Chapter 33
The Freshwater Molluscs of the Mesopotamian Plain

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Abstract The present paper revises diversity, endemism and threats for freshwater molluscs that inhabit the plains between the Tigris and Euphrates rivers. A systematic account of the extant freshwater mollusc fauna of Iraq includes 35 mollusc species, twenty species of Gastropoda, and five species of Bivalvia. The recent malacofauna in the Mesopotamian plain is the mix of the species that evolved from the saline tolerant freshwater taxa in the lakes that existed in former times and the geologically recent immigrants that either reached Mesopotamian plain from the Palaearctic or from the east.

The gastropods of the family Melanopsidae dominate in the gastropod assemblage, while the Asian clam *Corbicula fluminea* is the most common mussel in Tigris and Euphrates basins. The Mesopotamian plain harbours a few endemic species of freshwater molluscs.

Freshwater molluscs are affected by multiple threats: water abstraction, natural system modification by constructing large dams, draining of the lower basin marshes and impact of invasive species being found as most impacting. About 29% of Iraqi mollusc fauna is non-native, indicating that malacofauna of the Mesopotamian is among the most threatened in the world by invasive species.

Keywords Mesopotamia · Molluscs · Diversity · Endemism · Conservation

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33.1 Introduction

In the ancient Mesopotamia, molluscs were widely used, mainly as a source for food, but their shells were also exploited as a valuable raw material, employed in manufacture inlays, personal ornaments, seals and utensils (MacKay 1999). Moreover, the shells played role in religious life (Aynard 1966) and in specific socio-ritual functions (Gensheimer 1984). Freshwater molluscs played much less important role than marine ones, and the mussels of genus *Unio* were the most used freshwater molluscs. These mussels were used as food, whilst their shells were used as personal ornaments or containers (MacKay 1999). Some freshwater molluscs were found in bitumen stopper: for example, the bitumen stands for ostrich-egg cups at Kish, which were inlaid with pieces of *Anodonta* mussels in Early Dynastic III (Mackay 1999).

Much of the knowledge of the freshwater molluscan fauna for the Mesopotamian region is fragmented. The first paper about freshwater molluscs of Mesopotamia has been published in 1874 by Eduard von Martens who reported molluscs collected by the botanist Prof. Hausknecht from his expedition to Persia (Allouse 1956). In the same year, Mousson (1874) published new data on freshwater molluscs of Mesopotamia based on the material collected by Dr. Schlaefli. He listed 19 species of freshwater gastropods and eight bivalve species from Mesopotamia.

The most comprehensive papers on Mesopotamian malacofauna were published by Annandale (1918, 1920) and Prashad (1921) who listed 14 gastropod species. Germain (1921a, b, 1922, 1921-1924) and Pallary (1929, 1939) studied malacofauna of Syria. Over the following century, a number of subsequent works (Najim 1950, 1959, 1960; Soyer 1961) contributed to our knowledge of the molluscs of Mesopotamia and the most recent summary was provided by Ahmed (1975) who provided a complete checklist of species living in Iraq. Plaziat and Younis (2005) synthesised the data on the Quaternary freshwater malacofauna of lower Mesopotamia. This region was almost destroyed as a result of the draining of the lower basin marshes in the 1990s (Partow 2001).

In the last decade of the twenty-first century, a number of publications were published (Abdul-Sahib and Abdul-Sahib 2005, 2008; Naser 2006, 2010; Glöer and Naser 2007, 2008; Glöer et al. 2008; Naser and Son 2009; Haase and Wilke 2010; Mohammad 2014; Al-Fanharawi and Ibrahim 2014; Al-Waaly et al. 2014; Salman and Nassar 2014), increasing our knowledge on the Mesopotamian malacofauna. Most of these papers include faunistical information, including description of new species (Glöer and Naser 2008, 2013; Glöer et al. 2008). On the other hand, the current scientific literature on the ecology of freshwater malacofauna of Mesopotamia is still scant (Harris 1965) but with evident progress in the last few years (Mohammad 2014; Al-Fanharawi and Ibrahim 2014; Salman and Nassar 2014). Most of the published ecological works were devoted to *Bulinus truncatus* (the intermediate host for *Schistosoma haematobium*) and *Radix auricularia* (the intermediate host of *Fasciola gigantica*) (Watson 1958; Najarian 1961; Al-Asadi 2011; Al-Yaquob 2011).

