues in bivalves *Anodonta woodiana* from the Taihu Lake, China. *Archives of Environmental Contamination and Toxicology* **56**, 67–76.
- BIANCHI, V. A., CASTRO, J. M., ROCCHETTA, I., BIECZYNSKI, F. & LUQUET, C. M. (2014). Health status and bioremediation capacity of wild freshwater mussels (*Diplodon chilensis*) exposed to sewage water pollution in a glacial Patagonian lake. *Fish & Shellfish Immunology* **37**, 268–277.
- *BIGHIU, M. A., NORMAN HALDÉN, A., GOEDKOOP, W. & OTTOSON, J. (2019). Assessing microbial contamination and antibiotic resistant bacteria using zebra mussels (*Dreissena polymorpha*). *Science of the Total Environment* **650**, 2141–2149.
- *BIGOT, A., VASSEUR, P. & RODIUS, F. (2010). SOD and CAT cDNA cloning, and expression pattern of detoxification genes in the freshwater bivalve *Unio tumidus* transplanted into the Moselle river. *Ecotoxicology* **19**, 369–376.
- *BILOS, C., COLOMBO, J. C. & PRESA, M. J. R. (1998). Trace metals in suspended particles, sediments and Asiatic clams (*Corbicula fluminea*) of the Río de la Plata estuary, Argentina. *Environmental Pollution* **99**, 1–11.
- *BINELLI, A., BACCHETTA, R., VAILATI, G., GALASSI, S. & PROVINI, A. (2001a). DDT contamination in Lake Maggiore (N. Italy) and effects on zebra mussel spawning. *Chemosphere* **45**, 409–415.
- *BINELLI, A., GALASSI, S. & PROVINI, A. (2001b). Factors affecting the use of *Dreissena polymorpha* as a bioindicator: the PCB pollution in Lake Como (N. Italy). *Water, Air, and Soil Pollution* **125**, 19–32.
- *BINELLI, A., GUZZELLA, L. & ROSCIOLI, C. (2008). Levels and congener profiles of polybrominated diphenyl ethers (PBDEs) in zebra mussels (*D. polymorpha*) from Lake Maggiore (Italy). *Environmental Pollution* **153**, 610–617.
- *BINELLI, A., MAGNI, S., DELLA TORRE, C. & PAROLINI, M. (2015). Toxicity decrease in urban wastewaters treated by a new biofiltration process. *Science of the Total Environment* **537**, 235–242.
- BINELLI, A., MAGNI, S., SOAVE, C., MARAZZI, F., ZUCCATO, E., CASTIGLIONI, S., PAROLINI, M. & MEZZANOTTE, V. (2014). The biofiltration process by the bivalve *D. polymorpha* for the removal of some pharmaceuticals and drugs of abuse from civil wastewaters. *Ecological Engineering* **71**, 710–721.
- *BINELLI, A. & PROVINI, A. (2003). DDT is still a problem in developed countries: the heavy pollution of Lake Maggiore. *Chemosphere* **52**, 717–723.
- *BINELLI, A., RICCIARDI, F. & PROVINI, A. (2004). Present status of POP contamination in Lake Maggiore (Italy). *Chemosphere* **57**, 27–34.
- BINELLI, A., RICCIARDI, F., RIVA, C. & PROVINI, A. (2006). Integrated use of biomarkers and bioaccumulation data in zebra mussel (*Dreissena polymorpha*) for site-specific quality assessment. *Biomarkers* **11**, 428–448.
- BINKOWSKI, Ł. J., BIAŁSZCZYK, M., PRZYSTUPIŃSKA, A., OŹGO, M. & MASSANYI, P. (2019). Metal concentrations in archaeological and contemporary mussel shells (Unionidae): reconstruction of past environmental conditions and the present state. *Chemosphere* **228**, 756–761.
- BLACK, B. A., DUNHAM, J. B., BLUNDON, B. W., RAGGON, M. F. & ZIMA, D. (2010). Spatial variability in growth-increment chronologies of long-lived freshwater mussels: implications for climate impacts and reconstructions. *Ecoscience* **17**, 240–250.
- *BLACKWELL, B. D., DRISCOLL, C. T., SPADA, M. E., TODOROVA, S. G. & MONTESEDECA, M. R. (2013). Evaluation of zebra mussels (*Dreissena polymorpha*) as biomonitors of mercury contamination in aquatic ecosystems. *Environmental Toxicology and Chemistry* **32**, 638–643.
- *BIAZEJOWSKI, B., RACKI, G., GIESZCZ, P., MAŁKOWSKI, K., KIN, A. & KRZYWIECKA, K. (2013). Comparative oxygen and carbon isotopic records of miocene and recent lacustrine unionid bivalves from Poland. *Geological Quarterly* **57**, 113–122.
- *BODIS, E., TOTH, B. & SOUSA, R. (2014). Massive mortality of invasive bivalves as a potential resource subsidy for the adjacent terrestrial food web. *Hydrobiologia* **735**, 253–262.
- *BOEGMAN, L., LOEWEN, M. R., CULVER, D. A., HAMBLIN, P. F. & CHARLTON, M. N. (2008). Spatial-dynamic modeling of algal biomass in Lake Erie: relative impacts of dreissenid mussels and nutrient loads. *Journal of Environmental Engineering* **134**, 456–468.
- BOLLHÖFER, A. (2012). Stable lead isotope ratios and metals in freshwater mussels from a uranium mining environment in Australia's wet-dry tropics. *Applied Geochemistry* **27**, 171–185.
- *BOLOGNESI, C., BUSCHINI, A., BRANCHI, E., CARBONI, P., FURLINI, M., MARTINO, A., MONTEVERDE, M., POLI, P. & ROSSI, C. (2004). Comet and micronucleus assays in zebra mussel cells for genotoxicity assessment of surface drinking water treated with three different disinfectants. *Science of the Total Environment* **333**, 127–136.
- *BOLTOVSKOY, D., CORREA, N., CATALDO, D., STRIPEIKIS, J. & TUDINO, M. (1997). Environmental stress on *Corbicula fluminea* (Bivalvia) in the Parana River delta (Argentina): complex pollution-related disruption of population structures. *Archiv für Hydrobiologie* **138**, 483–507.
- *BONNAIL, E., BURUAEM, L. M., ARAUJO, G. S., ABESSA, D. M. S. & DELVALLS, T. Á. (2016). Multiple biomarker responses in *Corbicula fluminea* exposed to copper in laboratory toxicity tests. *Archives of Environmental Contamination and Toxicology* **71**, 278–285.
- BONNAIL, E., BURUAEM, L. M., MORAIS, L. G., ARAUJO, G. S., ABESSA, D. M. S., SARMIENTO, A. M. & DELVALLS, T. Á. (2018). Integrative assessment of sediment quality in lower basin affected by former mining in Brazil. *Environmental Geochemistry and Health* **40**, 1465–1480.
- BONNAIL, E., MACÍAS, F. & OSTA, V. (2019a). Ecological improvement assessment of a passive remediation technology for acid mine drainage: water quality biomonitoring using bivalves. *Chemosphere* **219**, 695–703.
- *BONNAIL, E., RIBA, I., DE SEABRA, A. A. & DELVALLS, T. Á. (2019b). Sediment quality assessment in the Guadalquivir River (SW, Spain) using caged Asian clams: a biomarker field approach. *Science of the Total Environment* **650**, 1996–2003.
- *BONTES, B. M., VERSCHOOR, A. M., DIONISIO PIRES, L. M., VAN DONK, E. & IBEINGS, B. W. (2007). Functional response of *Anodonta anatina* feeding on a green alga and four strains of cyanobacteria, differing in shape, size and toxicity. *Hydrobiologia* **584**, 191–204.
- *BORCHERDING, J. & JANTZ, B. (1997). Valve movement response of the mussel *Dreissena polymorpha*—the influence of pH and turbidity on the acute toxicity of pentachlorophenol under laboratory and field conditions. *Ecotoxicology* **6**, 153–165.
- *BORCHERDING, J. & WOLF, J. (2001). The influence of suspended particles on the acute toxicity of 2-chloro-4-nitro-aniline, cadmium, and pentachlorophenol on the

- valve movement response of the zebra mussel (*Dreissena polymorpha*). *Archives of Environmental Contamination and Toxicology* **40**, 497–504.
- *BORKOVIĆ-MITIĆ, S., PAVLOVIĆ, S., PERENDIJA, B., DESPOTOVIĆ, S., GAVRIĆ, J., GAČIĆ, Z. & SAJIĆIĆ, Z. (2013). Influence of some metal concentrations on the activity of antioxidant enzymes and concentrations of vitamin E and SH-groups in the digestive gland and gills of the freshwater bivalve *Unio tumidus* from the Serbian part of Sava River. *Ecological Indicators* **32**, 212–221.
- *BOULDIN, J. L., FARRIS, J. L., MOORE, M. T., SMITH, S. JR. & COOPER, C. M. (2007). Assessment of diazinon toxicity in sediment and water of constructed wetlands using deployed *Corbicula fluminea* and laboratory testing. *Archives of Environmental Contamination and Toxicology* **53**, 174–182.
- *BOURGEAULT, A., COUSIN, C., GEERTSEN, V., CASSIER-CHAUVAT, C., CHAUVAT, F., DURUPHY, O., CHANÉAC, C. & SPALLA, O. (2015). The challenge of studying TiO₂ nanoparticle bioaccumulation at environmental concentrations: crucial use of a stable isotope tracer. *Environmental Science and Technology* **49**, 2451–2459.
- *BOURGEAULT, A. & GOURLAY-FRANCÉ, C. (2013). Monitoring PAH contamination in water: comparison of biological and physico-chemical tools. *Science of the Total Environment* **454–455**, 328–336.
- *BOWEN, Z. H., MALVESTUTO, S. P., DAVIES, W. D. & CRANCE, J. H. (1994). Evaluation of the mussel fishery in Wheeler Reservoir, Tennessee River. *Journal of Freshwater Ecology* **9**, 313–319.
- *BRAUER, H., WAGNER, A., BOMAN, J. & VIET BINH, D. (2001). Use of total-reflection X-ray fluorescence in search of a biomonitor for environmental pollution in Vietnam. *Spectrochimica Acta—Part B Atomic Spectroscopy* **56**, 2147–2155.
- BRIM BOX, J., HOWARD, J., WOLF, D., O'BRIEN, C., NEZ, D. & CLOSE, D. (2006). Freshwater mussels (Bivalvia: Unionoida) of the Umatilla and middle fork John Day rivers in eastern Oregon. *Northwest Science* **80**, 95.
- BROCK, R. E., CINI, A. & SUMNER, S. (2021). Ecosystem services provided by aculeate wasps. *Biological Reviews* **96**, 1645–1675.
- *BROWN, M. E., CURTIN, T. M., GALLAGHER, C. J. & HALFMAN, J. D. (2012). Historic nutrient loading and recent species invasions caused shifts in water quality and zooplankton demography in two Finger Lakes (New York, USA). *Journal of Paleolimnology* **48**, 623–639.
- *BRUESEWITZ, D. A., TANK, J. L., BERNOT, M. J., RICHARDSON, W. B. & STRAUSS, E. A. (2006). Seasonal effects of the zebra mussel (*Dreissena polymorpha*) on sediment denitrification rates in Pool 8 of the Upper Mississippi River. *Canadian Journal of Fisheries and Aquatic Sciences* **63**, 957–969.
- *BUCCI, J. P., LEVINE, J. F. & SHOWERS, W. J. (2011). Spatial variability of the stable isotope ($\delta^{15}\text{N}$) composition in two freshwater bivalves (*Corbicula fluminea* and *Elliptio complanata*). *Journal of Freshwater Ecology* **26**, 19–24.
- *BUCCI, J. P., SHOWERS, W. J., GENNA, B. & LEVINE, J. F. (2009). Stable oxygen and carbon isotope profiles in an invasive bivalve (*Corbicula fluminea*) in North Carolina watersheds. *Geochimica et Cosmochimica Acta* **73**, 3234–3247.
- *BUDD, C., POTEKHINA, I. & LILLIE, M. (2020). Continuation of fishing subsistence in the Ukrainian Neolithic: diet isotope studies at Yasinovatka, Dnieper Rapids. *Archaeological and Anthropological Sciences* **12**, 64.
- BUELOW, C. A. & WALTHAM, N. J. (2020). Restoring tropical coastal wetland water quality: ecosystem service provisioning by a native freshwater bivalve. *Aquatic Sciences* **82**, 1–16.
- *BULLARD, A. E. & HERSHEY, A. E. (2013). Impact of *Corbicula fluminea* (Asian clam) on seston in an urban stream receiving wastewater effluent. *Freshwater Science* **32**, 976–990.
- *BURKET, S. R., WHITE, M., RAMIREZ, A. J., STANLEY, J. K., BANKS, K. E., WALLER, W. T., CHAMBLISS, C. K. & BROOKS, B. W. (2019). *Corbicula fluminea* rapidly accumulate pharmaceuticals from an effluent dependent urban stream. *Chemosphere* **224**, 873–883.
- BURLEIGH, R. (1983). Two radiocarbon dates for freshwater shells from Hierakonpolis: archaeological and geological interpretations. *Journal of Archaeological Science* **10**, 361–367.
- BUSKIRK, B. L., BOURGEOIS, J., MEYER, H. W., NESBITT, E. A. & DEVORE, M. L. (2016). Freshwater molluscan fauna from the Florissant Formation, Colorado: paleohydrologic reconstruction of a latest Eocene lake. *Canadian Journal of Earth Sciences* **53**, 630–643.
- *BUYNEVICH, I. V., DAMUŠYTE, A., BITINAS, A., OLENIN, S., MAŽEIKA, J. & PETROSIUS, R. (2011). Pontic-Baltic pathways for invasive aquatic species: geoarchaeological implications. In *Geology and Geoarchaeology of the Black Sea Region: Beyond the Flood Hypothesis* (Volume **473**), pp. 189–196. Geological Society of America, Boulder.
- *BYKOVA, O., LAURSEN, A., BOSTAN, V., BAUTISTA, J. & MCCARTHY, L. (2006). Do zebra mussels (*Dreissena polymorpha*) alter lake water chemistry in a way that favours *Microcystis* growth? *Science of the Total Environment* **371**, 362–372.
- CABI (2021). Invasive species compendium. Electronic file available at www.cabi.org/isc. Accessed 01.06.2021.
- CADENA, E.-A. & CASADO-FERRER, I. (2019). Late Miocene freshwater mussels from the intermontane Chota Basin, northern Ecuadorian Andes. *Journal of South American Earth Sciences* **89**, 39–46.
- ÇAKIRLAR, C. & ŞEŞEN, R. (2013). Reading between the lines: $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ isotopes of *Unio elongatulus* shell increments as proxies for local palaeoenvironments in mid-Holocene northern Syria. *Archaeological and Anthropological Sciences* **5**, 85–94.
- *CAMUSSO, M., BALESTRINI, R. & BINELLI, A. (2001). Use of zebra mussel (*Dreissena polymorpha*) to assess trace metal contamination in the largest Italian subalpine lakes. *Chemosphere* **44**, 263–270.
- *CAMUSSO, M., BALESTRINI, R., MURIANO, F. & MARIANI, M. (1994). Use of freshwater mussel *Dreissena polymorpha* to assess trace metal pollution in the lower River Po (Italy). *Chemosphere* **29**, 729–745.
- *CANALE, R. P. & CHAPRA, S. C. (2002). Modeling zebra mussel impacts on water quality of Seneca River, New York. *Journal of Environmental Engineering* **128**, 1158–1116.
- *CARRASCO, L., DIEZ, S., SOTO, D. X., CATALAN, J. & BAYONA, J. M. (2008). Assessment of mercury and methylmercury pollution with zebra mussel (*Dreissena polymorpha*) in the Ebro River (NE Spain) impacted by industrial hazardous dumps. *Science of the Total Environment* **407**, 178–184.
- CATALDO, D., BOLTOVSKOY, D., STRIPEIKIS, J. & POSE, M. (2001a). Condition index and growth rates of field caged *Corbicula fluminea* (Bivalvia) as biomarkers of pollution gradients in the Paraná river delta (Argentina). *Aquatic Ecosystem Health & Management* **4**, 187–201.
- *CATALDO, D., COLOMBO, J. C., BOLTOVSKOY, D., BILOS, C. & LANDONI, P. (2001b). Environmental toxicity assessment in the Paraná river delta (Argentina): simultaneous evaluation of selected pollutants and mortality rates of *Corbicula fluminea* (Bivalvia) early juveniles. *Environmental Pollution* **112**, 379–389.
- CHA, Y. K., STOW, C. A., NALEPA, T. F. & RECKHOW, K. H. (2011). Do invasive mussels restrict offshore phosphorus transport in Lake Huron? *Environmental Science & Technology* **45**, 7226–7231.
- CHAKRABORTY, A., PARVEEN, S., CHANDA, D. K. & ADITYA, G. (2020). An insight into the structure, composition and hardness of a biological material: the shell of freshwater mussels. *RSC Advances* **10**, 29543–29554.
- CHAKRABORTY, M., BHATTACHARYA, S., BHATTACHARJEE, P., DAS, R. & MISHRA, R. (2010). Prevention of the progression of adjuvant induced arthritis by oral supplementation of Indian fresh water mussel (*Lamellidens marginalis*) aqueous extract in experimental rats. *Journal of Ethnopharmacology* **132**, 316–320.
- *CHAKRABORTY, S., RAY, M. & RAY, S. (2013). Cell to organ: physiological, immunotoxic and oxidative stress responses of *Lamellidens marginalis* to inorganic arsenite. *Ecotoxicology and Environmental Safety* **94**, 153–163.
- CHAZANAH, N., MUNTALIF, B. S., RAHMAYANI, R. A. & SUDJONO, P. (2020). Macrozoobentos distribution as a bioindicator of water quality in the upstream of the Citarum River. *Journal of Ecological Engineering* **21**, 10–17.
- *CHEN, J.-Z., HE, Y.-P., MENG, S.-L., HU, G.-D., QU, J.-H. & FAN, L.-M. (2007). Purification effect of polyculture of fish-mussel in pond, a mode of circular economy. *Journal of Ecology and Rural Environment* **23**, 41–46.
- *CHEN, T.-Y., LIN, B.-C., SHIAO, M.-S. & PAN, B. S. (2008). Lipid-lowering and LDL-oxidation inhibitory effects of aqueous extract of freshwater clam (*Corbicula fluminea*)—using tilapia as an animal model. *Journal of Food Science* **73**, H148–H154.
- *CHEN, W.-Y. & LIAO, C.-M. (2010). Dynamic features of ecophysiological response of freshwater clam to arsenic revealed by BLM-based toxicological model. *Ecotoxicology* **19**, 1074–1083.
- CHEN, W.-Y., LIAO, C.-M., JOU, L.-J. & JAU, S.-F. (2010). Predicting bioavailability and bioaccumulation of arsenic by freshwater clam *Corbicula fluminea* using valve daily activity. *Environmental Monitoring and Assessment* **169**, 647–659.
- *CHEN, X., BAI, Z. & LI, J. (2019). The mantle exosome and microRNAs of *Hyriopsis cumingii* involved in nacre color formation. *Marine Biotechnology* **21**, 634–642.
- *CHEVREUIL, M., BLANCHARD, M., TEIL, M.-J., CARRU, A.-M., TESTARD, P. & CHESTERIKOFF, A. (1996). Evaluation of the pollution by organochlorinated compounds (polychlorobiphenyls and pesticides) and metals Cd, Cr, Cu and Pb in the water and in the zebra mussel (*Dreissena polymorpha* Pallas) of the river seine. *Water, Air, and Soil Pollution* **88**, 371–381.
- *CHIJIMATSU, T., UMEKI, M., KATAOKA, Y., KOBAYASHI, S., YAMADA, K., ODA, H. & MOCHIZUKI, S. (2013). Lipid components prepared from a freshwater Clam (*Corbicula fluminea*) extract ameliorate hypercholesterolaemia in rats fed high-cholesterol diet. *Food Chemistry* **136**, 328–334.
- CHIJIMATSU, T., UMEKI, M., OKUDA, Y., YAMADA, K., ODA, H. & MOCHIZUKI, S. (2011). The fat and protein fractions of freshwater clam (*Corbicula fluminea*) extract reduce serum cholesterol and enhance bile acid biosynthesis and sterol excretion in hypercholesterolaemic rats fed a high-cholesterol diet. *British Journal of Nutrition* **105**, 526–534.
- *CHMIST, J. & SZOSZKIEWICZ, K. (2017). Attempt at assessment of *Unio tumidus* bivalve mollusks suitability for monitoring water iron content. *Ochrona Srodowiska* **39**, 39–43.
- CHOI, M. H., LEE, K., KIM, M. Y., SHIN, H.-I. & JEONG, D. (2019). *Pisidium coreanum* inhibits multinucleated osteoclast formation and prevents estrogen-deficient oostoporosis. *International Journal of Molecular Sciences* **20**, 6076.
- *CHOWDHURY, G. W., ZIERITZ, A. & ALDRIDGE, D. C. (2016). Ecosystem engineering by mussels supports biodiversity and water clarity in a heavily polluted lake in Dhaka, Bangladesh. *Freshwater Science* **35**, 188–199.