The aim of this study is to synthesise all accumulated data concerning the species content, distribution and taxonomy of the freshwater molluscs that inhabit the plains between the Tigris and Euphrates rivers. This region is covered with alluvial sediments of Pleistocene and Holocene and represents a complex of shallow freshwater lakes, swamps, marshes and seasonally inundated plains.

33.2 Distribution and Species Richness of Molluscs of Mesopotamia

A total of 35 mollusc species, twenty species of Gastropoda and five species of Bivalvia have been included into annotated list of the freshwater molluscs of Iraq (Table 33.1). The fauna of freshwater molluscs of Iraq is taxonomically impoverished as compared to the fauna of neighbouring countries: Turkey (Yıldırım et al. 2006) and Iran (Glöer and Pešić 2012). It is worth mentioning that the compiling of the species list for the Mesopotamian region has been a difficult task and it is likely that a number of species that live in Syrian, Turkish and Iranian parts of the catchment may have been missed. For example, Pallary (1929, 1939) listed *Pyrgula syriaca* and *P. euphratica* for Mesopotamia, but these species have not been found by the later authors. It is possible that some of the ‘older‘species are valid taxa, but we cannot exclude that they are apparent synonyms of other species, which in the future require a thorough revision of this list from both nomenclatorial and taxonomic points of view. The taxonomy of some groups especially Melanopsidae and Planorbidae (see discussion below under these families) is either presently under revision or is in urgent need of revision. Moreover, it is very likely that new species will be discovered, particularly by applying molecular techniques.

The current molluscan fauna of Mesopotamian region is the result of spectacular changes in the evolution of the whole region, which are present in the region over the millions of years and primarily were shaped by the existence of vast lakes with marked salinity gradients and fluctuations and the possibility of migration among these ecosystems (Werner et al. 2007; Wesselingh 2007). From a biogeographic point of view, the Mesopotamian freshwater fauna belongs to Mediterranean palaearctic domain (Plaziat and Younis 2005). The Mesopotamian plain was formed at the end of Zagros orogeny in Miocene–Pliocene and the modern malacological fauna is a small relict of the fauna formed at that time (Seddon et al. 2014). The higher richness in some families like Neritidae and Melanopsidae is directly linked to the evolutionary radiation of saline tolerant freshwater taxa in the lakes that existed in former times (Seddon et al. 2014). On the other hand, a large part of the recent malacofauna consists of geologically recent immigrants that either reached Mesopotamian plain from the Palaearctic (e.g. *Bithynia* and *Radix)* or from the east (e.g. *Bellamya* and *Corbicula*).

Table 33.1 List of mollusc species occurring in Iraq. Endemic species are marked by an asterisk

Taxa	Red List Category
Neritidae Lamarck, 1809	
Neritina schlaeflii Mousson 1874	
Neritina mesopotamica Martens, 1874	
Neritina euphratica (Mousson 1874)	Least concern
Theodoxus jordani (Sowerby, 1832)	
Viviparidae J.E. Gray, 1847	
Bellamya bengalensis (Lamarck, 1822)	
Melanopsidae H. & A. Adams, 1854	
Melanoides tuberculatus O.F. Müller, 1774	Least concern
Melanopsis costata (Olivier, 1804)	Least concern
Melanopsis subtingitana Annandale 1918	
Melanopsis nodosa Férussac, 1823	Least concern
Melanopsis buccinoidea (Olivier, 1801)	Least concern
Bithyniidae Troschel, 1857	
Bithynia badiella (Küster, 1853) (?)	
Bithynia iraqensis Pallary 1939	
* *Bithynia hareerensis* Glöer and Naser 2008	
* *Bithynia ejecta* Mousson 1874	
Hydrobiidae Troschel, 1857	
Hydrobia lactea (Küster, 1852)	Near threatened
Ecrobia grimmi (Clessin & Dybowski, 1888)	
* *Assiminea mesopotamica* Glöer & Naser 2007	Data deficient
* *Assiminea zubairensis* Glöer and Naser 2013	
Potamopyrgus antipodarum (J.E. Gray, 1843)	
Lymnaeidae Rafinesque, 1815	
Radix auricularia (Linnaeus, 1758)	Least concern
Radix lagotis (Schrank, 1803)	Data deficient
Galba truncatula (O.F. Müller, 1774)	Least concern
Planorbidae Rafinesque, 1815	
Planorbis intermixtus Mousson 1874	
Gyraulus euphraticus (Mousson 1874)	Least concern
* *Gyraulus huwaizahensis* Glöer and Naser 2008	Data deficient
Gyraulus convexiusculus (Hutton, 1849)	Least concern
Gyraulus chinensis (Dunker, 1848)	Least concern
Bulinus truncatus (Audouin, 1827)	Least concern
Ferrissia californica (Rowell, 1863)	Least concern
Physidae Fitzinger, 1833	
Physa acuta (Draparnaud, 1805)	Least concern
Bivalvia	
Unionidae Rafinesque, 1820	
Unio tigridis Bourguignat, 1852	Least concern
Pseudodontopsis euphraticus (Bourguignat, 1852)	

(continued)

Table 33.1 (continued)

Taxa	Red List Category
Anodonta vescoiana Bourguignat, 1857	Near threatened
Corbiculidae J.E. Gray, 1847	
Corbicula fluminea (O.F. Müller, 1774)	Least concern
Dreissenidae J.E. Gray, 1840	
Dreissena siouffi Locard, 1893	

33.3 Diversity of Gastropoda

Altogether, there are 20 gastropod species belonging to eight families that have been recorded so far from Iraq (Table 33.1). The family Neritidae includes four species, three species of the genus *Neritina* and the widespread *Theodoxus jordani*, which inhabits lakes, marsh channels, fluviatile channels and estuaries (Plaziat and Younis 2005; Abdul-Sahib and Abdul-Sahib 2008). Molecular analysis revealed that the population of *Th. jordani* from its *locus typicus* (Jordan River) is genetically conspecific with the population from Shatt-Al Arab (Katharina Kurzrock pers. comm., FREDIE-Project). *Neritina* species predominantly inhabits brackish waters. Plaziat and Younis (2005) mentioned that *Neritina schlaeflii* forages in the muddy intertidal zone near the mouth of the Shatt al Arab where the salinity attained 2‰. Most *Neritina* species seem to be restricted to the Shatt al-Arab, i.e. the joined downstream part of the Tigris and Euphrates between Basrah and the Persian Gulf in Iraq, but some of the species such as *N. euphratica and N. mesopotamica* were also found in Khuzestan province in Iran (Glöer and Pešić 2012) (Figs. 33.1 and 33.2).

The family Viviparidae includes one species, *Bellamya bengalensis*. This species is a recent invader (Soyer 1961) and is common in the lower Euphrates, Tigris and Shatt Al-Arab Rivers (Nesemann 2007; Al-Fanharawi and Ibrahim 2014; Salman and Nassar 2014). It lives in fresh water on the bottom muds of ponds, marshes and marsh channels but can also be found in estuarine shore deposits (Plaziat and Younis 2005). The specimens of *Bellamya bengalensis* (as well as the species of the genus *Radix)* that inhabit habitats with high salinity in southern part are smaller than those that live in the central part of Mesopotamia (Al-Waaly et al. 2014).

The gastropods of the family Melanopsidae are the most common snails in Euphrates and Tigris drainage, but systematic status of many species is still unclear. For example, Harris (1965) listed 20 taxa of *Melanopsis*, but Plaziat and Younis (2005) lumped all these taxa together to *M. praemorsa*, indicating that further study is necessary to clarify taxonomic status of Mesopotamian melanopsid populations. In this paper, we list six species of Melanopsidae for the Tigris and Euphrates basin based on their conchological characteristics. Fossil specimens of the melanopsid species have been reported from the Euphrates valley in Syria (Freedman and Lundquist 1977). Most melanopsid snails are widespread and only *Melanopsis subtingitana* has a more restricted distribution in central and lower Euphrates (Naser 2006; Salman and Nassar 2014), Al-Hammar marshes and the Garmat-Ali, the canalised river that drains later marshes in the southern part of Mesopotamia