- *CIPARIS, S., SCHREIBER, M. E. & VOSHELL, J. R. JR. (2012). Using watershed characteristics, sediment, and tissue of resident mollusks to identify potential sources of trace elements to streams in a complex agricultural landscape. *Environmental Monitoring and Assessment* **184**, 3109–3126.
- *CLEARWATER, S. J., HICKEY, C. W. & THOMPSON, K. J. (2014). The effect of chronic exposure to phosphorus-inactivation agents on freshwater biota. *Hydrobiologia* **728**, 51–65.
- *COELHO, J. P., LILLEBØ, A. I., CRESPO, D., LESTON, S. & DOLBETH, M. (2018). Effect of the alien invasive bivalve *Corbicula fluminea* on the nutrient dynamics under climate change scenarios. *Estuarine, Coastal and Shelf Science* **204**, 273–282.
- *COLLAS, F. P. L., KOOPMAN, K. R., VAN DER VELDE, G. & LEUVEN, R. S. E. W. (2020). Quantifying the loss of filtration services following mass mortality of invasive dreissenid mussels. *Ecological Engineering* **149**, 105781.
- COLLIER, K. J., PROBERT, P. K. & JEFFRIES, M. (2016). Conservation of aquatic invertebrates: concerns, challenges and conundrums. *Aquatic Conservation: Marine and Freshwater Ecosystems* **26**, 817–837.
- *COLLINS, J., ANDRUS, C. F. T., SCOTT, R. J., MOE-HOFFMAN, A. & PEACOCK, E. (2020). Refit and oxygen isotope analysis of freshwater mussel shells from the Tillar Farms Site (3DR30), Southeast Arkansas. *Midcontinental Journal of Archaeology* **45**, 39–63.
- *COLOMBO, J. C., BILOS, C., CAMPANARO, M., RODRIGUEZ PRESA, M. J. & CATOGGIO, J. A. (1995). Bioaccumulation of polychlorinated biphenyls and chlorinated pesticides by the Asiatic clam *Corbicula fluminea*; its use as sentinel organism in the Rio de La Plata Estuary, Argentina. *Environmental Science and Technology* **29**, 914–927.
- *COLOMBO, J. C., BROCHU, C., BILOS, C., LANDONI, P. & MOORE, S. (1997). Long-term accumulation of individual PCBs, dioxins, furans, and trace metals in Asiatic clams from the Rio de la Plata Estuary, Argentina. *Environmental Science and Technology* **31**, 3551–3557.
- *COMPANY, R., SERAFIM, A., LOPES, B., CRAVO, A., SHEPHERD, T. J., PEARSON, G. & BEBIANNO, M. J. (2008). Using biochemical and isotope geochemistry to understand the environmental and public health implications of lead pollution in the lower Guadiana River, Iberia: a freshwater bivalve study. *Science of the Total Environment* **405**, 109–119.
- *CONTARDO-JARA, V., GALANTI, L. N., AMÉ, M. V., MONFERRÁN, M. V., WUNDERLIN, D. A. & WIEGAND, C. (2009a). Biotransformation and antioxidant enzymes of *Limnoperna fortunei* detect site impact in watercourses of Córdoba, Argentina. *Ecotoxicology and Environmental Safety* **72**, 1871–1880.
- *CONTARDO-JARA, V., KRUEGER, A., EXNER, H.-J. & WIEGAND, C. (2009b). Biotransformation and antioxidant enzymes of *Dreissena polymorpha* for detection of site impact in watercourses of Berlin. *Journal of Environmental Monitoring* **11**, 1147–1156.
- CONTARDO-JARA, V. & WIEGAND, C. (2008). Molecular biomarkers of *Dreissena polymorpha* for evaluation of renaturation success of a formerly sewage polluted stream. *Environmental Pollution* **155**, 182–189.
- *COOPER, S., HARE, L. & CAMPBELL, P. G. C. (2010). Modeling cadmium uptake from water and food by the freshwater bivalve *Pyganodon grandis*. *Canadian Journal of Fisheries and Aquatic Sciences* **67**, 1874–1888.
- *CORENBLOT, D., JULIEN, F., STEIGER, J., DARROZES, J. & MIALET, B. (2013). High shell deposition of the invasive clam *Corbicula fluminea* (Müller, 1774) on alluvial bars: exploratory investigations and biogeomorphological research perspectives [Dépôts massifs de coquilles du mollusque invasif *Corbicula fluminea* (Müller; 1774) Sur les bancs alluviaux: observations exploratoires et perspectives de recherche en biogeomorphologie]. *Geomorphologie Relief Processus Environnement* **19**, 153–164.
- *CRANE, M., DELANEY, P., MAINSTONE, C. & CLARKE, S. (1995). Measurement by *in situ* bioassay of water quality in an agricultural catchment. *Water Research* **29**, 2441–2448.
- *CYR, H., COLLIER, K. J., CLEARWATER, S. J., HICKS, B. J. & STEWART, S. D. (2017). Feeding and nutrient excretion of the New Zealand freshwater mussel *Echyridella menziesii* (Hyriidae, Unionida): implications for nearshore nutrient budgets in lakes and reservoirs. *Aquatic Sciences* **79**, 557–571.
- *CZARNEZI, J. M. (1987). Use of the pocketbook mussel, *Lampsilis ventricosa*, for monitoring heavy metal pollution in an Ozark stream. *Bulletin of Environmental Contamination and Toxicology* **38**, 641–646.
- DAI, J. P., CHEN, J., BEI, Y. F., HAN, B. X., GUO, S. B. & JIANG, L. L. (2010). Effects of pearl powder extract and its fractions on fibroblast function relevant to wound repair. *Pharmaceutical Biology* **48**, 122–127.
- *DAS, S. & JANA, B. B. (1999). Dose-dependent uptake and *Eichhornia*-induced elimination of cadmium in various organs of the freshwater mussel, *Lamellidens marginalis* (Linn.). *Ecological Engineering* **12**, 207–229.
- DAS, S. & JANA, B. B. (2003). *In situ* cadmium reclamation by freshwater bivalve *Lamellidens marginalis* from an industrial pollutant-fed river canal. *Chemosphere* **52**, 161–173.
- *DAS, S. & JANA, B. B. (2004). Distribution pattern of ambient cadmium in wetland ponds distributed along an industrial complex. *Chemosphere* **55**, 175–185.
- *DE LA CRUZ, C. P. P., DE VERA, N. M., LAPIE, L. P., CATALMA, M. N. A. & BUNAL, R. V. (2017). Bio accumulation and health risks assessment of lead (Pb) in freshwater Asian clams (*Corbicula fluminea*, Muller) from Laguna de Bay, Philippines. *Pollution Research* **36**, 366–372.
- DE LAFONTAINE, Y., GAGNÉ, F., BLAISE, C., COSTAN, G., GAGNON, P. & CHAN, H. M. (2000). Biomarkers in zebra mussels (*Dreissena polymorpha*) for the assessment and monitoring of water quality of the St Lawrence River (Canada). *Aquatic Toxicology* **50**, 51–71.
- DE STASIO, B. T., SCHRIMPF, M. B., BERANEK, A. E. & DANIELS, W. C. (2008). Increased Chlorophyll *a*, phytoplankton abundance, and cyanobacteria occurrence following invasion of Green Bay, Lake Michigan by dreissenid mussels. *Aquatic Invasions* **3**, 21–27.
- DE ZWART, D., KRAMER, K. J. M. & JENNER, H. A. (1995). Practical experiences with the biological early warning system “moschelmonitor”. *Environmental Toxicology and Water Quality* **10**, 237–247.
- DEBRUYNE, S. (2010). Tools and souvenirs: the shells from Kilise Tepe (1994–1998). *Anatolian Studies* **60**, 149–160.
- *DEE, K. H., ABDULLAH, F., MD NASIR, S. N. A., APPALASAMY, S., MOHD GHAZI, R. & EH RAK, A. (2019). Health risk assessment of heavy metals from smoked *Corbicula fluminea* collected on roadside vendors at Kelantan, Malaysia. *BioMed Research International* **2019**, 9596810.
- *DEMÉNY, A., KERN, Z., CZUPPON, G., NÉMETH, A., SCHÖLL-BARNA, G., SIKLÓSY, Z., LEÉL-ÖSSY, S., COOK, G., SERLEGI, G., BAJNÓCZI, B., SÜMEGI, P., KIRÁLY, Á., KISS, V., KULCSÁR, G. & BONDÁR, M. (2019). Middle bronze age humidity and temperature variations, and societal changes in East-Central Europe. *Quaternary International* **504**, 80–95.
- *DEMÉNY, A., SCHÖLL-BARNA, G., FÓRIZS, I., OSÁN, J., SÜMEGI, P. & BAJNÓCZI, B. (2012). Stable isotope compositions and trace element concentrations in freshwater bivalve shells (*Unio* sp.) as indicators of environmental changes at Tiszapüspöki, eastern Hungary. *Central European Geology* **55**, 441–460.
- *DEPEW, D. C., KOEHLER, G. & HIRIART-BAER, V. (2018). Phosphorus dynamics and availability in the nearshore of Eastern Lake Erie: insights from oxygen isotope ratios of phosphate. *Frontiers in Marine Science* **5**, 215.
- DI FIORI, E., PIZARRO, H., DOS SANTOS AFONSO, M. & CATALDO, D. (2012). Impact of the invasive mussel *Limnoperna fortunei* on glyphosate concentration in water. *Ecotoxicology and Environmental Safety* **81**, 106–113.
- DIGGS, T. P., BAIER, R. E., MEYER, A. E. & FORSBERG, R. L. (2002). Potential for selective, controlled biofouling by *Dreissena* species to intercept pollutants from industrial effluents. *Biofouling* **18**, 29–36.
- *DIONISIO PIRES, L. M., BONTES, B. M., SAMCHYSHYNA, L., JONG, J., VAN DONK, E. & IBELINGS, B. W. (2007). Grazing on microcystin-producing and microcystin-free phytoplankters by different filter-feeders: implications for lake restoration. *Aquatic Sciences* **69**, 534–543.
- *DIONISIO PIRES, L. M., BONTES, B. M., VAN DONK, E. & IBELINGS, B. W. (2005a). Grazing on colonial and filamentous, toxic and non-toxic cyanobacteria by the zebra mussel *Dreissena polymorpha*. *Journal of Plankton Research* **27**, 331–339.
- *DIONISIO PIRES, L. M., IBELINGS, B. W., BREHM, M. & VAN DONK, E. (2005b). Comparing grazing on lake seston by *Dreissena* and *Daphnia*: lessons for biomanipulation. *Microbial Ecology* **50**, 242–252.
- *DOBSON, E. P. & MACKIE, G. L. (1998). Increased deposition of organic matter, polychlorinated biphenyls, and cadmium by zebra mussels (*Dreissena polymorpha*) in western Lake Erie. *Canadian Journal of Fisheries and Aquatic Sciences* **55**, 1131–1139.
- DOMINGUES, A., ROSA, I. C., PINTO DA COSTA, J., ROCHA-SANTOS, T. A. P., GONÇALVES, F. J. M., PEREIRA, R. & PEREIRA, J. L. (2020). Potential of the bivalve *Corbicula fluminea* for the remediation of olive oil wastewaters. *Journal of Cleaner Production* **252**, 119773.
- *DONG, X., LV, L., ZHAO, W., YU, Y. & LIU, Q. (2018). Optimization of integrated multi-trophic aquaculture systems for the giant freshwater prawn *Macrobrachium rosenbergii*. *Aquaculture Environment Interactions* **10**, 547–556.
- *DOWNING, S., CONTARDO-JARA, V., PFLUGMACHER, S. & DOWNING, T. G. (2014). The fate of the cyanobacterial toxin β-N-methylamino-l-alanine in freshwater mussels. *Ecotoxicology and Environmental Safety* **101**, 51–58.
- *DRESLER, P. V. & CORY, R. L. (1980). The asiatic clam, *Corbicula fluminea* (Müller), in the tidal Potomac River, Maryland. *Estuaries* **3**, 150–151.
- *DROUILLARD, K. G., CHAN, S., O’ROURKE, S., DOUGLAS HAFFNER, G. & LETCHER, R. J. (2007). Elimination of 10 polybrominated diphenyl ether (PBDE) congeners and selected polychlorinated biphenyls (PCBs) from the freshwater mussel, *Elliptio complanata*. *Chemosphere* **69**, 362–370.
- *DROUILLARD, K. G., COOK, M., LEADLEY, T. A., DRCA, P., BRIGGS, T. & HAFFNER, G. D. (2016). Quantitative biomonitoring in the Detroit River using *Elliptio complanata*: verification of steady state correction factors and temporal trends of PCBs in water between 1998 and 2015. *Bulletin of Environmental Contamination and Toxicology* **97**, 757–762.
- *DROUILLARD, K. G., JEZDIC, I., O’ROURKE, S. M., GEWURTZ, S. B., RAESIDE, A. A., LEADLEY, T. A., DRCA, P. & DOUGLAS HAFFNER, G. (2013). Spatial and temporal variability of PCBs in Detroit River water assessed using a long term biomonitoring program. *Chemosphere* **90**, 95–102.

- *DUXBURY, C. V., GRACE, K. A., POPONI, A. & AUTER, T. (2005). Copper and zinc accumulation by a transplanted bivalve, *Elliptio buckleyi*, in freshwater systems in Central Florida. *Journal of Freshwater Ecology* **20**, 661–669.
- EAGAR, R. M. C. (1948). Variation in shape of shell with respect to ecological station. A review dealing with recent Unionidae and certain species of the Anthracosidae in Upper Carboniferous times. *Proceedings of the Royal Society of Edinburgh, Section B* **63**, 130–148.
- *ENGLUND, V. P. M. & HEINO, M. P. (1996). The freshwater mussel (*Anodonta anatina*) in monitoring of 2,4,6-trichlorophenol: behaviour and environmental variation considered. *Chemosphere* **32**, 391–403.
- ERDOĞAN, F. & ERDOĞAN, M. (2015). Use of the Asian Clam (*Corbicula fluminea* Müller, 1774) as a biomechanical filter in ornamental fish culture. *Turkish Journal of Fisheries and Aquatic Sciences* **15**, 861–867.
- *EVANS, M. A., FAHNSTIEL, G. & SCAVIA, D. (2011). Incidental oligotrophication of North American Great Lakes. *Environmental Science and Technology* **45**, 3297–3303.
- *EVERSOLE, A. G., STUART, K. R. & BRUNE, D. E. (2008). Effect of temperature and phytoplankton concentration of partitioned aquaculture system water on freshwater mussel filtration. *Aquaculture Research* **39**, 1691–1696.
- FABRA, M., GORDILLO, S. & PIOVANO, E. L. (2012). Arqueomalacología en las costas de Ansenúa: análisis de una almeja nacarífera (*Anodontites trapesialis*) hallada en contexto funerario del sitio El Diquecito (Laguna Mar Chiquita, Córdoba). *Arqueología* **18**, 257–266.
- *FACCHETTI, S. V., LA SPINA, R., FUMAGALLI, F., RICCARDI, N., GILLILAND, D. & PONTI, J. (2020). Detection of metal-doped fluorescent PVC microplastics in freshwater mussels. *Nanomaterials* **10**, 2363.
- *FALFUSHYNSKA, H. I., DELAHAUT, L., STOLYAR, O. B., GEFFARD, A. & BIAGIANTI-RISBOURG, S. (2009). Multi-biomarkers approach in different organs of *Anodonta cygnea* from the Dniester Basin (Ukraine). *Archives of Environmental Contamination and Toxicology* **57**, 86–95.
- *FALFUSHYNSKA, H. I., GNATYSHYNA, L. L., FARKAS, A., VEHOVSZKY, Á., GYORI, J. & STOLIAR, O. B. (2010). Vulnerability of biomarkers in the indigenous mollusk *Anodonta cygnea* to spontaneous pollution in a transition country. *Chemosphere* **81**, 1342–1351.
- *FARRIS, J. L., GRUDZIEN, J. L., BELANGER, S. E., CHERRY, D. S. & CAIRNS, J. JR. (1994). Molluscan cellulolytic activity responses to zinc exposure in laboratory and field stream comparisons. *Hydrobiologia* **287**, 161–178.
- *FENGQIN, C., HUCAI, Z., YUE, C., MINGSHENG, Y., JIE, N., HONGFANG, F., GUOLIANG, L., WENXIANG, Z., YANBIN, L. & LUNQING, Y. (2008). Sedimentation geochemistry and environmental changes during the Late Pleistocene of Paleolake Qarhan in the Qaidam Basin. *Journal of China University of Geosciences* **19**, 1–8.
- FERA, S. A., RENNIE, M. D. & DUNLOP, E. S. (2017). Broad shifts in the resource use of a commercially harvested fish following the invasion of dreissenid mussels. *Ecology* **98**, 1681–1692.
- *FERNALD, S. H., CARACO, N. F. & COLE, J. J. (2007). Changes in cyanobacterial dominance following the invasion of the zebra mussel *Dreissena polymorpha*: long-term results from the Hudson River estuary. *Estuaries and Coasts* **30**, 163–170.
- FERRERA, R., GOMES, J., MARTINS, R. C., COSTA, R. & QUINTA-FERRERA, R. M. (2018). Winery wastewater treatment by integrating Fenton's process with biofiltration by *Corbicula fluminea*. *Journal of Chemical Technology & Biotechnology* **93**, 333–339.
- *FERREIRA-RODRÍGUEZ, N., IGLESIAS, J. & PARDO, I. (2019). *Corbicula fluminea* affecting supporting ecosystem services through nutrient and biogenic matter incorporation in invaded estuaries. *Fundamental and Applied Limnology* **192**, 269–280.
- FIGUEIREDO, S. A., LOUREIRO, J. & BOAVENTURA, R. (2005). Natural waste materials containing chitin as adsorbents for textile dyestuffs: batch and continuous studies. *Water Research* **39**, 4142–4152.
- FISKE, D. & SHEPHERD, J. (2007). Continuity and change in Chinese freshwater pearl culture. *Gems & Gemology* **43**, 138–145.
- *FOSTER, R. B. & BATES, J. M. (1978). Use of freshwater mussels to monitor point source industrial discharges. *Environmental Science and Technology* **12**, 958–962.
- *FRANCOEUR, S. N., WINSLOW, K. A. P., MILLER, D. & PEACOR, S. D. (2017). Mussel-derived stimulation of benthic filamentous algae: the importance of nutrients and spatial scale. *Journal of Great Lakes Research* **43**, 69–79.
- *FRAU, D., MOLINA, F. R., DEVERCELLI, M. & DE PAGGI, S. J. (2013). The effect of an invading filter-feeding bivalve on a phytoplankton assemblage from the Paraná system: a mesocosm experiment. *Marine and Freshwater Behaviour and Physiology* **45**, 303–316.
- *FREITAS, M., AZEVEDO, J., CARVALHO, A. P., CAMPOS, A. & VASCONCELOS, V. (2014). Effects of storage, processing and proteolytic digestion on microcystin-LR concentration in edible clams. *Food and Chemical Toxicology* **66**, 217–223.
- FRIEDLAND, R., BUER, A.-L., DAHLKE, S. & SCHERNEWSKI, G. (2019). Spatial effects of different zebra mussel farming strategies in an eutrophic Baltic Lagoon. *Frontiers in Environmental Science* **6**, 158.
- *FRISCHER, M. E., NIERZWICKI-BAUER, S. A., PARSONS, R. H., VATHANODORN, K. & WAITKUS, K. R. (2000). Interactions between zebra mussels (*Dreissena polymorpha*) and microbial communities. *Canadian Journal of Fisheries and Aquatic Sciences* **57**, 591–599.
- FRITTS, A. K., FRITTS, M. W., HAAG, W. R., DEBOER, J. A. & CASPER, A. F. (2017). Freshwater mussel shells (Unionidae) chronicle changes in a North American river over the past 1000 years. *Science of the Total Environment* **575**, 199–206.
- *FRY, B. & ALLEN, Y. C. (2003). Stable isotopes in Zebra mussels as bioindicators of river-watershed linkages. *River Research and Applications* **19**, 683–696.
- *GAČIĆ, Z., KOLAREVIĆ, S., SUNJOG, K., KRAČUN-KOLAREVIĆ, M., PAUNOVIĆ, M., KNEŽEVIĆ-VUKČEVIĆ, J. & VUKOVIĆ-GAČIĆ, B. (2014). The impact of *in vivo* and *in vitro* exposure to base analogue 5-FU on the level of DNA damage in haemocytes of freshwater mussels *Unio pictorum* and *Unio tumidus*. *Environmental Pollution* **191**, 145–150.
- *GAIGALAS, A., PAZDUR, A., MICHYCZYNSKI, A., PAWLYTA, J., KLEIŠMANTAS, A., MELEŠYTE, M., RUDNICKAITE, E., KAZAKAUSKAS, V. & VAINORIUS, J. (2013). Peculiarities of sedimentation conditions in the oxbow lakes of Dubysa River (Lithuania). *Geochronometria* **40**, 22–32.
- *GAILLARD, B., LAZARETH, C. E., LESTRELIN, H., DUFOUR, E., SANTOS, R. V., FREITAS, C. E. C. & POUILLY, M. (2019). Seasonal oxygen isotope variations in freshwater bivalve shells as recorders of Amazonian rivers hydrogeochemistry. *Isotopes in Environmental and Health Studies* **55**, 511–525.
- GALLARDO, B., BOGAN, A. E., HARUN, S., JAINI, L., LOPES-LIMA, M., PIZARRO, M., RAHIM, K. A., SOUSA, R., VIRDIS, S. G. P. & ZIERITZ, A. (2018). Current and future effects of global change on a hotspot's freshwater diversity. *Science of the Total Environment* **635**, 750–760.
- *GAN, C., CHAMPAGNE, P. & HALL, G. (2018). Pilot-scale evaluation of semi-passive treatment technologies for the treatment of septage under temperate climate conditions. *Journal of Environmental Management* **216**, 357–371.
- GANDRUD, C. (2015). d3Network: tools for creating D3 JavaScript network, tree, dendrogram, and Sankey graphs from R. R package version 0.5.2.
- *GANJALI, S. & MORTAZAVI, S. (2014). The swan mussel (*Anodonta cygnea*) in Anzali wetland of Iran, a potential biomonitor for Cd and Pb. *Bulletin of Environmental Contamination and Toxicology* **93**, 154–158.
- *GAO, H., QIAN, X., WU, H., LI, H., PAN, H. & HAN, C. (2017). Combined effects of submerged macrophytes and aquatic animals on the restoration of a eutrophic water body—a case study of Gonghu Bay, Lake Taihu. *Ecological Engineering* **102**, 15–23.
- GARVEY, J. (2017). Australian aboriginal freshwater shell middens from late quaternary Northwest Victoria: prey choice, economic variability and exploitation. *Quaternary International* **427**, 85–102.
- *GATTÁS, F., ESPINOSA, M., BABAY, P., PIZARRO, H. & CATALDO, D. (2020). Invasive species versus pollutants: potential of *Limnoperna fortunei* to degrade glyphosate-based commercial formulations. *Ecotoxicology and Environmental Safety* **201**, 110794.
- *GATTÁS, F., VINOCUR, A., GRAZIANO, M., DOS SANTOS AFONSO, M., PIZARRO, H. & CATALDO, D. (2016). Differential impact of *Limnoperna fortunei*-herbicide interaction between Roundup Max[®] and glyphosate on freshwater microscopic communities. *Environmental Science and Pollution Research* **23**, 18869–18882.
- GÉBA, E., AUBERT, D., DURAND, L., ESCOTTE, S., LA CARBONA, S., CAZEAUX, C., BONNARD, I., BASTIEN, F., LADEIRO, M. P. & DUBEY, J. P. (2020a). Use of the bivalve *Dreissena polymorpha* as a biomonitoring tool to reflect the protozoan load in freshwater bodies. *Water Research* **170**, 115297.
- *GÉBA, E., ROUSSEAU, A., LE GUERNIC, A., ESCOTTE-BINET, S., FAVENNEC, L., LA CARBONA, S., GARGALA, G., DUBEY, J. P., VILLENA, I., BETOULLE, S., AUBERT, D. & BIGOT-CLIVOT, A. (2020b). Survival and infectivity of *Toxoplasma gondii* and *Cryptosporidium parvum* oocysts bioaccumulated by *Dreissena polymorpha*. *Journal of Applied Microbiology* **130**, 504–515.
- *GENÇ, T. O., PO, B. H. K., YILMAZ, F., LAU, T.-C., WU, R. S. S. & CHIU, J. M. Y. (2018). Differences in metal profiles revealed by native mussels and artificial mussels in Sariçay stream, Turkey: implications for pollution monitoring. *Marine and Freshwater Research* **69**, 1372–1378.
- *GEWURTZ, S. B., DROUILLARD, K. G., LAZAR, R. & HAFNER, G. D. (2002). Quantitative biomonitoring of PAHs using the Barnes mussel (*Elliptio complanata*). *Archives of Environmental Contamination and Toxicology* **43**, 497–504.
- *GEWURTZ, S. B., LAZAR, R. & HAFNER, G. D. (2003). Biomonitoring of bioavailable PAH and PCB water concentrations in the Detroit River using the freshwater mussel, *Elliptio complanata*. *Journal of Great Lakes Research* **29**, 242–255.
- *GHOSH, S., MAL, M. & MANDAL, S. (2020a). A dynamic model of cadmium bioaccumulation in *Lamellidens marginalis*, an edible shellfish in India. *Ecological Modelling* **419**, 108957.
- GHOSH, S., MONDAL, A., GANGOPADHYAY, S. & MANDAL, S. (2020b). Cadmium bioaccumulation in *Lamellidens marginalis* and human health risk assessment: a case study in India. *Human and Ecological Risk Assessment: An International Journal* **26**, 713–725.
- *GIARI, L., VINCENZI, F., FANO, E. A., GRALDI, I., GELLI, F. & CASTALDELLI, G. (2017). Sensitivity to selected contaminants in a biological early warning system using *Anodonta woodiana* (Mollusca). *Water SA* **43**, 200–208.
- *GOLOVKO, N., GOLOVKO, T. & GELIKH, A. (2015). Investigation of amino acid structure of proteins of freshwater bivalve mussels from the genus *Anodonta* of the northern Ukraine. *Eastern-European Journal of Enterprise Technologies* **5**, 10–16.

- *GOMES, J. F., LOPES, A., GONÇALVES, D., LUXO, C., GMUREK, M., COSTA, R., QUINTA-FERREIRA, R. M., MARTINS, R. C. & MATOS, A. (2018). Biofiltration using *C. fluminea* for *E. coli* removal from water: comparison with ozonation and photocatalytic oxidation. *Chemosphere* **208**, 674–681.
- GOOD, S. C. (2004). Paleoenvironmental and paleoclimatic significance of freshwater bivalves in the Upper Jurassic Morrison Formation, Western Interior, USA. *Sedimentary Geology* **167**, 163–176.
- *GRACZYK, T. K., CONN, D. B., LUCY, F., MINCHIN, D., TAMANG, L., MOURA, L. N. S. & DASILVA, A. J. (2004). Human waterborne parasites in zebra mussels (*Dreissena polymorpha*) from the Shannon River drainage area, Ireland. *Parasitology Research* **93**, 385–391.
- *GRACZYK, T. K., FAYER, R., CONN, D. B. & LEWIS, E. J. (1999). Evaluation of the recovery of waterborne *Giardia* cysts by freshwater clams and cyst detection in clam tissue. *Parasitology Research* **85**, 30–34.
- *GRACZYK, T. K., FAYER, R., CRANFIELD, M. R. & CONN, D. B. (1998a). Recovery of waterborne *Cryptosporidium parvum* oocysts by freshwater benthic clams (*Corbicula fluminea*). *Applied and Environmental Microbiology* **64**, 427–430.
- *GRACZYK, T. K., LUCY, F. E., TAMANG, L., MINCHIN, D. & MIRAFLOR, A. (2008). Assessment of human waterborne parasites in Irish river basin districts—use of zebra mussels (*Dreissena polymorpha*) as bioindicators. *Aquatic Invasions* **3**, 305–313.
- GRACZYK, T. K., MARCOGLIESE, D. J., DE LAFONTAINE, Y., DA SILVA, A. J., MHANGAMI-RUWENDE, B. & PIENIAZEK, N. J. (2001). *Cryptosporidium parvum* oocysts in zebra mussels (*Dreissena polymorpha*): evidence from the St. Lawrence River. *Parasitology Research* **87**, 231–234.
- *GRACZYK, T. K., ORTEGA, Y. R. & CONN, D. B. (1998b). Recovery of waterborne oocysts of *Cyclospora cayentensis* by Asian freshwater clams (*Corbicula fluminea*). *American Journal of Tropical Medicine and Hygiene* **59**, 928–932.
- GRAF, D. L. & CUMMINGS, K. S. (2021). The freshwater mussels (Unionoida) of the world (and other less consequential bivalves), updated 30 November 2020. MUSSEL Project Web Site. Electronic file available at <http://mussel-project.uwsp.edu/fimuotwaolcb/unionidae.html>. Accessed 01.06.2021.
- GREEN, A. J. & ELMBERG, J. (2014). Ecosystem services provided by waterbirds. *Biological Reviews* **89**, 105–122.
- *GREENE, S., MCELARNEY, Y. R. & TAYLOR, D. (2015). Water quality effects following establishment of the invasive *Dreissena polymorpha* (Pallas) in a shallow eutrophic lake: implications for pollution mitigation measures. *Hydrobiologia* **743**, 237–253.
- *GUERLET, E., LEDY, K., MEYER, A. & GIAMBÉRINI, L. (2007). Towards a validation of a cellular biomarker suite in native and transplanted zebra mussels: a 2-year integrative field study of seasonal and pollution-induced variations. *Aquatic Toxicology* **81**, 377–388.
- *GUERLET, E., VASSEUR, P. & GIAMBÉRINI, L. (2010). Spatial and temporal variations of biological responses to environmental pollution in the freshwater zebra mussel. *Ecotoxicology and Environmental Safety* **73**, 1170–1181.
- *GUIDI, P., BERNARDESCHI, M., PALUMBO, M., GENOVESE, M., SCARCELLI, V., FIORATI, A., RIVA, L., PUNTA, C., CORSI, I. & FRENZILLI, G. (2020). Suitability of a cellulose-based nanomaterial for the remediation of heavy metal contaminated freshwaters: a case-study showing the recovery of cadmium induced DNA integrity loss, cell proliferation increase, nuclear morphology and chromosomal alterations on *Dreissena polymorpha*. *Nanomaterials* **10**, 1837.
- *GUILHERMINO, L., VIEIRA, L. R., RIBEIRO, D., TAVARES, A. S., CARDOSO, V., ALVES, A. & ALMEIDA, J. M. (2018). Uptake and effects of the antimicrobial florfenicol, microplastics and their mixtures on freshwater exotic invasive bivalve *Corbicula fluminea*. *Science of the Total Environment* **622–623**, 1131–1142.
- *GUMARAES, V. & SIGOLO, J. B. (2008). Detection of contaminants in a bioindicator species (*Corbicula fluminea*)—Ribeira de Iguape River, Sao Paulo state. *Química Nova* **31**, 1696–1698.
- HAAG, W. R. (2012). *North American Freshwater Mussels: Natural History, Ecology, and Conservation*, p. 505. Cambridge University Press, New York.
- HAINES-YOUNG, R. & POTSCHIN, M. (2018). Common international classification of ecosystem services (CICES) V5. 1 and guidance on the application of the revised structure. Electronic file available at www.cices.eu. Accessed 1.10.2021.
- *HALDAR, A., DAS, M., CHATTERJEE, R., DEY, T. K., DHAR, P. & CHAKRABARTI, J. (2018). Functional properties of protein hydrolysates from fresh water mussel *Lamellidens marginalis* (Lam.). *Indian Journal of Biochemistry and Biophysics* **55**, 105–113.
- *HAMLI, H., IDRIS, M. H., ABU HENA, M. K. & WONG, S. K. (2012). Taxonomic study of edible bivalve from selected division of Sarawak, Malaysia. *International Journal of Zoological Research* **8**, 52–58.
- HANSEN, G. J., AHRENSTORFF, T. D., BETHKE, B. J., DUMKE, J. D., HIRSCH, J., KOVALENKO, K. E., LEDUC, J. F., MAKI, R. P., RANTALA, H. M. & WAGNER, T. (2020). Walleye growth declines following zebra mussel and *Bythotrephes* invasion. *Biological Invasions* **22**, 1481–1495.
- *HANUŠ, L. O., LEVITSKY, D. O., SHKROB, I. & DEMBITSKY, V. M. (2009). Plasmalogens, fatty acids and alkyl glycerol ethers of marine and freshwater clams and mussels. *Food Chemistry* **116**, 491–498.
- *HARTLEY, D. M. & JOHNSTON, J. B. (1983). Use of the freshwater clam *Corbicula manilensis* as a monitor for organochlorine pesticides. *Bulletin of Environmental Contamination and Toxicology* **31**, 33–40.
- HARZHAUSER, M. & TEMPFER, P. M. (2004). Late Pannonian wetland ecology of the Vienna Basin based on molluscs and lower vertebrate assemblages (Late Miocene, MN 9, Austria). *Courier Forschungsinstitut Senckenberg* **246**, 55–68.
- HASSAN, F. A., HAMDAN, M. A., FLOWER, R. J. & KEATINGS, K. (2012). The oxygen and carbon isotopic records in Holocene freshwater mollusc shells from the Faiyum paleolakes, Egypt: their paleoenvironmental and paleoclimatic implications. *Quaternary International* **266**, 175–187.
- HAUBROCK, P. J., CUTHBERG, R. N., RICCIARDI, A., DIAGNE, C. & COURCHAMP, F. (2022). Economic costs of invasive bivalves in freshwater ecosystems. *Diversity and Distributions* **28**, 1010–1021.
- HAYER, F., WAGNER, P. & PIHAN, J. C. (1996). Monitoring of extractable organic halogens (EOX) in chlorine bleached pulp and paper mill effluents using four species of transplanted aquatic mollusks. *Chemosphere* **33**, 2321–2334.
- HE, H., LIU, X., LIU, X., YU, J., LI, K., GUAN, B., JEPPESEN, E. & LIU, Z. (2014). Effects of cyanobacterial blooms on submerged macrophytes alleviated by the native Chinese bivalve *Hyriopsis cumingii*: a mesocosm experiment study. *Ecological Engineering* **71**, 363–367.
- *HEIFRICH, L. A., ZIMMERMAN, M. & WEIGMANN, D. L. (1995). Control of suspended solids and phytoplankton with fishes and a mussel. *JAWRA Journal of the American Water Resources Association* **31**, 307–316.
- *HELAMA, S. & NIELSEN, J. K. (2008). Construction of statistically reliable sclerochronology using subfossil shells of river pearl mussel. *Journal of Paleolimnology* **40**, 247–261.
- *HELAMA, S., NIELSEN, J. K. & VALOVIRTA, I. (2009). Evaluating contemporaneity and post-mortem age of malacological remains using sclerochronology and dendrochronology. *Archaeometry* **51**, 861–877.
- HERVE, S., PAASIVIRTA, J. & HEINONEN, P. (2001). Trends of organochlorine compounds in Finnish inland waters. *Environmental Science and Pollution Research* **8**, 19–26.
- *HERVE, S., PREST, H. F., HEINONEN, P., HYÖTYLÄINEN, T., KOISTINEN, J. & PAASIVIRTA, J. (1995). Lipid-filled semipermeable membrane devices and mussels as samplers of organochlorine compounds in lake water. *Environmental Science and Pollution Research* **2**, 24–30.
- HEWITT, T. L., BERGNER, J. L., WOOLNOUGH, D. A. & ZANATTA, D. T. (2018). Phylogeography of the freshwater mussel species *Lasmigona costata*: testing post-glacial colonization hypotheses. *Hydrobiologia* **810**, 191–206.
- *HICKEY, C. W., ROPER, D. S. & BUCKLAND, S. J. (1995). Metal concentrations of resident and transplanted freshwater mussels *Hyridella menziesi* (Unionacea: Hyrididae) and sediments in the Waikato River, New Zealand. *Science of the Total Environment* **175**, 163–177.
- *HIGH, K. A., BARTHET, V. J., McLAREN, J. W. & BLAIS, J.-S. (1997). Characterization of metallothionein-like proteins from zebra mussels (*Dreissena polymorpha*). *Environmental Toxicology and Chemistry* **16**, 1111–1118.
- *HOELLEIN, T. J., ZARNOCH, C. B., BRUESEWITZ, D. A. & DEMARTINI, J. (2017). Contributions of freshwater mussels (Unionidae) to nutrient cycling in an urban river: filtration, recycling, storage, and removal. *Biogeochemistry* **135**, 307–324.
- *HOGAN, L. S., MARSCHALL, E., FOLT, C. & STEIN, R. A. (2007). How non-native species in Lake Erie influence trophic transfer of mercury and lead to top predators. *Journal of Great Lakes Research* **33**, 46–61.
- HOLLAND, R. E. (1993). Changes in planktonic diatoms and water transparency in Hatchery Bay, Bass Island area, western Lake Erie since the establishment of the zebra mussel. *Journal of Great Lakes Research* **19**, 617–624.
- HORIKOSHI, M. (2020). The bounty of Lake Biwa and traditional culinary culture. In *Lake Biwa: Interaction between Nature and People* (eds H. KAWANABE, M. NISHINO and M. MAEHATA), pp. 467–472. Springer Nature, Cham.
- HOSSAIN, A., BHATTACHARYYA, S. R. & ADITYA, G. (2015). Biosorption of cadmium by waste shell dust of fresh water mussel *Lamellidens marginalis*: implications for metal bioremediation. *ACS Sustainable Chemistry & Engineering* **3**, 1–8.
- *HOWELL, E. T. (2018). Influences on water quality and abundance of *Cladophora*, a shore-fouling green alga, over urban shoreline in Lake Ontario. *Water (Switzerland)* **10**, 1569.
- *HOYLE, J. A., BOWLBY, J. N. & MORRISON, B. J. (2008). Lake whitefish and walleye population responses to dreissenid mussel invasion in eastern Lake Ontario. *Aquatic Ecosystem Health and Management* **11**, 403–411.
- HSIEH, C.-C., LIN, M.-S., HUA, K.-F., CHEN, W.-J. & LIN, C.-C. (2017). Neuroprotection by freshwater clam extract against the neurotoxin MPTP in C57BL/6 mice. *Neuroscience Letters* **642**, 51–58.
- *HSU, C.-L., Hsu, C.-C. & YEN, G.-C. (2010). Hepatoprotection by freshwater clam extract against CCl₄-induced hepatic damage in rats. *American Journal of Chinese Medicine* **38**, 881–894.
- HU, S., WANG, Y. & HAN, H. (2011). Utilization of waste freshwater mussel shell as an economic catalyst for biodiesel production. *Biomass and Bioenergy* **35**, 3627–3635.
- *HUA, D. & NEVES, R. J. (2007). Captive survival and pearl culture potential of the pink heelsplitter *Potamilius alatus*. *North American Journal of Aquaculture* **69**, 147–158.
- *HUANG, X., LUO, D., ZHAO, D., LI, N., XIAO, T., LIU, J., WEI, L., LIU, Y., LIU, L. & LIU, G. (2019). Distribution, source and risk assessment of heavy metal(oid)s in

- water, sediments, and *Corbicula fluminea* of Xijiang River, China. *International Journal of Environmental Research and Public Health* **16**, 1823.
- *HULL, M. S., CHAURAND, P., ROSE, J., AUFFAN, M., BOTTERO, J.-Y., JONES, J. C., SCHULTZ, I. R. & VIKESLAND, P. J. (2011). Filter-feeding bivalves store and biodeposit colloidal stable gold nanoparticles. *Environmental Science and Technology* **45**, 6592–6599.
- *HUYVAERT, K. P., CARLSON, J. S., BENTLER, K. T., COBBLE, K. R., NOLTE, D. L. & FRANKLIN, A. B. (2012). Freshwater clams as bioconcentrators of avian influenza virus in water. *Vector-Borne and Zoonotic Diseases* **12**, 904–906.
- ILARRI, M. I., ANTUNES, C., GUILHERMINO, L. & SOUSA, R. (2011). Massive mortality of the Asian clam *Corbicula fluminea* in a highly invaded area. *Biological Invasions* **13**, 277–280.
- *INZA, B., RIBEYRE, F. & BOUDOU, A. (1998). Dynamics of cadmium and mercury compounds (inorganic mercury or methylmercury): uptake and depuration in *Corbicula fluminea*. Effects of temperature and pH. *Aquatic Toxicology* **43**, 273–285.
- IPBES (2019). In *Global assessment report of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services* (eds E. S. BRONDIZIO, J. SETTELE, S. DIAZ and H. T. NGO), p. 1144. IPBES Secretariat, Bonn.
- *IRIANI, D., HASAN, B. & SUMARTO (2020). Physicochemical characteristics of freshwater mussel (*Pilsbryconcha* sp.) shell from Sungai Paku village Riau Province Indonesia. *IOP Conference Series: Earth and Environmental Science* **430**, 012003.
- ISMAL, F. A., ARIS, A. Z. & LATIF, P. A. (2014a). Dynamic behaviour of Cd²⁺ adsorption in equilibrium batch studies by CaCO₃-rich *Corbicula fluminea* shell. *Environmental Science and Pollution Research* **21**, 344–354.
- ISMAL, N. S., DODD, H., SASSOUBRE, L. M., HORNE, A. J., BOEHM, A. B. & LUTHY, R. G. (2015). Improvement of urban lake water quality by removal of *Escherichia coli* through the action of the bivalve *Anodonta californiensis*. *Environmental Science & Technology* **49**, 1664–1672.
- *ISMAL, N. S., MÜLLER, C. E., MORGAN, R. R. & LUTHY, R. G. (2014b). Uptake of contaminants of emerging concern by the bivalves *Anodonta californiensis* and *Corbicula fluminea*. *Environmental Science and Technology* **48**, 9211–9219.
- ISMAL, N. S., TOMMERDAHL, J. P., BOEHM, A. B. & LUTHY, R. G. (2016). *Escherichia coli* reduction by bivalves in an impaired river impacted by agricultural land use. *Environmental Science & Technology* **50**, 11025–11033.
- *ISPARNADI, E., HIDAYAT, M., AULANNI'AM, A. & PERMATASARI, N. (2015). Characterization and formulation of the bivalve *Anodonta*'s chitosan-platelet rich plasma-mesenchymal stem cells as a composite scaffold. *International Journal of ChemTech Research* **8**, 718–724.
- IUCN. (2021). The IUCN red list of threatened species. Version 2021-1. Electronic file available at <http://www.iucnredlist.org>. Accessed 10.08.2021.
- *IVANKOVIĆ, D., PAVIČIĆ, J., BEATOVIĆ, V., KLOBUČAR, R. S. & KLOBUČAR, G. I. V. (2010). Inducibility of metallothionein biosynthesis in the whole soft tissue of zebra mussels *Dreissena polymorpha* exposed to cadmium, copper, and pentachlorophenol. *Environmental Toxicology* **25**, 198–211.
- *IVANOVA, E. V., MURDMAA, I. O., CHEPALYGA, A. L., CRONIN, T. M., PASECHNIK, I. V., LEVCHENKO, O. V., HOWE, S. S., MANUSHKINA, A. V. & PLATONOVA, E. A. (2007). Holocene sea-level oscillations and environmental changes on the Eastern Black Sea shelf. *Palaeogeography, Palaeoclimatology, Palaeoecology* **246**, 228–259.
- IZUMI, T., YAGITA, K., IZUMIYAMA, S., ENDO, T. & ITOH, Y. (2012). Depletion of *Cryptosporidium parvum* oocysts from contaminated sewage by using freshwater benthic pearl clams (*Hyriopsis schlegelii*). *Applied and Environmental Microbiology* **78**, 7420–7428.
- JACKSON, D. & JACKSON, D. (2008). Antecedentes arqueológicos del genero *Diplodon* (SPIX, 1827) (Bivalvia, Hyriidae) en Chile. *Gayana (Concepción)* **72**, 188–195.
- *JACOBSEN, B. N., KJERSGAARD, D., WINTHER-NIELSEN, M. & GUSTAVSON, K. (2004). Combined chemical analyses and biomonitoring at Avedøre wastewater treatment plant in (2002). *Water Science and Technology* **50**, 37–43.
- *JAMES, W. F., BARKO, J. W., DAVIS, M., EAKIN, H. L., ROGALA, J. T. & MILLER, A. C. (2000). Filtration and excretion by zebra mussels: implications for water quality impacts in Lake Pepin, upper Mississippi River. *Journal of Freshwater Ecology* **15**, 429–437.
- JANA, B. B. & DAS, S. (1997). Potential of freshwater mussel (*Lamellidens marginalis*) for cadmium clearance in a model system. *Ecological Engineering* **8**, 179–193.
- JANAKIRAM, K. (2003). Freshwater pearl culture technology development in India. *Journal of Applied Aquaculture* **13**, 341–349.
- *JAVANSHIR, A., SHAPOORI, M. & MOÉZZI, F. (2011). Impact of water hardness on cadmium absorption by four freshwater mollusks *Physa fontinalis*, *Anodonta cygnea*, *Corbicula fluminea* and *Dreissena polymorpha* from South Caspian Sea region. *Journal of Food, Agriculture and Environment* **9**, 763–767.
- *JEFFREE, R. A., MARKICH, S. J., LEFEBVRE, F., THELLIER, M. & RIPOLL, C. (1995). Shell microlaminations of the freshwater bivalve *Hyridella depressa* as an archival monitor of manganese water concentration: experimental investigation by depth profiling using secondary ion mass spectrometry (SIMS). *Experientia* **51**, 838–848.
- *JEONG, J. E., KANG, S. W., HWANG, H. J., PARK, S. Y., PATNAIK, B. B., KIM, C., KIM, S., NAM, M. M., LEE, J. B., WANG, T. H., PARK, E. B., YI, S. S., HAN, Y. S., LEE, J. S., PARK, H. S. & LEE, Y. S. (2015). Expressed sequence tag analysis and annotation of genetic information from the freshwater clam, *Pisidium* (*Neopisidium*) *coreanum* endemic to Korea. *Genes & Genomics* **37**, 1041–1049.
- *JI, L., SONG, C., CAO, X., ZHOU, Y. & DENG, D. (2015). Spatial variation in nutrient excretion by macrozoobenthos in a Chinese large shallow Lake (Lake Taihu). *Journal of Freshwater Ecology* **30**, 169–180.
- *JIA, Y., WANG, L., QU, Z. & YANG, Z. (2018). Distribution, contamination and accumulation of heavy metals in water, sediments, and freshwater shellfish from Liuyang River, southern China. *Environmental Science and Pollution Research* **25**, 7012–7020.
- JIAO, D., QU, R. T., WENG, Z. Y., LIU, Z. Q. & ZHANG, Z. F. (2019). On the fracture mechanisms of nacre: effects of structural orientation. *Journal of Biomechanics* **96**, 109336.
- *JIN, C., ZHAO, J.-Y., LIU, X.-J. & LI, J.-L. (2019). Expressions of shell matrix protein genes in the pearl sac and its correlation with pearl weight in the first 6 months of pearl formation in *Hyriopsis cumingii*. *Marine Biotechnology* **21**, 240–249.
- *JIN, W., BAI, Z., FU, L., ZHANG, G. & LI, J. (2012). Genetic analysis of early growth traits of the triangle shell mussel, *Hyriopsis cumingii*, as an insight for potential genetic improvement to pearl quality and yield. *Aquaculture International* **20**, 927–933.
- JOHNS, C. (2001). Spatial distribution of total cadmium, copper, and zinc in the zebra mussel (*Dreissena polymorpha*) along the upper St. Lawrence River. *Journal of Great Lakes Research* **27**, 354–366.
- *JOHNS, C. (2011). Quagga mussels (*Dreissena bugensis*) as biomonitors of metal contamination: a case study in the upper St. Lawrence River. *Journal of Great Lakes Research* **37**, 140–146.
- *JOHNS, C. (2012). Trends of total cadmium, copper, and zinc in the zebra mussel (*Dreissena polymorpha*) along the upper reach of the St. Lawrence River: (1994–2005). *Environmental Monitoring and Assessment* **184**, 5371–5385.
- *JOHNSON, C. C., NJAU, J. K., VAN DAMME, D., SCHICK, K. & TOTH, N. (2016). Paleocological significance of malacofauna, Olduvai Gorge, Tanzania. *PALAIOS* **31**, 319–326.
- JONES, B. A. (2019). Infant health impacts of freshwater algal blooms: evidence from an invasive species natural experiment. *Journal of Environmental Economics and Management* **96**, 36–59.
- JOU, L.-J., CHEN, B.-C., CHEN, W.-Y. & LIAO, C.-M. (2016). Sensory determinants of valve rhythm dynamics provide *in situ* biotetection of copper in aquatic environments. *Environmental Science and Pollution Research* **23**, 5374–5389.
- *JOU, L.-J., CHEN, W.-Y. & LIAO, C.-M. (2009). Online detection of waterborne bioavailable copper by valve daily rhythms in freshwater clam *Corbicula fluminea*. *Environmental Monitoring and Assessment* **155**, 257–272.
- KAANDORP, R. J. G., WESSELENGH, F. P. & VONHOF, H. B. (2006). Ecological implications from geochemical records of Miocene Western Amazonian bivalves. *Journal of South American Earth Sciences* **21**, 54–74.
- KANG, Y., XIE, H., ZHANG, J., ZHAO, C., WANG, W., GUO, Y. & GUO, Z. (2018). Intensified nutrients removal in constructed wetlands by integrated *Tubifex tubifex* and mussels: performance and mechanisms. *Ecotoxicology and Environmental Safety* **162**, 446–453.
- *KARATAYEV, A. Y., BURLAKOVA, L. E., MEHLER, K., BARBIERO, R. P., HINCHEY, E. K., COLLINGSWORTH, P. D., KOVALENKO, K. E. & WARREN, G. (2018a). Life after *Dreissena*: the decline of exotic suspension feeder may have significant impacts on lake ecosystems. *Journal of Great Lakes Research* **44**, 650–659.
- *KARATAYEV, A. Y., BURLAKOVA, L. E., MEHLER, K., BOCANIOV, S. A., COLLINGSWORTH, P. D., WARREN, G., KRAUS, R. T. & HINCHEY, E. K. (2018b). Biomonitoring using invasive species in a large Lake: *Dreissena* distribution maps hypoxic zones. *Journal of Great Lakes Research* **44**, 639–649.
- *KARMANOVA, A. N. & ZIMIN, A. A. (2020). Experimental model for study bacteriophage bioaccumulation by a bivalve *Unio pictorum* (L.1758). *Journal of Physics: Conference Series* **1701**, 012012.
- *KAROUI-YAAKOUB, N., MTIMET, M. S., BEJAOU, S., AMRI, L., KHALLOUFI, N., BEN AISSA, L. & MARTINEZ-NAVARRO, B. (2016). Middle-to-late Pleistocene malacofauna from the archeopaleontological site of Oued Sarrat (Tajerouine area, NW Tunisia). *Arabian Journal of Geosciences* **9**, 345.
- *KARUBE, Z., SAKAI, Y., TAKEYAMA, T., OKUDA, N., KOHZU, A., YOSHIMIZU, C., NAGATA, T. & TAYASU, I. (2010). Carbon and nitrogen stable isotope ratios of macroinvertebrates in the littoral zone of Lake Biwa as indicators of anthropogenic activities in the watershed. *Ecological Research* **25**, 847–855.
- *KAUSS, P. B. & HAMDY, Y. S. (1985). Biological monitoring of organochlorine contaminants in the St. Clair and Detroit Rivers using introduced clams, *Elliptio complanatus*. *Journal of Great Lakes Research* **11**, 247–263.
- KE, L., ZHOU, J., LU, W., GAO, G. & RAO, P. (2011). The power of soups: super-hero or team-work? *Trends in Food Science & Technology* **22**, 492–497.
- *KELEMEN, Z., GILLIKIN, D. P., GRANIERO, L. E., HAVEL, H., DARCHAMBEAU, F., BORGES, A. V., YAMBÉLÉ, A., BASSIROU, A. & BOUILLON, S. (2017). Calibration of hydroclimate proxies in freshwater bivalve shells from Central and West Africa. *Geochimica et Cosmochimica Acta* **208**, 41–62.
- *KERAMBRUN, E., LADEIRO, M. P., BIGOT-CLIVOT, A., DEDOURGE-GEFFARD, O., DUPUIS, E., VILLENA, I., AUBERT, D. & GEFFARD, A. (2016). Zebra mussel as a