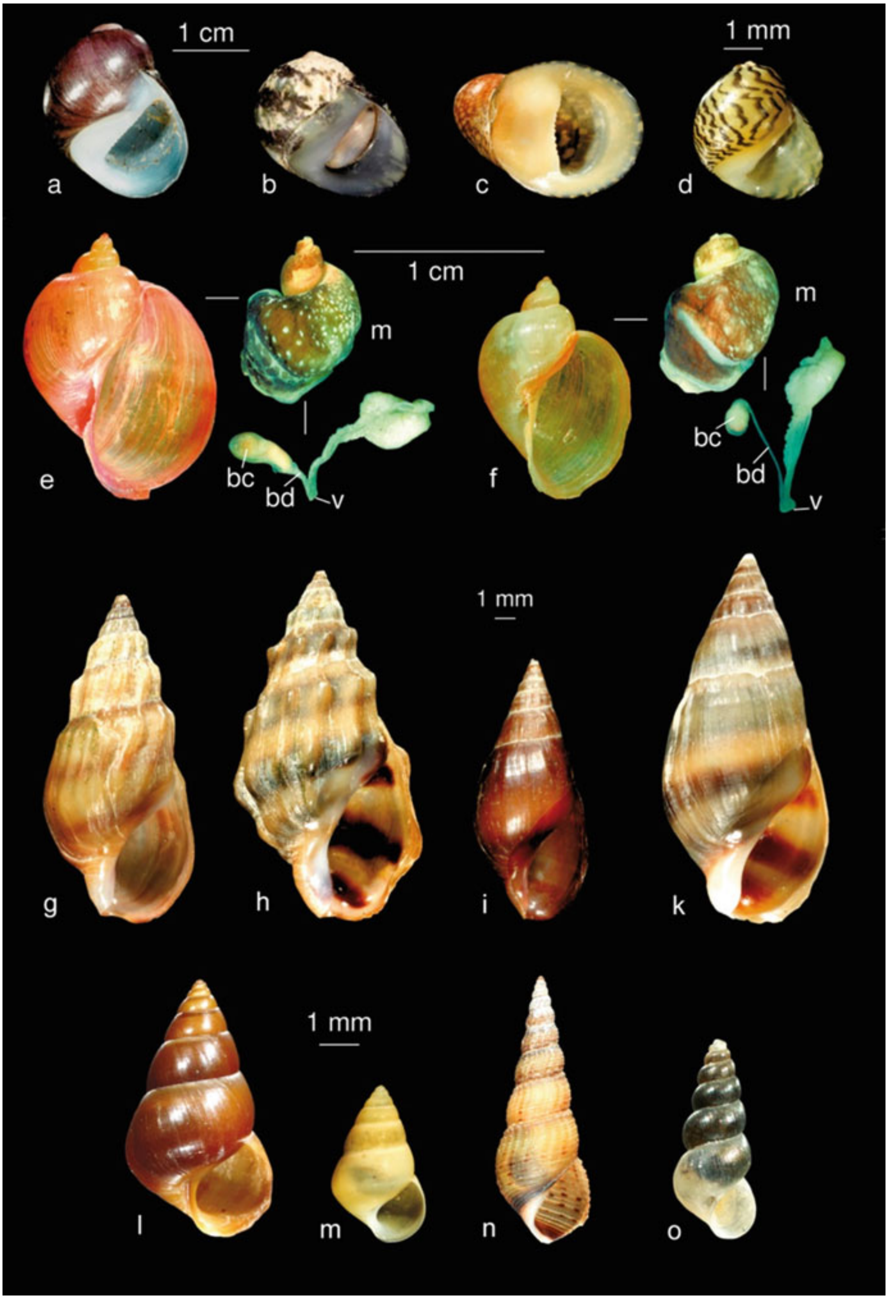

Fig. 33.1 Gastropod species occurring in the Mesopotamian plain. (**a**) *Neritina euphratica* (syntype); (**b**) *Neritina mesopotamica* (syntype ZMZ528916, photo Eike Neubert); (**c**) *Neritina schlaeflii*; (**d**) *Theodoxus jordani*; (**e**) *Radix lagotis*; (**f**) *R. auricularia*; (**g**) *Melanopsis costata*; (**h**) *M. nodosa*; (**i**) *M. subtingitana*; (**k**) *M. buccinoidea*; (**l**) *Assiminea mesopotamica*; (**m**) *A. zubairensis*; (**n**) *Melanoides tuberculatus*; (**o**) *Ecrobia grimmi*. (Photos by Peter Glöer)