- new tool to show evidence of freshwater contamination by waterborne *Toxoplasma gondii*. *Journal of Applied Microbiology* **120**, 498–508.
- *KHAZRI, A., SELAMI, B., DELLALI, M., CORCELLAS, C., ELJARRAT, E., BARCELÓ, D., BEYREM, H. & MAHMOUDI, E. (2016). Diastereomeric and enantiomeric selective accumulation of cypermethrin in the freshwater mussel *Unio gibbus* and its effects on biochemical parameters. *Pesticide Biochemistry and Physiology* **129**, 83–88.
- *KHUDDOLEI, V. V. & SIRENKO, O. A. (1977). Tumor development in the bivalve mollusk *Unio pictorum* induced by N-nitroso compounds. *Bulletin of Experimental Biology and Medicine* **83**, 684–686.
- *KIM, B.-H., LEE, J.-H. & HWANG, S.-J. (2011). Inter- and intra-specific differences in filtering activities between two unionids, *Anodonta woodiana* and *Unio douglasiae*, in ambient eutrophic lake waters. *Ecological Engineering* **37**, 1957–1967.
- *KIM, D. K., ZHANG, W. T., RAO, Y. R., WATSON, S., MUGALINGAM, S., LABENCKI, T., DITTRICH, M., MORLEY, A. & ARHONDITIS, G. B. (2013). Improving the representation of internal nutrient recycling with phosphorus mass balance models: a case study in the Bay of Quinte, Ontario, Canada. *Ecological Modelling* **256**, 53–68.
- *KIM, M. S., KWON, J. T., LEE, Y., HA, S. Y., HONG, S., YOON, S. H. & SHIN, K. H. (2018). Bio-control of *Microcystis aeruginosa* bloom using various aquatic organisms by dual stable isotope (¹³C and ¹⁵N) tracers. *Applied Ecology and Environmental Research* **16**, 931–953.
- *KINDERMANN, K., BUBENZER, O., NUSSBAUM, S., RIEMER, H., DARIUS, F., POLLATH, N. & SMETTAN, U. (2006). Palaeoenvironment and holocene land use of Djara, western desert of Egypt. *Quaternary Science Reviews* **25**, 1619–1637.
- *KINNEY, R. M., MANOS, C. G. JR., MILLS, E. L., MELLINA, E. & LISK, D. J. (1994). Zebra mussels (*Dreissena polymorpha*) as a biomonitoring tool for Sr90 contamination. *Chemosphere* **28**, 729–735.
- *KIRILOVA, I. V., LEVCHENKO, V. A., IPPOLITOV, A. P., POKROVSKY, B. G., SHISHLINA, N. I. & YANINA, T. A. (2018). The origin of objects of invertebrate descent from the Khvalynsk Eneolithic cemeteries (Northern Caspian region). *Quaternary International* **465**, 142–151.
- *KIRYUSHIN, Y. F., KIRYUSHIN, K. Y., SCHMIDT, A. V. & ABDULGANAYEV, M. T. (2012). Ornaments made from animal teeth in human burials at Tuzovskiy bugry-1 and their relevance to ethnic processes in the Altai, 3rd millennium BC. *Archaeology, Ethnology and Anthropology of Eurasia* **40**, 59–66.
- KIRYUSHIN, Y. F., KIRYUSHIN, K. Y., SCHMIDT, A. V., KUZMENKIN, D. V. & ABDULGANAYEV, M. T. (2011). Mollusk shells from burials of Tuzovskiy Bugry-1 as indicators of ethno-cultural processes in southern Siberia and western Central Asia in the 3rd millennium BC. *Archaeology, Ethnology and Anthropology of Eurasia* **39**, 37–45.
- *KLAMT, A. & SCHERNEWSKI, G. (2013). Climate change—a new opportunity for mussel farming in the Southern Baltic? In *Climate Change Adaptation in Practice: From Strategy Development to Implementation* (eds P. SCHMIDT-THOME and J. KLEIN), pp. 171–184. John Wiley & Sons, Ltd, Chichester.
- *KLERKS, P. L. & FRALEIGH, P. C. (1997). Uptake of nickel and zinc by the zebra mussel *Dreissena polymorpha*. *Archives of Environmental Contamination and Toxicology* **32**, 191–197.
- KLIMOVA, Y., CHUIKO, G., GAPEEVA, M. & PESNYA, D. (2017). The use of biomarkers of oxidative stress in zebra mussel *Dreissena polymorpha* (Pallas, 1771) for chronic anthropogenic pollution assessment of the Rybinsk Reservoir. *Contemporary Problems of Ecology* **10**, 178–183.
- *KLISHKO, O. K., KOVYCHEV, E. V., VINARSKI, M. V., BOGAN, A. E. & YURGENSON, G. A. (2020). The Pleistocene-Holocene aquatic molluscs as indicators of the past ecosystem changes in Transbaikalia (Eastern Siberia, Russia). *PLoS One* **15**, e0235588.
- *KNOLL, L. B., SARNELLE, O., HAMILTON, S. K., KISSMAN, C. E. H., WILSON, A. E., ROSE, J. B. & MORGAN, M. R. (2008). Invasive zebra mussels (*Dreissena polymorpha*) increase cyanobacterial toxin concentrations in low-nutrient lakes. *Canadian Journal of Fisheries and Aquatic Sciences* **65**, 448–455.
- *KNOX, A. S. & PALLER, M. H. (2020). Effect of bioturbation on contaminated sediment deposited over remediated sediment. *Science of the Total Environment* **713**, 136537.
- *KOISTINEN, J., HERVE, S., RUOKOJARVI, P., KOPONEN, J. & VARTIAINEN, T. (2010). Persistent organic pollutants in two Finnish watercourses: levels, congener profiles and source estimation by mussel incubation. *Chemosphere* **80**, 625–633.
- *KOLAREVIĆ, S., KNEŽEVIĆ-VUKČEVIĆ, J., PAUNOVIĆ, M., KRAČUN, M., VASIJEVIĆ, B., TOMOVIĆ, J., VUKOVIĆ-GAČIĆ, B. & GAČIĆ, Z. (2013). Monitoring of DNA damage in haemocytes of freshwater mussel *Sinanodonta woodiana* sampled from the Velika Morava River in Serbia with the comet assay. *Chemosphere* **93**, 243–251.
- *KOLAREVIĆ, S., KNEŽEVIĆ-VUKČEVIĆ, J., PAUNOVIĆ, M., TOMOVIĆ, J., GAČIĆ, Z. & VUKOVIĆ-GAČIĆ, B. (2011). The anthropogenic impact on water quality of the river Danube in Serbia: microbiological analysis and genotoxicity monitoring. *Archives of Biological Sciences* **63**, 1209–1217.
- *KONIECZNY, P., TOMASZEWSKA-GRAS, J., ANDRZEJEWSKI, W., MIKOŁAJCZAK, B., URBAŃSKA, M., MAZURKIEWICZ, J. & STANGIERSKI, J. (2016). DSC and electrophoretic studies on protein denaturation of *Anodonta woodiana* (Lea, 1834). *Journal of Thermal Analysis and Calorimetry* **126**, 69–75.
- KOROLEV, A., KOCHKINA, A., STASHENKOV, D., KHOKHLOV, A. & ROSLYAKOVA, N. (2018). The unique burial of the Ekaterinovskiy Cape Early Neolithic cemetery in the Middle Volga region. *Stratum Plus* **2**, 285–302.
- *KOVÁTS, N., ABDEL-HAMEID, N.-A., KOVÁCS, K. & PADISÁK, J. (2012). Evaluation of single and interactive toxicities of lead and iron using filtration rate of Zebra mussels (*Dreissena polymorpha*). *WIT Transactions on Ecology and the Environment* **162**, 577–585.
- *KRAAK, M. H. S., KUIPERS, F., SCHOON, H., DE GROOT, C. J. & ADMIRAAL, W. (1994). The filtration rate of the zebra mussel *Dreissena polymorpha* used for water quality assessment in Dutch rivers. *Hydrobiologia* **294**, 13–16.
- *KRAAK, M. H. S., SCHOLTEN, M. C. T., PEETERS, W. H. M. & DE KOCK, W. C. (1991). Biomonitoring of heavy metals in the Western European Rivers Rhine and Meuse using the freshwater mussel *Dreissena polymorpha*. *Environmental Pollution* **74**, 101–114.
- *KUMAR, S., PANDEY, R. K., DAS, S. & DAS, V. K. (2013). Temperature dependent mortality and behavioral changes in a freshwater mussel *Lamellidens marginalis* to dimethoate exposure. *Journal of Environmental Biology* **34**, 165–170.
- KUZUCUOĞLU, C., KARABIYIKOĞLU, M., FONTUGNE, M., PASTRE, J.-F. & ERCAN, T. (1997). Environmental changes in Holocene lacustrine sequences from Karapinar in the Konya plain (Turkey). In *Third Millennium BC Climate Change and Old World Collapse*, pp. 451–463. Springer, Berlin Heidelberg.
- *KWAN, K. H. M., CHAN, H. M. & DE LAFONTAINE, Y. (2003). Metal contamination in zebra mussels (*Dreissena polymorpha*) along the St. Lawrence River. *Environmental Monitoring and Assessment* **88**, 193–219.
- *LA GUARDIA, M. J., HALE, R. C., HARVEY, E., MAINOR, T. M. & CIPARIS, S. (2012). *In situ* accumulation of HBCD, PBDEs, and several alternative flame-retardants in the bivalve (*Corbicula fluminea*) and gastropod (*Elminia proxima*). *Environmental Science and Technology* **46**, 5798–5805.
- *LABROT, F., RIBERA, D., SAINT DENIS, M. & NARBONNE, J. F. (1996). *In vitro* and *in vivo* studies of potential biomarkers of lead and uranium contamination: lipid peroxidation, acetylcholinesterase, catalase and glutathione peroxidase activities in three non-mammalian species. *Biomarkers* **1**, 21–28.
- LABUSCHAGNE, M., WEPENER, V., NACHEV, M., ZIMMERMANN, S., SURES, B. & SMIT, N. J. (2020). The application of artificial mussels in conjunction with transplanted bivalves to assess elemental exposure in a platinum mining area. *Water* **12**, 32.
- *LACEY, J. H., LENG, M. J., PECKOVER, E. N., DEAN, J. R., WILKE, T., FRANCKE, A., ZHANG, X., MASI, A. & WAGNER, B. (2018). Investigating the environmental interpretation of oxygen and carbon isotope data from whole and fragmented bivalve shells. *Quaternary Science Reviews* **194**, 55–61.
- *LAKE, J. L., MCKINNEY, R. A., OSTERMAN, F. A., PRUELL, R. J., KIDDON, J., RYBA, S. A. & LIBBY, A. D. (2001). Stable nitrogen isotopes as indicators of anthropogenic activities in small freshwater systems. *Canadian Journal of Fisheries and Aquatic Sciences* **58**, 870–878.
- *LAURENT, T., OKUDA, Y., CHIJIMATSU, T., UMEKI, M., KOBAYASHI, S., KATAOKA, Y., TATSUGUCHI, I., MOCHIZUKI, S. & ODA, H. (2013). Freshwater clam extract ameliorates triglyceride and cholesterol metabolism through the expression of genes involved in hepatic lipogenesis and cholesterol degradation in rats. *Evidence-based Complementary and Alternative Medicine* **2013**, 830684.
- *LAVALLE, P. D., BROOKS, A. & LAKHAN, V. C. (1999). Zebra mussel wastes and concentrations of heavy metals on shipwrecks in western Lake Erie. *Journal of Great Lakes Research* **25**, 330–338.
- *LE GOFF, J., GALLOIS, J., PELHUET, L., DEVIER, M. H., BUDZINSKI, H., POTTIER, D., ANDRÉ, V. & CACHOT, J. (2006). DNA adduct measurements in zebra mussels, *Dreissena polymorpha*, Pallas. Potential use for genotoxicant biomonitoring of fresh water ecosystems. *Aquatic Toxicology* **79**, 55–64.
- *LEBRUN, J. D., DUFOUR, M., UHER, E., FABURE, J., MONS, R., CHARLATSKA, R., GOURLAY-FRANCÉ, C., FECHNER, L. C. & FERRARI, B. J. D. (2017). To what extent the dam dredging can influence the background level of metals in the Rhine River: using chemical and biological long-term monitoring to answer. *Knowledge and Management of Aquatic Ecosystems* **2017**, 54.
- LÉCRIVAIN, N., DUPARC, A., CLÉMENT, B., NAFFRECHOUX, E. & FROSSARD, V. (2020). Tracking sources and transfer of contamination according to pollutants variety at the sediment-biota interface using a clam as bioindicator in peri-alpine lakes. *Chemosphere* **238**, 124569.
- *LEE, C.-C., JHUANG, Y.-F., LIU, L.-L., HSIEH, C.-Y., CHEN, C. S. & TIEN, C.-J. (2009). The major source and impact of phenyltin contamination on freshwater aquaculture clam *Corbicula fluminea* and wild golden apple snail *Pomacea canaliculata*. *Environmental Chemistry* **6**, 341–349.
- *LEE, J. R. (2009). Patterns of preglacial sedimentation and glaciotectionic deformation within early Middle Pleistocene sediments at Sidestrand, north Norfolk, UK. *Proceedings of the Geologists' Association* **120**, 34–48.
- *LEE, J. S. & LEE, B. G. (2005). Effects of salinity, temperature and food type on the uptake and elimination rates of Cd, Cr, and Zn in the Asiatic clam *Corbicula fluminea*. *Ocean Science Journal* **40**, 79–89.

- LEECHMAN, D. (1949). Suggested use of clam shells. *American Antiquity* **15**, 56.
- *LEONARDT, S. (2014). Local production of shell beads in the forest of Northwest Patagonia. An approach from experimental archeology. *Relaciones* **39**, 463–482.
- *LEPOUTRE, A., GRILOT, T., JEAN, S., GEFFARD, A. & LANCE, E. (2020a). Free or protein-bound microcystin accumulation by freshwater bivalves as a tool to evaluate water contamination by *Microcystin*-producing cyanobacteria? *Applied Sciences-Basel* **10**, 3426.
- LEPOUTRE, A., HERVIEUX, J., FAASSEN, E. J., ZWEERS, A. J., LURLING, M., GEFFARD, A. & LANCE, E. (2020b). Usability of the bivalves *Dreissena polymorpha* and *Anodonta anatina* for a biosurvey of the neurotoxin BMAA in freshwater ecosystems. *Environmental Pollution* **259**, 113885.
- LEVINE, T. D., HANSEN, H. B. & GERALD, G. W. (2014). Effects of shell shape, size, and sculpture in burrowing and anchoring abilities in the freshwater mussel *Potamilius alatus* (Unionidae). *Biological Journal of the Linnean Society* **111**, 136–144.
- LEWIS, J. P., LENG, M. J., DEAN, J. R., MARCINIAK, A., BAR-YOSEF MAYER, D. E. & WU, X. (2017). Early Holocene palaeoseasonality inferred from the stable isotope composition of *Unio* shells from Çatalhöyük, Turkey. *Environmental Archaeology* **22**, 79–95.
- *LI, D., WANG, J., PI, J., YU, J. & ZHANG, T. (2019). Biota-sediment metal accumulation and human health risk assessment of freshwater bivalve *Corbicula fluminea* in Dongting Lake, China. *Environmental Science and Pollution Research* **26**, 14951–14961.
- LI, F., WU, N., LU, H., ZHANG, J., WANG, W., MA, M., ZHANG, X. & YANG, X. (2013a). Mid-Neolithic exploitation of mollusks in the Guanzhong basin of northwestern China: preliminary results. *PLoS One* **8**, e58999.
- LI, H., PAN, L., CHEN, T., ZHANG, H., ZHANG, L., YE, Y. & XIA, M. (2013b). Preparation of bio-filler from freshwater mussel shell and its surface property characterization. *Journal of Central South University (Science and Technology)* **4**, 1209–1214.
- *LI, Z., FENG, C., WU, Y. & GUO, X. (2020). Impacts of nanoplastics on bivalve: fluorescence tracing of organ accumulation, oxidative stress and damage. *Journal of Hazardous Materials* **392**, 122418.
- *LIANG, S. M., JI, H. M. & LI, X. W. (2020). Thickness-dependent mechanical properties of nacre in *Cristaria plicata* shell: critical role of interfaces. *Journal of Materials Science and Technology* **44**, 1–8.
- *LIAO, C.-M., JAU, S.-F., LIN, C.-M., JOU, L.-J., LIU, C.-W., LIAO, V. H.-C. & CHANG, F.-J. (2009). Valve movement response of the freshwater clam *Corbicula fluminea* following exposure to waterborne arsenic. *Ecotoxicology* **18**, 567–576.
- *LIAO, C.-M., JOU, L.-J. & CHEN, B.-C. (2005). Risk-based approach to appraise valve closure in the clam *Corbicula fluminea* in response to waterborne metals. *Environmental Pollution* **135**, 41–52.
- *LIAO, C.-M., LIN, C.-M., JOU, L.-J. & CHIANG, K.-C. (2007). Linking valve closure behavior and sodium transport mechanism in freshwater clam *Corbicula fluminea* in response to copper. *Environmental Pollution* **147**, 656–667.
- *LIAO, H., MUTVEI, H., SJÖSTRÖM, M., HAMMARSTRÖM, L. & LI, J. (2000). Tissue responses to natural aragonite (*Margaritifera* shell) implants *in vivo*. *Biomaterials* **21**, 457–468.
- LIMBURG, K. E., LUZADIS, V. A., RAMSEY, M., SCHULZ, K. L. & MAYER, C. M. (2010). The good, the bad, and the algae: perceiving ecosystem services and disservices generated by zebra and quagga mussels. *Journal of Great Lakes Research* **36**, 86–92.
- *LIN, J.-J., LIU, Y.-C., CHANG, C.-J., PAN, M.-H., LEE, M.-F. & PAN, B. S. (2018). Hepatoprotective mechanism of freshwater clam extract alleviates non-alcoholic fatty liver disease: elucidated: *in vitro* and *in vivo* models. *Food and Function* **9**, 6315–6325.
- LIN, P. & GUO, L. (2016). Do invasive quagga mussels alter CO₂ dynamics in the Laurentian Great Lakes? *Scientific Reports* **6**, 39078.
- *LIN, Y.-H., TSAI, J.-S. & CHEN, G.-W. (2017). Purification and identification of hypocholesterolemic peptides from freshwater clam hydrolysate with *in vitro* gastrointestinal digestion. *Journal of Food Biochemistry* **41**, e12385.
- *LIN, Y.-H., TSAI, J.-S., HUNG, L.-B. & PAN, B. S. (2011). Plasma lipid regulatory effect of compounded freshwater clam hydrolysate and *Gracilaria* insoluble dietary fibre. *Food Chemistry* **125**, 397–401.
- *LIU, C., ZHOU, H., SU, Y.-C., LI, Y. & LI, J. (2009). Chemical compositions and functional properties of protein isolated from by-product of triangle shell pearl mussel *Hyriopsis cumingii*. *Journal of Aquatic Food Product Technology* **18**, 193–208.
- *LIU, F., HUANG, J.-C., ZHOU, C., GAO, W., XIA, S., HE, S. & ZHOU, W. (2019). Development of an algal treatment system for selenium removal: effects of environmental factors and post-treatment processing of Se-laden algae. *Journal of Hazardous Materials* **365**, 546–554.
- LIU, F., LI, T., JIA, Z. & WANG, L. (2020). Combination of stiffness, strength, and toughness in 3D printed interlocking nacre-like composites. *Extreme Mechanics Letters* **35**, 100621.
- *LIU, S., WEI, W., BAI, Z., WANG, X., LI, X., WANG, C., LIU, X., LIU, Y. & XU, C. (2018). Rapid identification of pearl powder from *Hyriopsis cumingii* by tri-step infrared spectroscopy combined with computer vision technology. *Spectrochimica Acta—Part A: Molecular and Biomolecular Spectroscopy* **189**, 265–274.
- *LOGANATHAN, B. G., KAWANO, M., SAJWAN, K. S. & OWEN, D. A. (2001). Extractable organohalogen (EOX) in sediment and mussel tissues from the Kentucky Lake and Kentucky Dam Tailwater, USA. *Toxicological and Environmental Chemistry* **79**, 233–242.
- *LOPES, A., LOPES-LIMA, M., FERREIRA, J., ARAUJO, S., HINZMANN, M., OLIVEIRA, J., ROCHA, A., DOMINGUES, B., BOBOS, I. & MACHADO, J. (2014). Biom mineralization studies on cellulose membrane exposed to biological fluids of *Anodonta cygnea*. *Journal of Membrane Biology* **247**, 501–514.
- LOPES-LIMA, M., BURLAKOVA, L. E., KARATAYEV, A. Y., MEHLER, K., SEDDON, M. & SOUSA, R. (2018). Conservation of freshwater bivalves at the global scale: diversity, threats and research needs. *Hydrobiologia* **810**, 1–14.
- *LOUIS, F., ROCHER, B., BARJHOX, I., BULTELLE, F., DEDOURGE-GEFFARD, O., GAILLET, V., BONNARD, I., DELAHAUT, L., PAIN-DEVIN, S., GEFFARD, A., PARIS-PALACIOS, S. & DAVID, E. (2020). Seasonal monitoring of cellular energy metabolism in a sentinel species, *Dreissena polymorpha* (bivalve): effect of global change? *Science of the Total Environment* **725**, 138450.
- *LUCY, F. E., CONNOLLY, M., GRACZYK, T. K., TAMANG, L., SULLIVAN, M. R. & MASTITSKY, S. E. (2010). Zebra mussels (*Dreissena polymorpha*) are effective sentinels of water quality irrespective of their size. *Aquatic Invasions* **5**, 49–57.
- LUCY, F. E., GRACZYK, T. K., TAMANG, L., MIRAFLOR, A. & MINGCHIN, D. (2008). Biomonitoring of surface and coastal water for *Cryptosporidium*, *Giardia*, and human-virulent microsporidia using molluscan shellfish. *Parasitology Research* **103**, 1369–1375.
- LUKASHEV, D. (2008). Assessment of polymetallic pollution of the Dnieper River by the method of calculation of the background content of heavy metals in *Dreissena bugensis*. *Hydrobiological Journal* **44**, 60–75.
- LUKMAN, L., SETYUBUDIANDI, L., MUCHSIN, I. & HARIYADI, S. (2019). Population structure, growth and production of *Corbicula molitkiana* and their relation to cage aquaculture activity in Lake Maninjau, West Sumatra, Indonesia. *IOP Conference Series: Earth and Environmental Science* **308**, 12077.
- *LUMMER, E.-M., AUERSWALD, K. & GEIST, J. (2016). Fine sediment as environmental stressor affecting freshwater mussel behavior and ecosystem services. *Science of the Total Environment* **571**, 1340–1348.
- *MAGAR, V. S., DAVIS, J., DEKKER, T., ERICKSON, M., MATEY, D., PATMONT, C., SWINDOLL, M., BRENNER, R. & ZELLER, C. (2004). Characterization of fate and transport processes: comparing contaminant recovery with biological endpoint trends. Remediation of Contaminated Sediments. In *Proceedings of the Second International Conference on Remediation of Contaminated Sediments*.
- *MAGIONCALDA, R., DUPUIS, C., BLAMART, D., FAIRON-DEMARET, M., PERREAU, M., RENARD, M., RIVELINE, J., ROCHE, M. & KEPPENS, E. (2001). The palaeocene/eocene isotopic excursion of organic carbon ($\delta^{13}C_{org}$) in the continental palaeoenvironment at Varangeville (Haute-Normandie, Paris basin) [L'excursion isotopique du carbone organique ($\delta^{13}C_{org}$) dans les paléoenvironnements continentaux de l'intervalle paléocène/Eocène de Varangeville (Haute-Normandie)]. *Bulletin de la Société Géologique de France* **172**, 349–358.
- MAGNI, S., PAROLINI, M., SOAVE, C., MARAZZI, F., MEZZANOTTE, V. & BINELLI, A. (2015). Removal of metallic elements from real wastewater using zebra mussel bio-filtration process. *Journal of Environmental Chemical Engineering* **3**, 915–921.
- *MANDAL, R. N., KUMAR, K., MOHANTY, U. L. & MEHER, P. K. (2007). Estimation of gut contents of freshwater mussel, *Lamellidens marginalis* L. *Aquaculture Research* **38**, 1364–1369.
- MANSFIELD, R., WILLIAMS, A., HENDRY, K. & WHITE, K. (2014). Drivers of change in a redeveloped urban lake: long term trends in a simplified system. *Fundamental and Applied Limnology* **185**, 91–105.
- *MARASINGHE WADIGE, C. P. M., TAYLOR, A. M., MAHER, W. A. & KRKOWA, F. (2014a). Bioavailability and toxicity of zinc from contaminated freshwater sediments: linking exposure-dose-response relationships of the freshwater bivalve *Hyridella australis* to zinc-spiked sediments. *Aquatic Toxicology* **156**, 179–190.
- *MARASINGHE WADIGE, C. P. M., TAYLOR, A. M., MAHER, W. A., UBRIHJEN, R. P. & KRKOWA, F. (2014b). Effects of lead-spiked sediments on freshwater bivalve, *Hyridella australis*: linking organism metal exposure-dose-response. *Aquatic Toxicology* **149**, 83–93.
- *MÄRGÄRIT, M. (2016). Testing the endurance of prehistoric adornments: raw materials from the aquatic environment. *Journal of Archaeological Science* **70**, 66–81.
- MÄRGÄRIT, M. (2020). Personal adornments in the Romanian Eneolithic: local versus exotic raw materials. *Quaternary International* **539**, 49–61.
- MÄRGÄRIT, M., MIREA, P. & RADU, V. (2018). Exploitation of aquatic resources for adornment and tool processing at Măgura 'Buduiasca' ('Boldul lui Moș Ivăniș') Neolithic settlement (southern Romania). *Quaternary International* **472**, 49–59.
- *MARIANO, B., CRISTIAN, O., MARCELA, P. & PORTA, A. (2006). Evaluation of a biomarker of Cd(II) exposure on *Limnoperna fortunei*. *Environmental Pollution* **144**, 280–288.
- *MARLINA RADU, S., KQUEEN, C. Y., NAPIS, S., ZAKARIA, Z., MUTALIB, S. A. & NISHIBUCHI, M. (2007). Detection of TDH and TRH genes in *Vibrio parahaemolyticus* isolated from *Corbicula molitkiana* Prime in West Sumatera, Indonesia. *Southeast Asian Journal of Tropical Medicine and Public Health* **38**, 349–355.

- *MARTEL, P., KOVACS, T., VOSS, R. & MEGRAW, S. (2003). Evaluation of caged freshwater mussels as an alternative method for environmental effects monitoring (EEM) studies. *Environmental Pollution* **124**, 471–483.
- MARTIN, P., HANCOCK, G. J., JOHNSTON, A. & MURRAY, A. S. (1998). Natural-series radionuclides in traditional north Australian aboriginal foods. *Journal of Environmental Radioactivity* **40**, 37–58.
- *MASNADO, R. G., GEIS, S. W. & SONZOGNI, W. C. (1995). Comparative acute toxicity of a synthetic mine effluent to *Ceriodaphnia dubia*, larval fathead minnow and the freshwater mussel *Anodonta imbecilis*. *Environmental Toxicology and Chemistry* **14**, 1913–1920.
- *MASSON, S., COUILLARD, Y., CAMPBELL, P. G. C., OLSEN, C., PINEL-ALLOUL, B. & PERCEVAL, O. (2010). Responses of two sentinel species (*Hexagenia limbata*—Mayfly; *Pyganodon grandis*—Bivalve) along spatial cadmium gradients in lakes and rivers in northwestern Québec. *Journal of Environmental Monitoring* **12**, 143–158.
- *MATHAI, P. P., MAGNONE, P., DUNN, H. M. & SADOWSKY, M. J. (2020). Water and sediment act as reservoirs for microbial taxa associated with invasive dreissenid mussels. *Science of the Total Environment* **703**, 134915.
- MATTER, A., NEUBERT, E., PREUSSER, F., ROSENBERG, T. & AL-WAGDANI, K. (2015). Palaeo-environmental implications derived from lake and sabkha deposits of the southern Rub'al-Khali, Saudi Arabia and Oman. *Quaternary International* **382**, 120–131.
- *MATTHIAS, U. & ROMPP, S. (1994). Evaluation of the *Dreissena*-monitor at the River Rhine—a new biological monitoring-system based on the zebra mussel *Dreissena polymorpha*. *Acta Hydrochimica et Hydrobiologica* **22**, 161–165.
- *MATUSZAK, P., GRODZICKI, G., JANKOWSKI, T. & MATLAKIEWICZ, P. (2015). Biomonitoring of inland and inshore waters with use of *Dreissena polymorpha* mussels. *Polish Hydrobiological Research* **52**, 49–53.
- *MCKENZIE, J. F. & OZBAY, G. (2009). Viability of a freshwater mussel (*Elliptio complanata*) as a biomechanical filter for aquaculture ponds i: clearance rate of chlorophyll- α . *Journal of Applied Aquaculture* **21**, 205–214.
- *MCKNICKLE, G. G., RENNIE, M. D. & SPRULES, W. G. (2006). Changes in benthic invertebrate communities of South Bay, Lake Huron following invasion by zebra mussels (*Dreissena polymorpha*), and potential effects on lake whitefish (*Coregonus clupeaformis*) diet and growth. *Journal of Great Lakes Research* **32**, 180–193.
- MCLAUGHLAN, C. & ALDRIDGE, D. (2013). Cultivation of zebra mussels (*Dreissena polymorpha*) within their invaded range to improve water quality in reservoirs. *Water Research* **47**, 4357–4369.
- MCLAUGHLAN, C., ROSE, P. & ALDRIDGE, D. C. (2014). Making the best of a pest: the potential for using invasive zebra mussel (*Dreissena polymorpha*) biomass as a supplement to commercial chicken feed. *Environmental Management* **54**, 1102–1109.
- *MCLEESTER, M. & SCHURR, M. (2020). Paleoclimate of the little ice age to the present in the Kankakee Valley of Illinois and Indiana, USA based on O-18/O-16 isotope ratios of freshwater shells. *Environmental Archaeology* **26**, 555–566.
- MEA (2005). Ecosystems and human well-being. In *The Millennium Ecosystem Assessment Series* (Volume 5). Island Press, Washington, DC.
- *MELLINA, E., RASMUSSEN, J. B. & MILLS, E. L. (1995). Impact of zebra mussel (*Dreissena polymorpha*) on phosphorus cycling and chlorophyll in lakes. *Canadian Journal of Fisheries and Aquatic Sciences* **52**, 2553–2573.
- *MERSCH, J. & BEAUVAIS, M.-N. (1997). The micronucleus assay in the zebra mussel, *Dreissena polymorpha*, to *in situ* monitor genotoxicity in freshwater environments. *Mutation Research—Genetic Toxicology and Environmental Mutagenesis* **393**, 141–149.
- *MERSCH, J. & JOHANSSON, L. (1993). Transplanted aquatic mosses and freshwater mussels to investigate the trace metal contamination in the rivers meurthe and plaine, France. *Environmental Technology (United Kingdom)* **14**, 1027–1036.
- *MERSCH, J., MORHAIN, E. & MOUVET, C. (1993). Laboratory accumulation and depuration of copper and cadmium in the freshwater mussel *Dreissena polymorpha* and the aquatic moss *Rhynchosostegia riparioides*. *Chemosphere* **27**, 1475–1485.
- *MERSCH, J. & PIHAN, J.-C. (1993). Simultaneous assessment of environmental impact on condition and trace metal availability in zebra mussels *Dreissena polymorpha* transplanted into the Wiltz River, Luxembourg. Comparison with the aquatic moss. *Archives of Environmental Contamination and Toxicology* **25**, 353–364.
- *MERSCH, J., WAGNER, P. & PIHAN, J.-C. (1996). Copper in indigenous and transplanted zebra mussels in relation to changing water concentrations and body weight. *Environmental Toxicology and Chemistry* **15**, 886–893.
- *METCALFE, J. L. & HAYTON, A. (1989). Comparison of leeches and mussels as biomonitors for chlorophenol pollution. *Journal of Great Lakes Research* **15**, 654–668.
- *METCALFE-SMITH, J. L. (1994). Influence of species and sex on metal residues in fresh-water mussels (family unionidae) from the St. Lawrence river, with implications for biomonitoring programs. *Environmental Toxicology and Chemistry* **13**, 1433–1443.
- *METCALFE-SMITH, J. L., GREEN, R. H. & GRAPENTINE, L. C. (1996). Influence of biological factors on concentrations of metals in the tissues of freshwater mussels (*Elliptio complanata* and *Lampsilis radiata radiata*) from the St. Lawrence River. *Canadian Journal of Fisheries and Aquatic Sciences* **53**, 205–219.
- MEZZANOTTE, V., MARAZZI, F., BISSA, M., PACCHIONI, S., BINELLI, A., PAROLINI, M., MAGNI, S., RUGGERI, F. M., MORGHEN, C. D. G. & ZANOTTO, C. (2016). Removal of enteric viruses and *Escherichia coli* from municipal treated effluent by zebra mussels. *Science of the Total Environment* **539**, 395–400.
- MICHEL, C., BOURGEAULT, A., GOURLAY-FRANCÉ, C., PALAIS, F., GEFFARD, A. & VINCENT-HUBERT, F. (2013). Seasonal and PAH impact on DNA strand-break levels in gills of transplanted zebra mussels. *Ecotoxicology and Environmental Safety* **92**, 18–26.
- MICHEL, P., DOBSON-WAITERE, A., HOHAIA, H., MCEWAN, A. & SHANAHAN, D. F. (2019). The reconnection between mana whenua and urban freshwaters to restore the mouri/life force of the Kaiwharawhara. *New Zealand Journal of Ecology* **43**, 1–10.
- *MILLANE, M., KELLY-QUINN, M. & CHAMP, T. (2008). Impact of the zebra mussel invasion on the ecological integrity of Lough Sheelin, Ireland: distribution, population characteristics and water quality changes in the lake. *Aquatic Invasions* **3**, 271–281.
- *MILLER, E. J., TOMASIC, J. J. & BARNHART, M. C. (2014). A comparison of freshwater mussels (Unionidae) from a late-archaic archeological excavation with recently sampled Verdigris River, Kansas, populations. *American Midland Naturalist* **171**, 16–26.
- *MILLS, E. L., ROSEMAN, E. F., RUTZKE, M., GUTENMANN, W. H. & LISK, D. J. (1993). Contaminant and nutrient element levels in soft tissues of zebra and quagga mussels from waters of southern Lake Ontario. *Chemosphere* **27**, 1465–1473.
- *MISERAZZI, A., SOW, M., GELBER, C., CHARIFI, M., CIRET, P., DALENS, J. M., WEBER, C., LE FLOCH, S., LACROIX, C., BLANG, P. & MASSABUAU, J. C. (2020). Asiatic clam *Corbicula fluminea* exhibits distinguishable behavioural responses to crude oil under semi-natural multiple stress conditions. *Aquatic Toxicology* **219**, 105381.
- *MOHAMED, A. S., BIN DAJEM, S., AL-KAHTANI, M., ALI, S. B., ALSHEHRI, M., SHATI, A., MORSY, K. & FAHMY, S. R. (2020). Freshwater clam as a potential bioindicator for silver/saponin nanocomposites toxicity. *Bulletin of Environmental Contamination and Toxicology* **105**, 827–834.
- MONTGOMERY, H. & BARNES, K. (2012). Paleolimnology of uppermost cretaceous lacustrine deposits in western Texas. *PALAIOS* **27**, 386–394.
- *MOREY, D. F. & CROTHERS, G. M. (1998). Clearing up clouded waters: palaeoenvironmental analysis of freshwater mussel assemblages from the Green River shell middens, western Kentucky. *Journal of Archaeological Science* **25**, 907–926.
- *MORING, J. B. & ROSE, D. R. (1997). Occurrence and concentrations of polycyclic aromatic hydrocarbons in semipermeable membrane devices and clams in three urban streams of the dallas-fort worth metropolitan area, Texas. *Chemosphere* **34**, 551–566.
- *MORRISON, H., YANKOVICH, T., LAZAR, R. & HAFFNER, G. D. (1995). Elimination rate constants of 36 PCBs in zebra mussels (*Dreissena polymorpha*) and exposure dynamics in the Lake St Clair Lake Erie corridor. *Canadian Journal of Fisheries and Aquatic Sciences* **52**, 2574–2582.
- *MOSTEO, R., GOÑI, P., MIGUEL, N., ABADÍAS, J., VALERO, P. & ORMAD, M. P. (2016). Bioaccumulation of pathogenic bacteria and amoeba by zebra mussels and their presence in watercourses. *Environmental Science and Pollution Research* **23**, 1833–1840.
- MOUABAD, A., FDI, M. A., MAAROUF, A. & PIHAN, J. (2001). Pumping behaviour and filtration rate of the freshwater mussel *Potomida littoralis* as a tool for rapid detection of water contamination. *Aquatic Ecology* **35**, 51–60.
- *MUELLER, C. R., EVERSOLE, A. G., TURKER, H. & BRUNE, D. E. (2004). Effect of silver cap Hypophthalmichthys molitrix and freshwater mussel *Elliptio complanata* filtration on the phytoplankton community of partitioned aquaculture system units. *Journal of the World Aquaculture Society* **35**, 372–382.
- *MUETING, S. A. & GERSTENBERGER, S. L. (2010). Mercury concentrations in Quagga Mussels, *Dreissena bugensis*, from Lakes Mead, Mohave and Havasu. *Bulletin of Environmental Contamination and Toxicology* **84**, 497–501.
- *MUETING, S. A. & GERSTENBERGER, S. L. (2011). The 100th meridian initiative at the lake mead national recreation area, NV, USA: differences between boater behaviors before and after a quagga mussel, *Dreissena rostriformis bugensis*, invasion. *Aquatic Invasions* **6**, 223–229.
- *NACK, C. C., LIMBURG, K. E. & SCHMIDT, R. E. (2015). Diet composition and feeding behavior of larval American Shad, *Alosa sapidissima* (Wilson), after the introduction of the invasive Zebra Mussel, *Dreissena polymorpha* (Pallas), in the Hudson River estuary, NY. *Northeastern Naturalist* **22**, 437–450.
- *NAIMO, T. J., ATCHISON, G. J. & HOLLAND-BARTELS, L. E. (1992a). Sublethal effects of cadmium on physiological responses in the pocketbook mussel, *Lampsilis ventricosa*. *Environmental Toxicology and Chemistry* **11**, 1013–1021.
- *NAIMO, T. J., WALLER, D. L. & HOLLAND-BARTELS, L. E. (1992b). Heavy metals in the threeidge mussel *Amblema plicata plicata* (Say, 1817) in the upper Mississippi River. *Journal of Freshwater Ecology* **7**, 209–217.
- *NAVARRO, A., FARIA, M., BARATA, C. & PINA, B. (2011). Transcriptional response of stress genes to metal exposure in zebra mussel larvae and adults. *Environmental Pollution* **159**, 100–107.
- *NEGRI, A. P. & JONES, G. J. (1995). Bioaccumulation of paralytic shellfish poisoning (PSP) toxins from the cyanobacterium *Anabaena circinalis* by the freshwater mussel *Alathyria condola*. *Toxicol* **33**, 667–678.

- *NETPAE, T. & PHALARAKSH, C. (2009). Water quality and heavy metal monitoring in water, sediments, and tissues of *Corbicula* sp. from Bung Boraphet Reservoir, Thailand. *Chiang Mai Journal of Science* **36**, 395–402.
- *NEUFELD, D. S. G. (2010). Mercury accumulation in caged *Corbicula*: rate of uptake and seasonal variation. *Environmental Monitoring and Assessment* **168**, 385–396.
- *NEVES, R. J. (1999). Biological feasibility of freshwater mussel and pearl culture in gulf coast states. *Gulf of Mexico Science* **17**, 103–108.
- NG, T. H., TAN, S. K., WONG, W. H., MEIER, R., CHAN, S. Y., TAN, H. H. & YEO, D. C. (2016). Molluscs for sale: assessment of freshwater gastropods and bivalves in the ornamental pet trade. *PLoS One* **11**, e0161130.
- NGOR, P. B., SOR, R., PRAK, L. H., SO, N., HOGAN, Z. S. & LEK, S. (2018). Mollusc fisheries and length–weight relationship in Tonle Sap flood pulse system, Cambodia. *Annales de Limnologie-International Journal of Limnology* **54**, 34.
- *NICKLIN, L. & BALAS, M. T. (2007). Correlation between unionid mussel density and EPA habitat-assessment parameters. *Northeast Naturalist* **14**, 225–234.
- NICODEMUS, A. (2011). The bronze age and Dacian fauna from new excavations at Pecica Șanțul Marc. *Analele Banatului, Serie Nouă* **19**, 79–84.
- *NIELSEN, J. K., HELAMA, S. & NIELSEN, J. K. (2008). Taphonomy of freshwater molluscs in carbonate-poor deposits: a case study of the river pearl mussel in northeastern Finnish Lapland. *Norsk Geologisk Tidsskrift* **88**, 103–116.
- NOBLE, M., DUNCAN, P., PERRY, D., PROSPER, K., ROSE, D., SCHNIERER, S., TIPA, G., WILLIAMS, E., WOODS, R. & PITTOCK, J. (2016). Culturally significant fisheries: keystones for management of freshwater social-ecological systems. *Ecology and Society* **21**, 22.
- NODA, Y., ZHAO, Y., JIN, X. & LI, Y. (2007). Molluscan remains from the Liangzhu archaeological sites of Zhejiang Province, China. *Memoir of the Fukui Prefectural Dinosaur Museum* **6**, 45–55.
- *NOGARO, G. & STEINMAN, A. D. (2014). Influence of ecosystem engineers on ecosystem processes is mediated by lake sediment properties. *Oikos* **123**, 500–512.
- OKLAND, J. (1963). Notes on population density, age distribution, growth, and habitat of *Anodonta piscinalis* Nils. (Moll., Lamellibr.) in a eutrophic Norwegian lake. *Nytt Magazin for Zoologi* **11**, 19–43.
- *OLIVEIRA, L. F. D., CABRAL, M. T., VIEIRA, C. E. D., ANTONIAZZI, M. H., RISSO, W. E. & MARTINEZ, C. B. D. R. (2016). Metals bioaccumulation and biomarkers responses in the Neotropical freshwater clam *Anodontites trapesialis*: implications for monitoring coal mining areas. *Science of the Total Environment* **571**, 983–991.
- *OLIVEIRA, P., BARBOZA, L. G. A., BRANCO, V., FIGUEIREDO, N., CARVALHO, C. & GUILHERMINO, L. (2018). Effects of microplastics and mercury in the freshwater bivalve *Corbicula fluminea* (Müller, 1774): filtration rate, biochemical biomarkers and mercury bioconcentration. *Ecotoxicology and Environmental Safety* **164**, 155–163.
- O'NEIL, D. D. & GILLIKIN, D. P. (2014). Do freshwater mussel shells record road-salt pollution? *Scientific Reports* **4**, 7168.
- *OSMAN, A. M., VAN DEN HEUVEL, H. & VAN NOORT, P. C. M. (2007). Differential responses of biomarkers in tissues of a freshwater mussel, *Dreissena polymorpha*, to the exposure of sediment extracts with different levels of contamination. *Journal of Applied Toxicology* **27**, 51–59.
- *OTHMAN, F., ISLAM, M. S., SHARIFAH, E. N., SHAHROM-HARRISON, F. & HASSAN, A. (2015). Biological control of streptococcal infection in Nile tilapia *Oreochromis niloticus* (Linnaeus, 1758) using filter-feeding bivalve mussel *Pilsbryconcha exilis* (Lea, 1838). *Journal of Applied Ichthyology* **31**, 724–728.
- *OUTA, J. O., KOWENJE, C. O., AVENANT-OLDEWAGE, A. & JIRSA, F. (2020). Trace elements in crustaceans, mollusks and fish in the Kenyan part of Lake Victoria: bioaccumulation, bioindication and health risk analysis. *Archives of Environmental Contamination and Toxicology* **78**, 589–603.
- OZERSKY, T., EVANS, D. O. & GINN, B. K. (2015). Invasive mussels modify the cycling, storage and distribution of nutrients and carbon in a large lake. *Freshwater Biology* **60**, 827–843.
- OZERSKY, T., MALKIN, S. Y., BARTON, D. R. & HECKY, R. E. (2009). Dreissenid phosphorus excretion can sustain *C. glomerata* growth along a portion of Lake Ontario shoreline. *Journal of Great Lakes Research* **35**, 321–328.
- *PAIN-DEVIN, S., COSSU-LEGUILLÉ, C., GEFFARD, A., GIAMBÉRINI, L., JOUENNE, T., MINGUEZ, L., NAUDIN, B., PARANT, M., RODIUS, F., ROUSSELLE, P., TARNOWSKA, K., DAGUIN-THIÉBAUT, C., VIARD, F. & DEVIN, S. (2014). Towards a better understanding of biomarker response in field survey: a case study in eight populations of zebra mussels. *Aquatic Toxicology* **155**, 52–61.
- *PALLER, M. H., JAGOE, C. H., BENNETT, H., BRANT, H. A. & BOWERS, J. A. (2004). Influence of methylmercury from tributary streams on mercury levels in Savannah River Asiatic clams. *Science of the Total Environment* **325**, 209–219.
- *PALOS LADEIRO, M., AUBERT, D., VILLENA, I., GEFFARD, A. & BIGOT, A. (2014). Bioaccumulation of human waterborne protozoa by zebra mussel (*Dreissena polymorpha*): interest for water biomonitoring. *Water Research* **48**, 148–155.
- *PALOS LADEIRO, M., BIGOT-CLIVOT, A., AUBERT, D., VILLENA, I. & GEFFARD, A. (2015). Assessment of *Toxoplasma gondii* levels in zebra mussel (*Dreissena polymorpha*) by real-time PCR: an organotropism study. *Environmental Science and Pollution Research* **22**, 13693–13701.
- *PANDEY, A. & SINGH, A. (2015). Effect of different pearl nuclei implantation and rearing methods on survival, growth and pearl formation in freshwater mussel, *Lamellidens marginalis* in Punjab. *Ecology, Environment and Conservation* **21**, AS331–AS335.
- PARADA, E., PEREDO, S., CARDENAS, S., VALDEBENITO, I. & PEREDO, M. (2008). *Diplodon chilensis* gray, 1828 (Bivalvia: Hyriidae) a potential residual waters depurator on inland water salmonid, fish-farms: a laboratory scale study. *Gayana (Concepción)* **72**, 68–78.
- *PARANT, M. & PAIN, S. (2001). Potential use of multixenobiotic defense mechanism (mxdm) in *Dreissena polymorpha* as a biomarker for the monitoring of freshwater pollution. *Water Research* **35**, 3743–3748.
- PARK, H., YOKOYAMA, A. & OKINO, T. (2001). Fate of microcystin in Lake Suwa. *Japanese Journal of Limnology* **62**, 229–248.
- *PATRICK, C. H., WATERS, M. N. & GOLLADAY, S. W. (2017). The distribution and ecological role of *Corbicula fluminea* (Müller, 1774) in a large and shallow reservoir. *BioInvasions Records* **6**, 39–48.
- *PEACOCK, E. & JENKINS, C. (2010). The distribution and research value of archaeological mussel shell: an overview from Mississippi. *Midcontinental Journal of Archaeology* **35**, 91–116.
- *PEACOCK, E. & SELTZER, J. L. (2008). A comparison of multiple proxy data sets for paleoenvironmental conditions as derived from freshwater bivalve (Unionid) shell. *Journal of Archaeological Science* **35**, 2557–2565.
- *PELLACANI, C., BUSCHINI, A., FURLINI, M., POLI, P. & ROSSI, C. (2006). A battery of *in vivo* and *in vitro* tests useful for genotoxic pollutant detection in surface waters. *Aquatic Toxicology* **77**, 1–10.
- *PELTIER, G. L., MEYER, J. L., JAGOE, C. H. & HOPKINS, W. A. (2008). Using trace element concentrations in *Corbicula fluminea* to identify potential sources of contamination in an urban river. *Environmental Pollution* **154**, 283–290.
- PENG, Y. C., SUBEQ, Y. M., TIEN, C. C. & LEE, R. P. (2017). Freshwater clam extract supplementation improves wound healing by decreasing the tumor necrosis factor α level in blood. *Journal of the Science of Food and Agriculture* **97**, 1193–1199.
- *PENKMAN, K. E. H., PREECE, R. C., KEEN, D. H., MADDY, D., SCHREVE, D. C. & COLLINS, M. J. (2007). Testing the aminostratigraphy of fluvial archives: the evidence from intra-crystalline proteins within freshwater shells. *Quaternary Science Reviews* **26**, 2958–2969.
- *PERCEVAL, O., COUILLARD, Y., PINEL-ALLOU, B., BONNERIS, E. & CAMPBELL, P. G. C. (2006). Long-term trends in accumulated metals (Cd, Cu and Zn) and metallothionein in bivalves from lakes within a smelter-impacted region. *Science of the Total Environment* **369**, 403–418.
- *PEREIRA, W. E., DOMAGALSKI, J. L., HOSTETTLER, F. D., BROWN, L. R. & RAPP, J. B. (1996). Occurrence and accumulation of pesticides and organic contaminants in river sediment, water and clam tissues from the San Joaquin River and tributaries, California. *Environmental Toxicology and Chemistry* **15**, 172–180.
- *PERETO, C., COYNEL, A., LERAT-HARDY, A., GOURVES, P.-Y., SCHÄFER, J. & BAUDRIMONT, M. (2020). *Corbicula fluminea*: a sentinel species for urban Rare Earth Element origin. *Science of the Total Environment* **732**, 138552.
- PÉREZ, A. E., BATRES, D. A., ROCCHETTA, I., EPPIS, M. R., BIANCHI, M. L. & LUQUET, C. M. (2020). Paleoenvironmental reconstruction using stable isotopes and trace elements from archaeological freshwater bivalve shell fragments in Northwest Patagonia, Argentina. *Quaternary International* **547**, 22–32.
- *PETERSON, M. J., SOUTHWORTH, G. R. & HAM, K. D. (1994). Effect of sublethal chlorinated discharges on PCB accumulation in transplanted Asiatic clams (*Corbicula fluminea*). *Water, Air, & Soil Pollution* **73**, 169–178.
- PETSCH, D. K., RIBAS, L. G. D. S., MANTOVANO, T., PULZATTO, M. M., ALVES, A. T., PINHA, G. D. & THOMAZ, S. M. (2021). Invasive potential of golden and zebra mussels in present and future climatic scenarios in the new world. *Hydrobiologia* **848**, 2319–2330.
- *PHAM, T. L. (2020). Accumulation, depuration and risk assessment of cadmium (cd) and lead (Pb) in clam (*Corbicula fluminea*) (O. F. Muller, 1774) under laboratory conditions. *Iranian Journal of Fisheries Sciences* **19**, 1062–1072.
- PHAM, T.-L., SHIMIZU, K., KANAZAWA, A., GAO, Y., DAO, T.-S. & UTSUMI, M. (2016). Microcystin accumulation and biochemical responses in the edible clam *Corbicula leana* P. exposed to cyanobacterial crude extract. *Journal of Environmental Sciences* **44**, 120–130.
- PIERCE, H. G. & CONSTENIUS, K. (2001). Late Eocene–Oligocene nonmarine mollusks of the Northern Kishenehn Basin, Montana and British Columbia. *Annals of Carnegie Museum* **70**, 1–112.
- PIPOLO, M., MARTINS, R. C., QUINTA-FERREIRA, R. M. & COSTA, R. (2017). Integrating the Fenton's process with biofiltration by *Corbicula fluminea* to reduce chemical oxygen demand of winery effluents. *Journal of Environmental Quality* **46**, 436–442.
- *PIZARRO, H., DI FIORI, E., SINISTRO, R., RAMÍREZ, M., RODRÍGUEZ, P., VINOGRU, A. & CATALDO, D. (2016). Impact of multiple anthropogenic stressors