Fig. 33.2 Gastropod species occurring in the Mesopotamian plain. (**a**) *Potamopyrgus antipodarum*; (**b**) *Galba truncatula* (topotype); (**c**) *Physa acuta*; (**d**) *Bithynia ejecta* (Syntype ZMZ524006, Samava); (**e**) *Bithynia hareerensis*; (**f**) *Bellamya bengalensis*; (**g**) *Bulinus truncatus*; (**h**) *Gyraulus huwaizahensis*; (**i**) *Gyraulus convexiusculus*; (**k**) *Gyraulus chinensis*; (**l**) *Gyraulus euphraticus*; (**m**) *Planorbis intermixtus*. (Photos by Peter Glöer)

(Naser 2006). Most species are ubiquitous and inhabit diverse habitats including springs and pools, irrigation canals, ponds, streams, swamps, ditches and rivers. Some species, i.e. *Melanoides tuberculatus* and *Melanopsis costata*, are resistant to severe drought (Dzikowski et al. 2003) and most species of the family tolerate salinities. For example, *M. costata* has been recorded to withstand salinity of almost 0.4 psu (Falniowski et al. 2002), while *M. tuberculatus* can tolerate salinities of up to 23 psu (Plaziat and Younis 2005).

The euryhaline *Melanoides tuberculatus* is widely distributed in mountain streams in the northern part of Iraq and the rivers, pools, lakes and ditches in the southern part of the country (Al-Waaly et al. 2014). *Melanopsis nodata* is widely distributed in Tigris and Euphrates drainage (Al-Fanharawi and Ibrahim 2014; Salman and Nassar 2014), but more common in the lower Mesopotamia (Naser 2006) reaching an abundance of 245.45 ind./m^2 in the lower part of Euphrates (Al-Fanharawi and Ibrahim 2014). *Melanopsis costata* is known from Euphrates River but also from the agriculture canals of Khuzestan Province in southwest Iran (Farahnak et al. 2006). Haller et al. (2005]) showed that the latter species hybridises with *M. buccinoidea* over the last 1.5 Myr. *Melanopsis buccinoidea*, widely distributed in artesian springs and irrigation channels of Ain Al-Tamura area (Mohammad 2014) and the upper part of Euphrates (Heller et al. 2005), seems to be absent from the lower Mesopotamia. On the other hand, the smooth shelled *Melanopsis* populations from Iranian Khuzestan and Bushehr provinces belong to *Melanopsis doriae* (see Glöer and Pešić 2012), whose presence in Iraq is still not confirmed.

The Bithyniidae include four species known from Mesopotamia. Occurrence of some species in Mesopotamia like *Bithynia badiella* (Annandale 1918) is questionable. The genus seems to be more common in the northern part of the catchment and Al-Waaly et al. (2014) failed to find bithyniid species in central and southern part of Iraq. *Bithynia iraqensis* was described from Gireza spring (Qalkand) in the northern part of Iraq (Pallary 1939). Prashad (1921) reported *Bithynia ejecta* from the Euphrates at Nasiriyah and at Fallujah. Glöer and Naser (2008) described *B. hareerensis* from Garmat Ali River, a naturally regulated river that drains the Al-Hammar marsh.

The Hydrobiid snails are neither abundant nor diverse in the water bodies in the Mesopotamian plain. Taxonomic status of some species like *Hydrobia lactea* (originally described from Tigris near Mosul) is unresolved and requires application of molecular techniques (Neubert and Amr 2012). Most hydrobiid species like those belonging to *Assiminea* and *Ecrobia* show tolerance to brackish waters. Two endemic *Assiminea* species recently were described for Shatt Al-Arab-Fao region (Glöer and Naser 2008, 2013). *Assiminea zubairensis* lives where salinity may exceed 37 psu, while *A. mesopotamica* occurs in regions of lower salinity (Glöer and Naser 2013). Two hydrobiid species *Ecrobia grimmi and Potamopyrgus antipodarum* are recent invaders. Based on the molecular results, Haase and Wilke (2010) hypothesised that population of *Ecrobia grimmi* from the mixomesohaline Lake Sawa (Iraq) was possibly transported by migrating birds from the Caspian Sea. However, it should be taken into account that there is no direct evidence for hydrobiids travelling with birds and is possible that the lake has not been colonised directly from the Caspian Sea. *Potamopyrgus antipodarum* was found first time in 2008 collected from the banks of Garmat Ali River, part of Shatt Al-Arab (Naser and Son 2009).