- on freshwater: how do glyphosate and the invasive mussel *Limnoperna fortunei* affect microbial communities and water quality? *Ecotoxicology* **25**, 56–68.
- *POTET, M., GIAMBÉRINI, L., PAIN-DEVIN, S., LOUIS, F., BERTRAND, C. & DEVIN, S. (2018). Differential tolerance to nickel between *Dreissena polymorpha* and *Dreissena rostriformis bugensis* populations. *Scientific Reports* **8**, 700.
- *POURANG, N., RICHARDSON, C. A. & MORTAZAVI, M. S. (2010). Heavy metal concentrations in the soft tissues of swan mussel (*Anodonta cygnea*) and surficial sediments from Anzali wetland, Iran. *Environmental Monitoring and Assessment* **163**, 195–213.
- *PRADHAN, S., SAURABH, S., PADHI, N., KUMAR, T., KUMAR, R., MOHANTY, U. L. & SUNDARAY, J. K. (2020). Length-weight, width-weight and height-weight relationships of cultured freshwater pearl mussel, *Lamellidens marginalis* (Lamarck, 1819). *Indian Journal of Fisheries* **67**, 157–160.
- *PUGSLEY, C. W., HEBERT, P. D. N. & MCQUARRIE, P. M. (1988). Distribution of contaminants in clams and sediments from the Huron-Erie corridor. II—Lead and cadmium. *Journal of Great Lakes Research* **14**, 356–368.
- *PUTRI, S. R., ANJANI, G., WIJAYANTI, H. S. & NURYANTO (2018). Freshwater clams (*Pilsbryconcha exilis*) as an potential local mineral sources in weaning food to overcome stunting in Grobogan, Central Java, Indonesia. *IOP Conference Series: Earth and Environmental Science* **116**, 012077.
- QIAO, D., HE, X., WEI, C., XIA, L. & BAO, L. (2016). Effects of *Hyriopsis cumingii* polysaccharides on mice immunologic receptor, transcription factor, and cytokine. *Journal of Food Science* **81**, H1288–H1294.
- RAIKOW, D. F., SARNELLE, O., WILSON, A. E. & HAMILTON, S. K. (2004). Dominance of the noxious cyanobacterium *Microcystis aeruginosa* in low-nutrient lakes is associated with exotic zebra mussels. *Limnology and Oceanography* **49**, 482–487.
- RAK, A. E., AZIZAN, A. T., YAACOB, M. R., HAMZAH, Z., OMAR, S. A. S., ZAKARIA, M. N., ISMAIL, M., IBRAHIM, W. K. W., RANI, W. S. F. M. & ZAKI, M. Z. (2020a). Traditional processing method of smoked *Corbicula fluminea* (Etak): case of Etak vendor in Kelantan, Malaysia. *IOP Conference Series: Earth and Environmental Science* **596**, 012057.
- *RAK, A. E., NASIR, S. N. A. M., NOR, M. M., HAN, D. K., APPALASAMY, S., ABDULLAH, F. & GHAZI, R. M. (2020b). Proximate analysis and fatty acid of *Corbicula fluminea* (*C. fluminea*) tissue in Kelantan, Malaysia. *Environmental Science and Pollution Research* **27**, 24772–24785.
- *RAMESHA, M. M. & SOPHIA, S. (2015). Morphometry, length-weight relationships and condition index of *Parreyssia javidens* (Benson, 1862) (Bivalvia: Unionidae) from River Sceta in the Western Ghats, India. *Indian Journal of Fisheries* **62**, 18–24.
- *RANDKLEV, C. R., WOLVERTON, S. & KENNEDY, J. H. (2009). A biometric technique for assessing prehistoric freshwater mussel population dynamics (family: Unionidae) in North Texas. *Journal of Archaeological Science* **36**, 205–213.
- *RAVERA, O., BEONE, G. M., CENCI, R. & LODIGIANI, P. (2003). Metal concentrations in *Unio pictorum manicus* (Mollusca, Lamellibranchia) from 12 Northern Italian lakes in relation to their trophic level. *Journal of Limnology* **62**, 121–138.
- *REEDERS, H. H. & BIJ DE VAATE, A. (1990). Zebra mussels (*Dreissena polymorpha*): a new perspective for water quality management. *Hydrobiologia* **200–201**, 437–450.
- *REEDERS, H. H. & BIJ DE VAATE, A. (1992). Bioprocessing of polluted suspended matter from the water column by the zebra mussel (*Dreissena polymorpha* Pallas). *Hydrobiologia* **239**, 53–63.
- *REEDERS, H. H., DE VAATE, A. B. & SLIM, F. J. (1989). The filtration rate of *Dreissena polymorpha* (Bivalvia) in three Dutch lakes with reference to biological water quality management. *Freshwater Biology* **22**, 133–141.
- REGOLI, L., CHAN, H. M., DE LAFONTAINE, Y. & MIKAEILIAN, I. (2001). Organotin in zebra mussels (*Dreissena polymorpha*) and sediments of the Quebec City Harbour area of the St. Lawrence River. *Aquatic Toxicology* **53**, 115–126.
- REIS, P. A., GUILHERMINO, L., ANTUNES, C. & SOUSA, R. G. (2014). Assessment of ecological quality of the Minho estuary (Northwest Iberian Peninsula) based on metal concentrations in sediments and in *Corbicula fluminea*. *Limnetica* **33**, 161–174.
- *REN, J. Y., SHA, W. Q., SHANG, S. M. & YUAN, E. D. (2020). Hepatoprotective peptides purified from *Corbicula fluminea* and its effect against ethanol-induced LO2 cells injury. *International Journal of Food Science and Technology* **56**, 352–361.
- *RENAUD, C. B., KAISER, K. L. E., COMBA, M. E. & METCALFE-SMITH, J. L. (1995). Comparison between lamprey ammocoetes and bivalve mollusks as biomonitors of organochlorine contaminants. *Canadian Journal of Fisheries and Aquatic Sciences* **52**, 276–282.
- *RICCIARDI, F., BINELLI, A. & PROVINI, A. (2006). Use of two biomarkers (CYP450 and acetylcholinesterase) in zebra mussel for the biomonitoring of Lake Maggiore (northern Italy). *Ecotoxicology and Environmental Safety* **63**, 406–412.
- *RICE, C. P. & WHITE, D. S. (1987). PCB availability assessment of river dredging using caged clams and fish. *Environmental Toxicology and Chemistry* **6**, 259–274.
- RICHMAN, L. A., HOBSON, G., WILLIAMS, D. J. & REINER, E. (2011). The Niagara River mussel biomonitoring program (*Elliptio complanata*): 1983–2009. *Journal of Great Lakes Research* **37**, 213–225.
- *RICHMAN, L. A. & SOMERS, K. (2005). Can we use zebra and quagga mussels for biomonitoring contaminants in the Niagara River? *Water, Air, and Soil Pollution* **167**, 155–178.
- RICHMAN, L. A. & SOMERS, K. (2010). Monitoring metal and persistent organic contaminant trends through time using quagga mussels (*Dreissena bugensis*) collected from the Niagara River. *Journal of Great Lakes Research* **36**, 28–36.
- *RICHTER, A. F. (1986). Biomanipulation and its feasibility for water quality management in shallow eutrophic water bodies in The Netherlands. *Hydrobiological Bulletin* **20**, 165–172.
- *RICKEN, W., STEUBER, T., FREITAG, H., HIRSCHFELD, M. & NIEDENZU, B. (2003). Recent and historical discharge of a large European river system—oxygen isotopic composition of river water and skeletal aragonite of Unionidae in the Rhine. *Palaeogeography, Palaeoclimatology, Palaeoecology* **193**, 73–86.
- *RIDOUT-SHARPE, J. (2015). Changing lifestyles in the northern Levant: late Epipalaeolithic and early Neolithic shells from tell Abu Hureyra. *Quaternary International* **390**, 102–116.
- *RIGONATO, J., MANTOVANI, M. S. & JORDAO, B. Q. (2005). Comet assay comparison of different *Corbicula fluminea* (Mollusca) tissues for the detection of genotoxicity. *Genetics and Molecular Biology* **28**, 464–468.
- *RIGONATO, J., MANTOVANI, M. S. & JORDAO, B. Q. (2010). Detection of genotoxicity of water from an urbanized stream, in *Corbicula fluminea* (Mollusca) (*in vivo*) and CHO-K1 cells (*in vitro*) using comet assay. *Archives of Environmental Contamination and Toxicology* **59**, 31–38.
- RIVA, C., BINELLI, A., PAROLINI, M. & PROVINI, A. (2010). The case of pollution of Lake Maggiore: a 12-year study with the bioindicator mussel *Dreissena polymorpha*. *Water, Air, & Soil Pollution* **210**, 75–86.
- *ROCHE, H., VOLLAIRE, Y., MARTIN, E., ROUER, C., COULET, E., GRILLAS, P. & BANAS, D. (2009). Rice fields regulate organochlorine pesticides and PCBs in lagoons of the Nature Reserve of Camargue. *Chemosphere* **75**, 526–533.
- *RODITI, H. A. & FISHER, N. S. (1999). Rates and routes of trace element uptake in zebra mussels. *Limnology and Oceanography* **44**, 1730–1749.
- *RODITI, H. A., FISHER, N. S. & SAÑUDO-WILHELMY, S. A. (2000). Field testing a metal bioaccumulation model for zebra mussels. *Environmental Science and Technology* **34**, 2817–2825.
- *RODITI, H. A., STRAYER, D. L. & FINDLAY, S. E. G. (1997). Characteristics of zebra mussel (*Dreissena polymorpha*) biodeposits in a tidal freshwater estuary. *Archiv für Hydrobiologie* **140**, 207–219.
- RODRIGUES, T. F., MANTELLATTO, A. M., SUPERINA, M. & CHIARELLO, A. G. (2020). Ecosystem services provided by armadillos. *Biological Reviews* **95**, 1–21.
- *ROE, S. L. & MACISAAC, H. J. (1998). Temporal variation of organochlorine contaminants in the zebra mussel *Dreissena polymorpha* in Lake Erie. *Aquatic Toxicology* **41**, 125–140.
- ROMANUS, K., VAN NEER, W., MARINOVA, E., VERBEKE, K., LUYPAERTS, A., ACCARDO, S., HERMANS, I., JACOBS, P., DE VOS, D. & WAELEKENS, M. (2008). Brassicaceae seed oil identified as illuminant in Nilotic shells from a first millennium AD Coptic church in Bawit, Egypt. *Analytical and Bioanalytical Chemistry* **390**, 783–793.
- ROSA, I. C., COSTA, R., GONÇALVES, F. & PEREIRA, J. L. (2014). Bioremediation of metal-rich effluents: could the invasive bivalve *Corbicula fluminea* work as a biofilter? *Journal of Environmental Quality* **43**, 1536–1545.
- *ROUSSEAU, A., ESCOTTE-BINET, S., LA CARBONA, S., DUMÈTRE, A., CHAGNEAU, S., FAVENNEC, L., KUBINA, S., DUBEY, J. P., MAJOU, D., BIGOT-CLIVOT, A., VILLENA, I. & AUBERT, D. (2019). *Toxoplasma gondii* oocyst infectivity assessed using a sporocyst-based cell culture assay combined with quantitative PCR for environmental applications. *Applied and Environmental Microbiology* **85**, e01189–e01119.
- ROXBURGH, T., ELLIS, K., JOHNSON, J., BALDOS, U. L., HERTEL, T., NOOTENBOOM, C. & POLASKY, S. (2020). *Global Future: Assessing the Global Economic Impacts of Environmental Change to Support Policy-Making*, p. 32. WWF, Global Trade Analysis Project, Natural Capital Project, Washington, DC.
- ROY, E. D., MARTIN, J. F., IRWIN, E. G., CONROY, J. D. & CULVER, D. A. (2010). Transient social-ecological stability: the effects of invasive species and ecosystem restoration on nutrient management compromise in Lake Erie. *Ecology and Society* **15**, 20.
- *RUSSELL, R. W. & GOBAS, F. A. P. C. (1989). Calibration of the freshwater mussel, *Elliptio complanata*, for quantitative biomonitoring of hexachlorobenzene and octachlorostyrene in aquatic systems. *Bulletin of Environmental Contamination and Toxicology* **43**, 576–582.
- *RYAN, B., BOLLHÖFER, A. & MARTIN, P. (2008). Radionuclides and metals in freshwater mussels of the upper South Alligator River, Australia. *Journal of Environmental Radioactivity* **99**, 509–526.
- *SAITOH, M., KIMURA, H., KOZAWA, K., NISHIO, O. & SHOJI, A. (2007). Detection and phylogenetic analysis of norovirus in *Corbicula fluminea* in a freshwater river in Japan. *Microbiology and Immunology* **51**, 815–822.
- SAKALAUŠKAITE, J., ANDERSEN, S. H., BIAGI, P., BORRELLO, M. A., COCQUEREZ, T., COLONESE, A. C., DAL BELLO, F., GIROD, A., HEUMÜLLER, M. & KOON, H. (2019). 'Palaeoshellomics' reveals the use of freshwater mother-of-pearl in prehistory. *eLife* **8**, e45644.

- *SALÁNKI, J., V-BALOGH, K. & BERTA, E. (1982). Heavy metals in animals of Lake Balaton. *Water Research* **16**, 1147–1152.
- *SALGUEIRO-GONZÁLEZ, N., TURNES-CAROU, I., BESADA, V., MUNIATEGUI-LORENZO, S., LÓPEZ-MAHÍA, P. & PRADA-RODRÍGUEZ, D. (2015). Occurrence, distribution and bioaccumulation of endocrine disrupting compounds in water, sediment and biota samples from a European river basin. *Science of the Total Environment* **529**, 121–130.
- SANKO, A., GAIGALAS, A. & YELOVICHEVA, Y. (2011). Paleoclimatic and stratigraphic significance of *Belgrandia marginata* (Michaud) in Late Quaternary malacofauna of Belarus and Lithuania. *Quaternary International* **241**, 68–78.
- *SANTOS, H. M., DINIZ, M. S., COSTA, P. M., PERES, I., COSTA, M. H., ALVES, S. & CAPELO, J. L. (2007). Toxicological effects and bioaccumulation in the freshwater clam (*Corbicula fluminea*) following exposure to trivalent arsenic. *Environmental Toxicology* **22**, 502–509.
- *SAPONE, A., CANISTRO, D., VIVARELLI, F. & PAOLINI, M. (2016). Perturbation of xenobiotic metabolism in *Dreissena polymorpha* model exposed *in situ* to surface water (Lake Trasimene) purified with various disinfectants. *Chemosphere* **144**, 548–554.
- *SARIKHANI, I. & JAVANSHIR, A. (2010). Evaluation of bivalve (*Anodonta cygnea*) in filtration of nitrogen and phosphorus compounds. *Journal of Environmental Studies* **36**, 119–126.
- *SARNELE, O., WHITE, J. D., HORST, G. P. & HAMILTON, S. K. (2012). Phosphorus addition reverses the positive effect of zebra mussels (*Dreissena polymorpha*) on the toxic cyanobacterium, *Microcystis aeruginosa*. *Water Research* **46**, 3471–3478.
- *SCHÄFER, S., HAMER, B., TREURSIĆ, B., MÖHLENKAMP, C., SPIRA, D., KORLEVIĆ, M., REIFFERSCHIED, G. & CLAUS, E. (2012). Comparison of bioaccumulation and biomarker responses in *Dreissena polymorpha* and *D. bugensis* after exposure to resuspended sediments. *Archives of Environmental Contamination and Toxicology* **62**, 614–627.
- *SCHALLER, J. & PLANER-FRIEDRICH, B. (2017). The filter feeder *Dreissena polymorpha* affects nutrient, silicon, and metal(loid) mobilization from freshwater sediments. *Chemosphere* **174**, 531–537.
- *SCHERNEWSKI, G., FRIEDLAND, R., BUER, A.-L., DAHLKE, S., DREWS, B., HÖFT, S., KLUMPE, T., SCHADACH, M., SCHUMACHER, J. & ZAIKO, A. (2019). Ecological-social-economic assessment of zebra-mussel cultivation scenarios for the Oder (Szczecin) Lagoon. *Journal of Coastal Conservation* **23**, 913–929.
- SCHERNEWSKI, G., STYBEL, N. & NEUMANN, T. (2012). Zebra mussel farming in the Szczecin (Oder) Lagoon: water-quality objectives and cost-effectiveness. *Ecology and Society* **17**, 4.
- *SCHMITT, N., MARIN, F., THOMAS, J., PLASSERAUD, L. & DEMOY-SCHNEIDER, M. (2018). Pearl grafting: tracking the biological origin of nuclei by straightforward immunological methods. *Aquaculture Research* **49**, 692–700.
- *SCHÖLL-BARNA, G. (2011). An isotope mass balance model for the correlation of freshwater bivalve shell (*Unio pictorum*) carbonate $\delta^{18}\text{O}$ to climatic conditions and water $\delta^{18}\text{O}$ in Lake Balaton (Hungary). *Journal of Limnology* **70**, 272–282.
- SCHÖLL-BARNA, G., DEMÉNY, A., SERLEGI, G., FÁBIÁN, S., SÜMEGI, P., FÓRIZS, I. & BAJNÓCZI, B. (2012). Climatic variability in the Late Copper Age: stable isotope fluctuation of prehistoric *Unio pictorum* (Unionidae) shells from Lake Balaton (Hungary). *Journal of Paleolimnology* **47**, 87–100.
- SCHÖNE, B. R., MERET, A. E., BAIER, S. M., FIEBIG, J., ESPER, J., McDONNELL, J. & PFISTER, L. (2020). Freshwater pearl mussels from northern Sweden serve as long-term, high-resolution stream water isotope recorders. *Hydrology and Earth System Sciences* **24**, 673–696.
- *SEBE, K., SELMECZI, I., SZUROMI-KOREZ, A., HABLY, L., KOVACS, A. & BENKO, Z. (2019). Miocene syn-rift lacustrine sediments in the Mecsek Mts. (SW Hungary). *Swiss Journal of Geosciences* **112**, 83–100.
- *SEBESVARI, Z., FRIEDERIKE ETTWIG, K. & EMONS, H. (2005). Biomonitoring of tin and arsenic in different compartments of a limnic ecosystem with emphasis on *Corbicula fluminea* and *Dikoregammarus villosus*. *Journal of Environmental Monitoring* **7**, 203–207.
- *SEKER, E., SARIEYUPOGLU, M. & CETINKAYA, B. (2003). Identification of *Salmonella* isolated from freshwater mussels (*Unio elongatulus eucirrus* Bourguignat, 1860) by polymerase chain reaction. *Turkish Journal of Veterinary & Animal Sciences* **27**, 201–206.
- SELEGEAN, J. P. W., KUSSEROW, R., PATEL, R., HEIDTKE, T. M. & RAM, J. L. (2001). Using zebra mussels to monitor *Escherichia coli* in environmental waters. *Journal of Environmental Quality* **30**, 171–179.
- *SHELINSKY, V. E., GUROVA, M., TESAKOV, A. S., TITOV, V. V., FROLOV, P. D. & SIMAKOVA, A. N. (2016). The Early Pleistocene site of Kermek in western Ciscaucasia (southern Russia): stratigraphy, biotic record and lithic industry (preliminary results). *Quaternary International* **393**, 51–69.
- *SHEN, R., GU, X., CHEN, H., MAO, Z., ZENG, Q. & JEPPESEN, E. (2020). Combining bivalve (*Corbicula fluminea*) and filter-feeding fish (*Aristichthys nobilis*) enhances the bioremediation effect of algae: an outdoor mesocosm study. *Science of the Total Environment* **727**, 138692.
- *SHOULTS-WILSON, W. A., ELSAYED, N., LECKRONE, K. & UNRINE, J. (2015). Zebra mussels (*Dreissena polymorpha*) as a biomonitor of trace elements along the southern shoreline of Lake Michigan. *Environmental Toxicology and Chemistry* **34**, 412–419.
- *SHOULTS-WILSON, W. A., PETERSON, J. T., UNRINE, J. M., RICKARD, J. & BLACK, M. C. (2009). The Asian clam *Corbicula fluminea* as a biomonitor of trace element contamination: accounting for different sources of variation using an hierarchical linear model. *Environmental Toxicology and Chemistry* **28**, 2224–2232.
- SICURO, B., CASTELAR, B., MUGETTI, D., PASTORINO, P., CHIARANDON, A., MENCONI, V., GALLONI, M. & PREARO, M. (2020). Bioremediation with freshwater bivalves: a sustainable approach to reducing the environmental impact of inland trout farms. *Journal of Environmental Management* **276**, 111327.
- *SILANTIEV, V., URAZAeva, M. N. & VALERIY, G. (2018). The nonmarine bivalve *Pernianaia* gen. nov., the last member of Naiaditidae from the terminal Permian the east European platform. *Paleontological Journal* **52**, 777–790.
- SILVA, C., ANSELMO, A., MACÁRIO, I. P., DE FIGUEIREDO, D., GONÇALVES, F. J. & PEREIRA, J. L. (2020). The bad against the villain: suitability of *Corbicula fluminea* as a bioremediation agent towards cyanobacterial blooms. *Ecological Engineering* **152**, 105881.
- *SILVA, F. A. E. & GIANI, A. (2018). Population dynamic of bloom-forming *Microcystis aeruginosa* in the presence of the invasive bivalve *Limnoperna fortunei*. *Harmful Algae* **73**, 148–156.
- *SILVA, V., ABRANTES, N., COSTA, R., KEIZER, J. J., GONÇALVES, F. & PEREIRA, J. L. (2016). Effects of ash-loaded post-fire runoff on the freshwater clam *Corbicula fluminea*. *Ecological Engineering* **90**, 180–189.
- *SILVERMAN, H., LYNN, J. W., ACHBERGER, E. C. & DIETZ, T. H. (1996). Gill structure in zebra mussels: bacterial-sized particle filtration. *American Zoologist* **36**, 373–384.
- *SŁODKOWICZ-KOWALSKA, A., MAJEWSKA, A. C., RZYMSKI, P., SKRZYPCZAK, T. & WERNER, A. (2015). Human waterborne protozoan parasites in freshwater bivalves (*Anodonta anatina* and *Unio tumidus*) as potential indicators of fecal pollution in urban reservoir. *Limnologia* **51**, 32–36.
- *SMITH, R. M. H., SIDOR, C. A., ANGIELCZYK, K. D., NESBITT, S. J. & TABOR, N. J. (2017). Taphonomy and paleoenvironments of middle Triassic bone accumulations in the Lifua member of the Manda beds, Songea group (Ruhuhu basin), Tanzania. *Journal of Vertebrate Paleontology* **37**, 65–79.
- *SMOLDERS, R., BERVOETS, L. & BLUST, R. (2002). Transplanted zebra mussels (*Dreissena polymorpha*) as active biomonitors in an effluent-dominated river. *Environmental Toxicology and Chemistry* **21**, 1889–1896.
- *SMOLDERS, R., BERVOETS, L. & BLUST, R. (2004). *In situ* and laboratory bioassays to evaluate the impact of effluent discharges on receiving aquatic ecosystems. *Environmental Pollution* **132**, 231–243.
- *SOHAIL, M., KHAN, M. N., CHAUDHRY, A. S. & QURESHI, N. A. (2016). Bioaccumulation of heavy metals and analysis of mineral element alongside proximate composition in foot, gills and mantle of freshwater mussels (*Anodonta anatina*). *Rendiconti Lincei* **27**, 687–696.
- *SOHAIL, M., KHAN, M. N., QURESHI, N. A. & CHAUDHRY, A. S. (2017). Monitoring DNA damage in gills of freshwater mussels (*Anodonta anatina*) exposed to heavy metals. *Pakistan Journal of Zoology* **49**, 305–311.
- *SONG, E. J., CHAN, M. W. Y., SHIN, J. W. & CHEN, C. C. (2017). Hard clam extracts induce atypical apoptosis in human gastric cancer cells. *Experimental and Therapeutic Medicine* **14**, 1409–1418.
- *SONG, H., LI, X., LI, W. & LU, X. (2014). Role of biologic components in a novel floating-bed combining *Ipomoea aquatica*, *Corbicula fluminea* and biofilm carrier media. *Frontiers of Environmental Science and Engineering* **8**, 215–225.
- *SONG, H.-L., LI, X.-N., WANG, X.-J. & LU, X.-W. (2011). Enhancing nitrogen removal performance of vegetated floating-bed by adding *Hyriopsis cumingii* Lea and an artificial medium. *Fresenius Environmental Bulletin* **20**, 2435–2441.
- *SONG, Y., SUN, B., GAO, Y. & YI, H. (2019). The environment and subsistence in the lower reaches of the Yellow River around 10,000 BP—faunal evidence from the bianbiandong cave site in Shandong Province, China. *Quaternary International* **521**, 35–43.
- SONOWAL, J. & KARDONG, D. (2020). Nutritional evaluation of freshwater bivalve, *Lamellidens* spp. from the upper Brahmaputra basin, Assam with special reference to dietary essential amino acids, omega fatty acids and minerals. *Journal of Environmental Biology* **41**, 931–941.
- SORONTOU, Y. & AGUSSALIM. (2016). Effectiveness lime shells of *Anodonta anatina* for larvae of *Anopheles* and *Aedes aegypti* mosquitoes in Jayapura District, Indonesia. *Research Journal of Pharmaceutical, Biological and Chemical Sciences* **7**, 3180–3186.
- *SOTO, D. X., ROIG, R., GACIA, E. & CATALAN, J. (2011). Differential accumulation of mercury and other trace metals in the food web components of a reservoir impacted by a chlor-alkali plant (Flix, Ebro River, Spain): implications for biomonitoring. *Environmental Pollution* **159**, 1481–1489.
- SOUSA, R., DIAS, S., FREITAS, V. & ANTUNES, C. (2008). Subtidal macrozoobenthic assemblages along the River Minho estuarine gradient (north-west Iberian Peninsula). *Aquatic Conservation: Marine and Freshwater Ecosystems* **18**, 1063–1077.
- SOUSA, R., GUTIÉRREZ, J. L. & ALDRIDGE, D. C. (2009). Non-indigenous invasive bivalves as ecosystem engineers. *Biological Invasions* **11**, 2367–2385.
- SOUSA, R., NOVAIS, A., COSTA, R. & STRAYER, D. L. (2014). Invasive bivalves in fresh waters: impacts from individuals to ecosystems and possible control strategies. *Hydrobiologia* **735**, 233–251.

- *STĀB, J. A., FRENAY, M., FRERIKS, I. L., COFINO, W. P. & TH. BRINKMAN, U. A. (1995). Survey of nine organotin compounds in The Netherlands using the zebra mussel (*Dreissena polymorpha*) as biomonitor. *Environmental Toxicology and Chemistry* **14**, 2023–2032.
- *STALTER, D., MAGDEBURG, A. & OEHLMANN, J. (2010). Comparative toxicity assessment of ozone and activated carbon treated sewage effluents using an *in vivo* test battery. *Water Research* **44**, 2610–2620.
- *ŠTAMBUK, A., PAVLICA, M., VIGNJEVIĆ, G., BOLARIĆ, B. & KLOBUČAR, G. I. V. (2009). Assessment of genotoxicity in polluted freshwaters using caged painter's mussel, *Unio pictorum*. *Ecotoxicology* **18**, 430–439.
- *STANGIERSKI, J., ANDRZEJEWSKI, W., TOMASZEWSKA-GRAS, J., GRZES, B., KONIECZNY, P. & URBANSKA, M. (2018). Effect of washing on the quality of surimi-like preparation obtained from soft tissue of freshwater mussel *Sinanodonta woodiana* (Lea, 1834). *Journal of Aquatic Food Product Technology* **27**, 961–974.
- *STERNECKER, K., GEIST, J., BEGEL, S., DIETZ-LAURSONN, K., DE LA FUENTE, M., FRANK, H.-G., FURIA, J. P., MILZ, S. & SCHMITZ, C. (2018). Exposure of zebra mussels to extracorporeal shock waves demonstrates formation of new mineralized tissue inside and outside the focus zone. *Biology Open* **7**, bio033258.
- *STOREY, A. W. & EDWARD, D. H. D. (1989). The freshwater mussel, *westralunio carteri* iredale, as a biological monitor of organochlorine pesticides. *Marine and Freshwater Research* **40**, 587–593.
- STORK, H. & ASTRIN, J. J. (2014). Trends in biodiversity research—a bibliometric assessment. *Open Journal of Ecology* **4**, 354–370.
- *STOYANOVA, S., MOLLOV, I., VELCHEVA, I., GEORGIEVA, E. & YANCHEVA, V. (2020). Cadmium and polyaromatic hydrocarbons exposure changes the condition indices in *Dreissena polymorpha* (Pallas, 1771): a case study. *Acta Zoologica Bulgarica* **15**, 141–146.
- STRACK, E. (2015). European freshwater pearls: part 1—Russia. *The Journal of Gemmology* **34**, 580–592.
- STRAYER, D. L. (1999). Effects of alien species of freshwater mollusks in North America. *Journal of the North American Benthological Society* **18**, 74–98.
- STRAYER, D. L. (2017). What are freshwater mussels worth? *Freshwater Mollusk Biology and Conservation* **20**(103–113), 11.
- *STUART, K. R., EVERSOLE, A. G. & BRUNE, D. E. (2001). Filtration of green algae and cyanobacteria by freshwater mussels in the partitioned aquaculture system. *Journal of the World Aquaculture Society* **32**, 105–111.
- SU, L., CAI, H., KOLANDHASAMY, P., WU, C., ROCHMAN, C. M. & SHI, H. (2018). Using the Asian clam as an indicator of microplastic pollution in freshwater ecosystems. *Environmental Pollution* **234**, 347–355.
- *SU, L., XUE, Y., LI, L., YANG, D., KOLANDHASAMY, P., LI, D. & SHI, H. (2016). Microplastics in Taihu Lake, China. *Environmental Pollution* **216**, 711–719.
- *SUN, Y., HAYAKAWA, S., OGAWA, M., NAKNUKOL, S., GUAN, Y. & MATSUMOTO, Y. (2011). Evaluation of angiotensin I-converting enzyme (ACE) inhibitory activities of hydrolysates generated from byproducts of freshwater clam. *Food Science and Biotechnology* **20**, 303–310.
- *SURES, B., TARASCHIEWSKI, H. & RYDLO, M. (1997). Intestinal fish parasites as heavy metal bioindicators: a comparison between *Acanthocephalus lucii* (Palaeacanthocephala) and the Zebra Mussel, *Dreissena polymorpha*. *Bulletin of Environmental Contamination and Toxicology* **59**, 14–21.
- *SURES, B., ZIMMERMANN, S., MESSERSCHMIDT, J. & VON BOHLEN, A. (2002). Relevance and analysis of traffic related platinum group metals (Pt, Pd, Rh) in the aquatic biosphere, with emphasis on palladium. *Ecotoxicology* **11**, 385–392.
- *SZYMANEK, M. (2013). Palaeoecology of the Holsteinian Lake in vicinity of Wilczyn (eastern Poland) based on molluscan studies. *Geological Quarterly* **57**, 637–648.
- TAKABE, Y., TSUNO, H., NISHIMURA, F., TANI, N., MARUNO, H., TSURUKAWA, M., SUZUKI, M. & MATSUMURA, C. (2012). Bioaccumulation and primary risk assessment of persistent organic pollutants with various bivalves. *Water Science and Technology* **66**, 2620–2629.
- *TAN, K., XU, C. & LONG, C. X. (2020). Association of microbiota in the stomach of *Sinanodonta woodiana* and its cultured soil. *BIOTECH* **10**, 319.
- *TANG, J. Y., DAI, Y. X., WANG, Y., QIN, J. G., SU, S. S. & LI, Y. M. (2015). Optimization of fish to mussel stocking ratio: development of a state-of-art pearl production mode through fish-mussel integration. *Aquacultural Engineering* **66**, 11–16.
- *TAYLOR, A. M., EDGE, K. J., UBRIHIEN, R. P. & MAHER, W. A. (2017). The freshwater bivalve *Corbicula australis* as a sentinel species for metal toxicity assessment: an *in situ* case study integrating chemical and biomarker analyses. *Environmental Toxicology and Chemistry* **36**, 709–719.
- *TEVESZ, M. J. S., MATISOFF, G., FRANK, S. A. & MCCALL, P. L. (1989). Interspecific differences in manganese levels in freshwater bivalves. *Water, Air, and Soil Pollution* **47**, 65–70.
- TEVESZ, M. J. S., SMITH, J. E., COAKLEY, J. P. & RISK, M. J. (1997). Stable carbon and oxygen isotope records from Lake Erie sediment cores: mollusc aragonite 4600 BP–200 BP. *Journal of Great Lakes Research* **23**, 307–316.
- THE CENTER FOR BIOLOGICAL DIVERSITY (2021). 23 species from 19 states lost to extinction [Press release]. Electronic file available at <https://biologicaldiversity.org/w/news/press-releases/23-species-from-19-states-lost-to-extinction-2021-09-29/>. Accessed 25.03.2022.
- THE PARTNERSHIP FOR THE DELAWARE ESTUARY (2017). Mussels for clean water initiative fact sheet. Electronic file available at <https://delawareestuary.org/science-and-research/mussels-clean-water-initiative-mucwi/>. Accessed 25.03.2022.
- THELER, J. L. & HILL, M. G. (2019). Late Holocene shellfish exploitation in the Upper Mississippi River valley. *Quaternary International* **530**, 146–156.
- THITIPHUREE, T., KITANA, J., VARANUSUPAKUL, P. & KITANA, N. (2013). Atrazine contamination and potential health effects on freshwater mussel *Unioandria contradens* living in agricultural catchment at Nan Province, Thailand. *EnvironmentAsia* **6**, 13–18.
- *TRAN, D., BOUDOU, A. & MASSABUAU, J.-C. (2001). How water oxygenation level influences cadmium accumulation pattern in the asiatic clam *Corbicula fluminea*: a laboratory and field study. *Environmental Toxicology and Chemistry* **20**, 2073–2080.
- TRAN, D., FOURNIER, E., DURRIEU, G. & MASSABUAU, J. C. (2007). Inorganic mercury detection by valve closure response in the freshwater clam *Corbicula fluminea*: integration of time and water metal concentration changes. *Environmental Toxicology and Chemistry* **26**, 1545–1551.
- TSAI, J.-S., LIN, T., CHEN, J. & PAN, B. (2006). The inhibitory effects of freshwater clam (*Corbicula fluminea*, Muller) muscle protein hydrolysates on angiotensin I converting enzyme. *Process Biochemistry* **41**, 2276–2281.
- TURKELBOOM, F., THOONEN, M., JACOBS, S., GARCÍA-LLORENTE, M., MARTÍN-LÓPEZ, B. & BERRY, P. (2016). Ecosystem services trade-offs and synergies. In *OpenNESS Ecosystem Services Reference Book*. EC FP7 Grant Agreement no. 308428 (eds Potschin, M. and K. Jax). Electronic file available at www.openness-project.eu/library/reference-book. Accessed 20.08.2021.
- UN (2021). Overall total population—world population prospects: the 2019 revision. Electronic file available at [https://population.un.org/wpp/Download/Files/1_Indicators%20\(Standard\)/EXCEL_FILES/1_Population/WPP2019_POP_F01_1_TOTAL_POPULATION_BOTH_SEXES.xlsx](https://population.un.org/wpp/Download/Files/1_Indicators%20(Standard)/EXCEL_FILES/1_Population/WPP2019_POP_F01_1_TOTAL_POPULATION_BOTH_SEXES.xlsx). Accessed 10.08.2021.
- *UTIDA, G., OLIVEIRA, E. C., TUCKER, M., PETRI, S. & BOGGIANI, P. C. (2017). Palaeoenvironmental interpretations based on molluscs from mid-Holocene lacustrine limestones, Mato Grosso do Sul, Brazil. *Quaternary International* **437**, 186–198.
- *VALKOVA, E., ATANASOV, V. & VELEVA, P. (2020). Content of Fe and Mn in waters and zebra mussel (*Dreissena polymorpha*) from Ovcharitsa Dam, Stara Zagora region, Bulgaria. *Bulgarian Journal of Agricultural Science* **26**, 870–876.
- *VALLADAO, G. M. R., DE PÁDUA, S. B., LEVY-PEREIRA, N., FARIAS, T. H. V. & PILARSKI, F. (2017). Pathological assessment of exotic channel catfish infected by south American *Anodonte trapesialis* from Brazilian fish farm. *Aquaculture Research* **48**, 3975–3979.
- VAN BOCKLAER, B. (2020). Paleocological insights from fossil freshwater mollusks of the Kanapoi formation (Omo-Turkana Basin, Kenya). *Journal of Human Evolution* **140**, 102341.
- *VAN PLANTINGA, A. A. & GROSSMAN, E. L. (2018). Stable and clumped isotope sclerochronologies of mussels from the Brazos River, Texas (USA): environmental and ecologic proxy. *Chemical Geology* **502**, 55–65.
- VANDERPLOEG, H. A., LIEBIG, J. R., CARMICHAEL, W. W., AGY, M. A., JOHNGEN, T. H., FAHNENSTIEL, G. L. & NALEPA, T. F. (2001). Zebra mussel (*Dreissena polymorpha*) selective filtration promoted toxic *Microcystis* blooms in Saginaw Bay (Lake Huron) and Lake Erie. *Canadian Journal of Fisheries and Aquatic Sciences* **58**, 1208–1221.
- *VANGHELuwe, M. L. U., VERDONCK, F. A. M., BESSER, J. M., BRUMBAUGH, W. G., INGERSOLL, C. G., SCHLEKAT, C. E. & GARMAN, E. R. (2013). Improving sediment-quality guidelines for nickel: development and application of predictive bioavailability models to assess chronic toxicity of nickel in freshwater sediments. *Environmental Toxicology and Chemistry* **32**, 2507–2519.
- *VAROL, M. & SÜNBÜL, M. R. (2017). Organochlorine pesticide, antibiotic and heavy metal residues in mussel, crayfish and fish species from a reservoir on the Euphrates River, Turkey. *Environmental Pollution* **230**, 311–319.
- *VAROL, M. & SÜNBÜL, M. R. (2018). Biomonitoring of trace metals in the Keban Dam Reservoir (Turkey) using mussels (*Unio elongatulus eucirrus*) and crayfish (*Astacus leptodactylus*). *Biological Trace Element Research* **185**, 216–224.
- VAUGHN, C. C. (2018). Ecosystem services provided by freshwater mussels. *Hydrobiologia* **810**, 15–27.
- *VAUGHN, C. C., ATKINSON, C. L. & JULIAN, J. P. (2015). Drought-induced changes in flow regimes lead to long-term losses in mussel-provided ecosystem services. *Ecology and Evolution* **5**, 1291–1305.
- VAUGHN, C. C. & HAKENKAMP, C. C. (2001). The functional role of burrowing bivalves in freshwater ecosystems. *Freshwater Biology* **46**, 1431–1446.
- VAUGHN, C. C. & HOELLEIN, T. J. (2018). Bivalve impacts in freshwater and marine ecosystems. *Annual Review of Ecology, Evolution, and Systematics* **49**, 183–208.
- VAZ, A. S., KUEFFER, C., KULL, C. A., RICHARDSON, D. M., SCHINDLER, S., MUÑOZ-PAJARES, A. J., VICENTE, J. R., MARTINS, J., HUI, C. & KÜHN, I. (2017). The progress of interdisciplinarity in invasion science. *Ambio* **46**, 428–442.

- *VENUGOPAL, A., SUDHEER KUMAR, C., SIVA KUMAR, N. & SWAMY, M. J. (2017). Kinetic and biophysical characterization of a lysosomal α -L-fucosidase from the fresh water mussel, *Lamellidens corrianus*. *International Journal of Biological Macromolecules* **104**, 432–441.
- *VERSTEEGH, E. A. A., TROELSTRA, S. R., VONHOF, H. B. & KROON, D. (2009). Oxygen isotope composition of bivalve seasonal growth increments and ambient water in the rivers Rhine and Meuse. *PALAIOS* **24**, 497–504.
- *VERSTEEGH, E. A. A., VONHOF, H. B., TROELSTRA, S. R. & KROON, D. (2011). Can shells of freshwater mussels (Unionidae) be used to estimate low summer discharge of rivers and associated droughts? *International Journal of Earth Sciences* **100**, 1423–1432.
- *VESK, P. A. & BYRNE, M. (1999). Metal levels in tissue granules of the freshwater bivalve *Hyridella depressa* (Unionida) for biomonitoring: the importance of cryopreservation. *Science of the Total Environment* **225**, 219–229.
- *VIDAL, M.-L., BASSÈRES, A. & NARBONNE, J.-F. (2001). Interest of a multibiomarker approach in the assessment of freshwater ecosystem quality: laboratory and field studies. *Water Science and Technology* **44**, 305–312.
- *VILLAR, C., STRIPEIKIS, J., D'HUICQUE, L., TUDINO, M., TROCCOLI, O. & BONETTO, C. (1999). Cd, Cu and Zn concentrations in sediments and the invasive bivalves *Limnoperna fortunei* and *Corbicula fluminea* at the Rio de la Plata basin, Argentina. *Hydrobiologia* **416**, 41–49.
- *VILLELA, I. V., DE OLIVEIRA, I. M., DA SILVA, J. & HENRIQUES, J. A. P. (2006). DNA damage and repair in haemolymph cells of golden mussel (*Limnoperna fortunei*) exposed to environmental contaminants. *Mutation Research—Genetic Toxicology and Environmental Mutagenesis* **605**, 78–86.
- *VINCENT-HUBERT, F., ARINI, A. & GOURLAY-FRANÇÉ, C. (2011). Early genotoxic effects in gill cells and haemocytes of *Dreissena polymorpha* exposed to cadmium, B[a]P and a combination of B[a]P and Cd. *Mutation Research—Genetic Toxicology and Environmental Mutagenesis* **723**, 26–35.
- *VOETS, J., TALLOEN, W., DE TENDER, T., VAN DONGEN, S., COVACI, A., BLUST, R. & BERVOETS, L. (2006). Microcontaminant accumulation, physiological condition and bilateral asymmetry in zebra mussels (*Dreissena polymorpha*) from clean and contaminated surface waters. *Aquatic Toxicology* **79**, 213–225.
- *VRANKOVIĆ, J. (2015). Environmental impact on the antioxidant responses in *Corbicula fluminea* (Bivalvia: Veneroidea: Corbiculidae) from the Danube River. *Italian Journal of Zoology* **82**, 378–386.
- *VUKOVIĆ-GAČIĆ, B., KOLAREVIĆ, S., SUNJOG, K., TOMOVIĆ, J., KNEŽEVIĆ-VUKČEVIĆ, J., PAUNOVIĆ, M. & GAČIĆ, Z. (2014). Comparative study of the genotoxic response of freshwater mussels *Unio tumidus* and *Unio pictorum* to environmental stress. *Hydrobiologia* **735**, 221–231.
- VYSNA, V., MAES, J., PETERSEN, J. E., LA NOTTE, A., VALLECILLO, S., AIZPURUA, N., IVITS, E. & TELLER, A. (2021). *Accounting for Ecosystems and their Services in the European Union (LNCA)*. Publications Office of the European Union, Luxembourg.
- WAJEN, G. W. A. M., VAN BRUGGEN, N. C. B., PIRES, L. M. D., LENGKEEK, W. & LÜRLING, M. (2016). Biomaniipulation with quagga mussels (*Dreissena rostriformis bugensis*) to control harmful algal blooms in eutrophic urban ponds. *Ecological Engineering* **90**, 141–150.
- *WAGNER, A. & BOMAN, J. (2004). Biomonitoring of trace elements in Vietnamese freshwater mussels. *Spectrochimica Acta—Part B Atomic Spectroscopy* **59**, 1125–1132.
- *WALLACE, J. S. & BLERSCH, D. M. (2015). Dynamic modeling predicts continued bioaccumulation of polybrominated diphenyl ethers (PBDEs) in smallmouth bass (*Micropterus dolomieu*) post phase-out due to invasive prey and shifts in predation. *Environmental Pollution* **206**, 289–297.
- *WANG, G., WANG, X., WU, L. & LI, X. (2012). Transformation and removal of organic matter and nitrogen by integrated ecological floating bed. *Jiangsu Daxue Xuebao (Ziran Kexue Ban)/Journal of Jiangsu University (Natural Science Edition)* **33**, 591–595.
- *WANG, H., QIN, D., SUN, Y., WANG, P., WANG, Y. & RUI, Y. (2019). Study on the *Unio douglasiae* shell as an environmental indicator of heavy metals in the upstream of Songhua River. *Fresenius Environmental Bulletin* **28**, 271–279.
- WANG, L., HE, F., SUN, J., HU, Y., HUANG, T., ZHANG, Y. & WU, Z. (2017). Effects of three biological control approaches and their combination on the restoration of eutrophicated waterbodies. *Limnology* **18**, 301–313.
- *WANG, L., LIU, P., SUN, J., ZHANG, Y., ZHOU, Q., WU, Z. & HE, F. (2018a). Comparison and combination of selective grazing on natural seston by benthic bivalves (*Hyriopsis cumingii*) and pelagic fish (*Hypophthalmichthys molitrix*). *Environmental Science and Pollution Research* **25**, 33423–33431.
- *WANG, L., MA, L., SUN, J., ZHANG, Y., ZHOU, Q., WU, Z. & HE, F. (2018b). Effects of different aquaculture methods for introduced bivalves (*Hyriopsis cumingii*) on seston removal and phosphorus balance at the water–sediment interface. *Journal of Freshwater Ecology* **33**, 251–265.
- *WANG, P., WANG, R., WANG, C., QIAN, J. & HOU, J. (2016). Exposure-dose-response relationships of the freshwater bivalve *Corbicula fluminea* to inorganic mercury in sediments. *Journal of Computational and Theoretical Nanoscience* **13**, 5714–5723.
- WANG, X. X., XIE, L., LUO, C. & WANG, R. Z. (2006). Natural nacre coatings on titanium implant grown by fresh water bivalve shell. *Key Engineering Materials* **309**, 743–746.
- *WANG, Y., WANG, W. L., QIN, J. G., WANG, X. D. & ZHU, S. B. (2009). Effects of integrated combination and quicklime supplementation on growth and pearl yield of freshwater pearl mussel, *Hyriopsis cumingii* (Lea, 1852). *Aquaculture Research* **40**, 1634–1641.
- *WANG, Y. & ZHANG, J. (2018). The influence of calcination temperature on the physicochemical characteristics of *Pteria martensii*. *Journal of Thermal Analysis and Calorimetry* **131**, 49–55.
- *WANG, Y.-Y., QIU, W.-Y., SUN, L., DING, Z.-C. & YAN, J.-K. (2018). Preparation, characterization, and antioxidant capacities of selenium nanoparticles stabilized using polysaccharide–protein complexes from *Corbicula fluminea*. *Food Bioscience* **26**, 177–184.
- WANG, Z., ADZIGBLI, L., ZHENG, Z., YANG, C. & DENG, Y. (2020). How cultured pearls acquire their colour. *Aquaculture Research* **51**, 3925–3934.
- *WARREN, C. N. & COSTA, J. D. (1964). Dating Lake Mohave artifacts and beaches. *American Antiquity* **30**, 206–209.
- *WATANABE, M. F., PARK, H.-D., KONDO, F., HARADA, K.-I., HAYASHI, H. & OKINO, T. (1997). Identification and estimation of microcystins in freshwater mussels. *Natural Toxins* **5**, 31–35.
- WATSON, S. B. & RIDAL, J. (2004). Periphyton: a primary source of widespread and severe taste and odour. *Water Science and Technology* **49**, 33–39.
- *WAYKAR, B. & DESHMUKH, G. (2012). Evaluation of bivalves as bioindicators of metal pollution in freshwater. *Bulletin of Environmental Contamination and Toxicology* **88**, 48–53.
- *WAYKAR, B. & SHINDE, S. M. (2011). Assessment of the metal bioaccumulation in three species of freshwater bivalves. *Bulletin of Environmental Contamination and Toxicology* **87**, 267–271.
- *WEBB, K., CRAFT, C. & ELSWICK, E. (2008). The evaluation of the freshwater western pearl mussel, *Margaritifera falcata* (Gould, 1850), as a bioindicator through the analysis of metal partitioning and bioaccumulation. *Northwest Science* **82**, 163–173.
- *WEHRMEISTER, U., JACOB, D. E., SOLDATI, A. L., HAGER, T. & HOFMEISTER, W. (2007). Vaterite in freshwater cultured pearls from China and Japan. *Journal of Gemmology* **30**, 399–412.
- *WEI, Y., D'ERRICO, F., VANHAEREN, M., LI, F. & GAO, X. (2016). An early instance of upper Palaeolithic personal ornamentation from China: the freshwater shell bead from Shuidonggou 2. *PLoS One* **11**, e0155847.
- WESTON, E., SZABÓ, K. & STERN, N. (2017). Pleistocene shell tools from Lake Mungo lunette, Australia: identification and interpretation drawing on experimental archaeology. *Quaternary International* **427**, 229–242.
- *WIESNER, L., GÜNTHER, B. & FENSKE, C. (2001). Temporal and spatial variability in the heavy-metal content of *Dreissena polymorpha* (Pallas) (Mollusca: Bivalvia) from the Kleines Haff (northeastern Germany). *Hydrobiologia* **443**, 137–145.
- *WILSON, W. A., FRITTS, A. K., FRITTS, M. W., UNRINE, J. M. & CASPER, A. F. (2018). Freshwater mussel (Unionidae) shells document the decline of trace element pollution in the regional watersheds of Chicago (Illinois, USA). *Hydrobiologia* **816**, 179–196.
- *WINTERS, A. D., MARSH, T. L. & FAISAL, M. (2011). Heterogeneity of bacterial communities within the zebra mussel (*Dreissena polymorpha*) in the Laurentian Great Lakes Basin. *Journal of Great Lakes Research* **37**, 318–324.
- *WOJTAL-FRANKIEWICZ, A. & FRANKIEWICZ, P. (2011). The impact of pelagic (*Daphnia longispina*) and benthic (*Dreissena polymorpha*) filter feeders on chlorophyll and nutrient concentration. *Limnologia* **41**, 191–200.
- *WONG, K. W., YAP, C. K., NULIT, R., HAMZAH, M. S., CHEN, S. K., CHENG, W. H., KARAMI, A. & AL-SHAMI, S. A. (2017). Effects of anthropogenic activities on the heavy metal levels in the clams and sediments in a tropical river. *Environmental Science and Pollution Research* **24**, 116–134.
- WOOD, S. A., BRIGGS, L. R., SPROSEN, J., RUCK, J. G., WEAR, R. G., HOLLAND, P. T. & BLOXHAM, M. (2006). Changes in concentrations of microcystins in rainbow trout, freshwater mussels, and cyanobacteria in Lakes Rotoiti and Rotoehu. *Environmental Toxicology* **21**, 205–222.
- *WOZNICKI, P., LEWANDOWSKA, R., BRZUZAN, P., ZIOMEK, E. & BARDEGA, R. (2004). The level of DNA damage and the frequency of micronuclei in haemolymph of freshwater mussels *Anodonta woodiana* exposed to benzo[a]pyrene. *Acta Toxicologica* **12**, 41–45.
- *WU, C. F., CHEN, C. H., WU, C. Y., LIN, C. S., SU, Y. C., WU, C. F., TSAI, H. P., FAN, P. S., YE, C. H., YANG, W. C. & CHANG, G. R. (2020). Quinolone and organophosphorus insecticide residues in bivalves and their associated risks in Taiwan. *Molecules* **25**, 3636.
- *WU, X., WU, H., GU, X., ZHANG, R., YE, J. & SHENG, Q. (2019). Biomagnification characteristics and health risk assessment of the neurotoxin BMAA in freshwater aquaculture products of Taihu Lake Basin, China. *Chemosphere* **229**, 332–340.

- *WU, Y., ZHOU, Y., QIU, Y., CHEN, D., ZHU, Z., ZHAO, J. & BERGMAN, Å. (2017). Occurrence and risk assessment of trace metals and metalloids in sediments and benthic invertebrates from Dianshan Lake, China. *Environmental Science and Pollution Research* **24**, 14847–14856.
- *WÜRSTER, C. M. & PATTERSON, W. P. (2001). Seasonal variation in stable oxygen and carbon isotope values recovered from modern lacustrine freshwater molluscs: paleoclimatological implications for sub-weekly temperature records. *Journal of Paleolimnology* **26**, 205–218.
- *XIA, T. & LIU, X. (2011). Copper and zinc interaction on water clearance and tissue metal distribution in the freshwater mussel, *Cristaria plicata*, under laboratory conditions. *Frontiers of Environmental Science and Engineering in China* **5**, 236–242.
- *XU, H., LV, S., JIANG, S., LU, J. & LIN, L. (2020). Radical scavenging activities of peptide from Asian clam (*Corbicula fluminea*) and its protective effects on oxidative damage induced by hydrogen peroxide in HepG2 cells. *Journal of Food Biochemistry* **44**, e13146.
- *XU, M., WANG, Z., DUAN, X. & PAN, B. (2014). Effects of pollution on macroinvertebrates and water quality bio-assessment. *Hydrobiologia* **729**, 247–259.
- *YAN, H., DETTMAN, D. L., CHEN, J. & SHEN, N. J. (2020). Delta C-1(3) in *Corbicula fluminea* shells: implication for dissolved inorganic carbon reconstruction. *Geochemical Journal* **54**, 71–79.
- *YAN, H., LEE, X., ZHOU, H., CHENG, H., PENG, Y. & ZHOU, Z. (2009a). Stable isotope composition of the modern freshwater bivalve *Corbicula fluminea*. *Geochemical Journal* **43**, 379–387.
- *YAN, H., LI, Z., LEE, X., ZHOU, H., CHENG, H. & CHEN, J. (2012). Metabolic effects on stable carbon isotopic composition of freshwater bivalve shell *Corbicula fluminea*. *Chinese Journal of Geochemistry* **31**, 103–108.
- *YAN, J.-K., WANG, Y.-Y., QIU, W.-Y., WANG, Z.-B. & MA, H. (2018). Ultrasound synergized with three-phase partitioning for extraction and separation of *Corbicula fluminea* polysaccharides and possible relevant mechanisms. *Ultrasonics Sonochemistry* **40**, 128–134.
- *YAN, J.-K., WANG, Y.-Y., QIU, W.-Y., WU, L.-X., DING, Z.-C. & CAI, W.-D. (2017). Purification, structural characterization and bioactivity evaluation of a novel proteoglycan produced by *Corbicula fluminea*. *Carbohydrate Polymers* **176**, 11–18.
- *YAN, L.-L., ZHANG, G.-F., LIU, Q.-G. & LI, J.-L. (2009b). Optimization of culturing the freshwater pearl mussels, *Hyriopsis cumingii* with filter feeding Chinese carps (bighead carp and silver carp) by orthogonal array design. *Aquaculture* **292**, 60–66.
- *YANCHEVA, V., VELCHEVA, I., ILIEV, I., VASILEVA, T., BIVOLARSKI, V., GEORGIEVA, E. & STOYANOVA, S. (2020). Histochemical and biochemical alterations in zebra mussel *Dreissena polymorpha* (Pallas, 1771) after cadmium and polyaromatic hydrocarbons exposure. *Acta Zoologica Bulgarica* **15**, 155–164.
- *YANG, J., HARINO, H., LIU, H. & MIYAZAKI, N. (2008). Monitoring the organotin contamination in the Taihu Lake of China by bivalve mussel *Anodonta woodiana*. *Bulletin of Environmental Contamination and Toxicology* **81**, 164–168.
- *YANG, J., KARROW, P. F. & MACKIE, G. L. (2001). Paleocological analysis of molluscan assemblages in two marl deposits in the Waterloo region, southwestern Ontario, Canada. *Journal of Paleolimnology* **25**, 313–328.
- YANG, S., PENG, Z., WANG, L., WANG, T. & YANG, C. (2019). Calcinated shell powder from *Corbicula fluminea* as a natural antimicrobial agent for soybean curd (tofu) preservation. *Food Science and Technology Research* **25**, 545–553.
- *YAO, H.-T., LEE, P.-F., LI, C.-K., LIU, Y.-T. & CHEN, S.-H. (2018). Freshwater clam extract reduces liver injury by lowering cholesterol accumulation, improving dysregulated cholesterol synthesis and alleviating inflammation in high-fat, high-cholesterol and cholic acid diet-induced steatohepatitis in mice. *Food and Function* **9**, 4876–4887.
- YEH, K. T., WU, W. T., SUBEQ, Y. M., NIU, C. C., LIAO, K. W., CHEN, I. H. & LEE, R. P. (2017). Effects of freshwater clam extract on fracture induced inflammation at early stage. *Experimental and Therapeutic Medicine* **14**, 5039–5044.
- *YOKOYAMA, A. & PARK, H.-D. (2002). Mechanism and prediction for contamination of freshwater bivalves (Unionidae) with the cyanobacterial toxin microcystin in hypereutrophic Lake Suwa, Japan. *Environmental Toxicology* **17**, 424–433.
- *YOLOĞLU, E. (2019). Investigation of metallothionein level, reduced GSH level, MDA level, and metal content in two different tissues of freshwater mussels from Atatürk Dam Lake coast, Turkey. *Chemistry and Ecology* **35**, 644–659.
- *YOLOĞLU, E., UÇKUN, M. & UÇKUN, A. A. (2018). Metal accumulation and biochemical variations in the freshwater mussels (*Unio mancus*) collected from Atatürk Dam Lake, Turkey. *Biochemical Systematics and Ecology* **79**, 60–68.
- *YOSHIMURA, T., IZUMIDA, H., NAKASHIMA, R., ISHIMURA, T., SHIKAZONO, N., KAWAHATA, H. & SUZUKI, A. (2015). Stable carbon isotope values in dissolved inorganic carbon of ambient waters and shell carbonate of the freshwater pearl mussel (*Hyriopsis* sp.). *Journal of Paleolimnology* **54**, 37–51.
- *YU, Z., GAO, G., WANG, H., KE, L., ZHOU, J., RAO, P., CHEN, T., PENG, Z., ZOU, J. & LUO, S. (2020). Identification of protein-polysaccharide nanoparticles carrying hepatoprotective bioactives in freshwater clam (*Corbicula fluminea* Muller) soup. *International Journal of Biological Macromolecules* **151**, 781–786.
- YU, Z., WALKER, K. N., EVENSON, E. B. & HAJDAS, I. (2008). Lateglacial and early Holocene climate oscillations in the Matanuska Valley, south-central Alaska. *Quaternary Science Reviews* **27**, 148–161.
- *YUSSEPPONE, M. S., BIANCHI, V. A., CASTRO, J. M., NOYA ABAD, T., MINABERRY, Y. S., SABATINI, S. E., LUQUET, C. M., RIOS DE MOLINA, M. C. & ROCCHETTA, I. (2020). *In situ* experiment to evaluate biochemical responses in the freshwater mussel *Diplodon chilensis* under anthropogenic eutrophication conditions. *Ecotoxicology and Environmental Safety* **193**, 110341.
- *YUX, B., ZHAO, Z., TANG, R., XIONG, B., WU, Z. L., SUS, Q. & YAO, W. Z. (2020). Assessment of the environmental purification of triangle sail mussel (*Hyriopsis cumingii*) in recirculating aquaculture systems. *Applied Ecology and Environmental Research* **18**, 3439–3454.
- ZARYKHTA, V. V., ZHANG, Z., KHOLODKEVICH, S. V., KUZNETSOVA, T. V., SHAROV, A. N., ZHANG, Y., SUN, K., LV, M. & FENG, Y. (2019). Comprehensive assessments of ecological states of Songhua River using chemical analysis and bivalves as bioindicators. *Environmental Science and Pollution Research* **26**, 33341–33350.
- ZENG, Y., LI, Z., WANG, Q., XU, C., LI, Y. & TANG, J. (2019). Metal accumulation in Asiatic clam from the Lower Min River (China) and implications for human health. *Frontiers of Earth Science* **13**, 361–370.
- *ZHANG, G. F., LUO, Y., ZHANG, W. F., FANG, A. P., YE, R. H., REN, G. & YANG, S. B. (2019). The effect of two selected strains of mussels as donor or host on the color of cultivated pearls. *Journal of Shellfish Research* **38**, 363–369.
- *ZHANG, H., CULVER, D. A. & BOEGMAN, L. (2011). Dreissenids in Lake Erie: an algal filter or a fertilizer? *Aquatic Invasions* **6**, 175–194.
- *ZHANG, H., LEI, G., CHANG, F., PU, Y., FAN, H., LEI, Y., YANG, M., ZHANG, W. & YANG, L. (2008). Chronology of the shell bar section and a discussion on the ages of the Late Pleistocene lacustrine deposits in the paleolake Qarhan, Qaidam basin. *Frontiers of Earth Science in China* **2**, 225–235.
- *ZHANG, H., XIA, W.-S., XU, Y.-S., JIANG, Q.-X., WANG, C.-X. & WANG, W.-J. (2013a). Effects of spray-drying operational parameters on the quality of freshwater mussel powder. *Food and Bioprocess Technology* **91**, 242–248.
- *ZHANG, N., WEI, C. & YANG, L. (2013b). Occurrence of arsenic in two large shallow freshwater lakes in China and a comparison to other lakes around the world. *Microchemical Journal* **110**, 169–177.
- ZHANG, R., CUI, B. & HUANG, S. (2015). Degradation of forchlorfenuron by nitrification and denitrification reactions in the gut and shell biofilm of *Limnoperna fortunei*. *Ecotoxicology* **24**, 381–390.
- *ZHANG, X., LIU, Z., JEPPESEN, E. & TAYLOR, W. D. (2014). Effects of deposit-feeding tubificid worms and filter-feeding bivalves on benthic-pelagic coupling: implications for the restoration of eutrophic shallow lakes. *Water Research* **50**, 135–146.
- *ZHANG, Y., HU, X. & YU, T. (2012). Distribution and risk assessment of metals in sediments from Taihu Lake, China using multivariate statistics and multiple tools. *Bulletin of Environmental Contamination and Toxicology* **89**, 1009–1015.
- *ZHAO, L., WALLISER, E. O., MERTZ-KRAUS, R. & SCHÖNE, B. R. (2017). Unionid shells (*Hyriopsis cumingii*) record manganese cycling at the sediment-water interface in a shallow eutrophic lake in China (Lake Taihu). *Palaeogeography, Palaeoclimatology, Palaeoecology* **484**, 97–108.
- *ZHENG, X., TANG, J., REN, G. & WANG, Y. (2017a). The effect of four microbial products on production performance and water quality in integrated culture of freshwater pearl mussel and fishes. *Aquaculture Research* **48**, 4897–4909.
- *ZHENG, X., TANG, J., ZHANG, C., QIN, J. & WANG, Y. (2017b). Bacterial composition, abundance and diversity in fish polyculture and mussel-fish integrated cultured ponds in China. *Aquaculture Research* **48**, 3950–3961.
- *ZHENG, X., ZHANG, D., QIN, J. & WANG, Y. (2018). The effect of C/N ratio on bacterial community and water quality in a mussel-fish integrated system. *Aquaculture Research* **49**, 1699–1708.
- *ZHONG, H., KRAEMER, L. & EVANS, D. (2013). Influence of body size on Cu bioaccumulation in zebra mussels *Dreissena polymorpha* exposed to different sources of particle-associated Cu. *Journal of Hazardous Materials* **261**, 746–752.
- *ZHOU, C., HUANG, J.-C., LIU, F., HE, S. & ZHOU, W. (2018). Removal of selenium containing algae by the bivalve *Sinanodonta woodiana* and the potential risk to human health. *Environmental Pollution* **242**, 73–81.
- *ZHOU, Y., HE, Q. & ZHOU, D. (2017). Optimization extraction of protein from mussel by high-intensity pulsed electric fields. *Journal of Food Processing and Preservation* **41**, e12962.
- ZHU, L., WANG, H., XU, J., LIN, J. & WANG, X. (2011). Effects of nacre-coated titanium surfaces on cell proliferation and osteocalcin expression in MG-63 osteoblast-like cells. *African Journal of Biotechnology* **10**, 15387–15393.
- *ZHU, Z.-Y., LIU, N., LIU, Y., SI, C.-L., LIU, R.-Q., CHEN, J., LIU, C.-J., LIU, A.-J. & ZHANG, Y.-M. (2012). Chemical analysis of a polysaccharide from *Cristaria plicata* (Leach). *International Journal of Food Sciences and Nutrition* **63**, 506–511.
- ZIERITZ, A. & ALDRIDGE, D. C. (2009). Identification of ecophenotypic trends within three European freshwater mussel species (Bivalvia: Unionoida) using traditional and modern morphometric techniques. *Biological Journal of the Linnean Society* **98**, 814–825.

- ZIERITZ, A., AZAM-ALI, S., MARRIOTT, A. L., NASIR, N. A. B. M., NG, Q. N., RAZAK, N. A. A. B. A. & WATTS, M. (2018*a*). Biochemical composition of freshwater mussels in Malaysia: a neglected nutrient source for rural communities. *Journal of Food Composition and Analysis* **72**, 104–114.
- ZIERITZ, A., BOGAN, A. E., FROUFE, E., KLISHKO, O., KONDO, T., KOVITVADHI, U., KOVITVADHI, S., LEE, J. H., LOPES-LIMA, M., PFEIFFER, J. M., SOUSA, R., VAN DO, T., VIKHREV, I. & ZANATTA, D. T. (2018*b*). Diversity, biogeography and conservation of freshwater mussels (Bivalvia: Unionida) in East and Southeast Asia. *Hydrobiologia* **810**, 29–44.
- *ZIMMERMANN, S., MESSERSCHMIDT, J., VON BOHLEN, A. & SURES, B. (2005). Uptake and bioaccumulation of platinum group metals (Pd, Pt, Rh) from automobile catalytic converter materials by the zebra mussel (*Dreissena polymorpha*). *Environmental Research* **98**, 203–209.
- *ZIMMERMANN, S. & SURES, B. (2018). Lessons learned from studies with the freshwater mussel *Dreissena polymorpha* exposed to platinum, palladium and rhodium. *Science of the Total Environment* **615**, 1396–1405.

(Received 14 August 2021; revised 23 May 2022; accepted 25 May 2022)

XI. SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Appendix S1. List of key words used in the search string performed in ISI *Web of Science* and *Scopus*.

Appendix S2. Classification of papers by continents according to the country(ies)/regions where the case studies took place.

Appendix S3. Final list of publications considered in the literature review.