Several studies demonstrated the presence of exceptionally rich hydrobiid fauna in the springs and streams in Eastern Anatolia, which belongs to Euphrates drainage (Schütt and Şeşen 1993; Yıldırım et al. 2006; Sahin et al. 2012). Twelve hydrobiid genera, i.e. *Islamia, Sadleriana, Pseudamnicola, Belgrandiella, Sheitanokok, Hydrobia, Ventrosia, Pyrgorientalia, Bythinella, Kirelia, Anadoludamnicola* and *Sivasi*, have been reported from Eastern Anatolia (Sahin et al. 2012). The rich hydrobiid fauna can also be expected in the springs and streams on the western slopes of Zagros Mountains of Iran, which belongs to the Tigris drainage (Glöer and Pešić 2009; Delicado et al. 2016). Glöer and Pešić (2009) described two species *Intermaria zagrosensis* and *I. kermanshahensis* from the springs and streams in Kermanshah province in Iran.

The diversity of lymnaeid snails in Mesopotamia is low. The family includes the common and widespread *Galba truncatula* (Najim 1959; Dautzenberg 1894) and two species of the genus *Radix*, i.e. *R. auricularia* and *R. lagotis*, which are rather common in Mesopotamian plain especially in the waters rich in vegetation. *Radix auricularia* is one of the most dominant species in Shatt Al-Arab (Ahmed 1975; Plaziat and Younis 2005). Taxonomic status of Mesopotamian populations of *Radix lagotis* should be verified by the application of molecular methods (Schniebs et al. 2015).

The seven species of Planorbidae have been recorded from the Mesopotamian plain so far, but systematic of this group requires further study. Occurrence of some species in Mesopotamia, like *Gyraulus ehrenbergi* (Najim 1959), an African species, is probably a misidentification. *Planorbis intermixtus*, a common species in Iran (Glöer and Pešić 2012), is not very abundant in southern Mesopotamia and usually is found in the subaqueous portion of the rooted vegetation of lakes and swamps (Plaziat and Younis 2005). Records of Annandale (1920) are questionable: his specimen of *P. intermixtus* from the river deposits of Lower Mesopotamia has a diameter of about 4 mm, while the typical *P. intermixtus* is a larger species, with a diameter of about 6.5-8.6 mm. *Gyraulus euphraticus* is a common species in the Euphrates floodplain. Only one planorbid species have a restricted distribution: *Gyraulus huwaizahensis* described from the Al Huwaizah marshes in the upper Tigris-Euphrates delta in Iraq (Glöer and Naser 2008). Three species *Ferrissia californica, Gyraulus convexiusculus* and *G. chinensis* are invaders. Two later *Gyraulus* species are native to south Asia: *G. convexiusculus* has been reported from Euphrates (Annandale 1918, 1920) and Shatt Al-Arab and the Garmat-Ali River (Ahmed 1975), while *G. chinensis* has been found in the region of lower Euphrates near Basra and in Al-Hammar Marshes (Glöer and Naser unpublished). *Ferrissia californica*, a North American cryptic invader, was recently reported by Marrone et al. (2014) from Tigris River at Qurna.

Bulinus truncatus is one of the best studied gastropod species (Watson 1958; Najim 1959; Al-Waaly et al. 2014). This species occurs in marshes, swamps, irrigation canals and drains in central Iraq along the Tigris and Euphrates rivers; in the northern part of the country, it is extinct and it does not occur in southern Mesopotamia (Watson 1958). Najarian (1961) found *B. truncatus* in the canals of central Iraq. Nowadays, this species could not be found in Iraq, which is the result of the intense chemical control campaign against *Bulinus truncatus* over the last five decades (Al-Waaly et al. 2014).

The family Physidae includes one species *Physa acuta*, which is one recent invader, first time discovered in Addawoudy near Bagdad city (Najim 1959). Today, this species, whose impact on the indigenous taxa is well documented (Naser et al. 2011), is a common gastropod in Iraq (Al-Waaly et al. 2014).

33.4 Diversity of Bivalvia

Five species included in our checklist belong to three families and 4 genera of Bivalvia. *Unio tigridis* is widely distributed mussel species in most of the Tigris-Euphrates catchment (Falkner 1994; Ahmed 1975; Al-Mahdawi and Al-Dulaimi 2004; Al-Fanharawi and Ibrahim 2014). According to Plaziat and Younis (2005), it is the most common unionid species in Lower Mesopotamia. Naser (2010) mentioned that *Unio tigridis*, *Pseudodontopsis euphraticus* and *Anodonta vescoiana* are rare in Shatt Al-Arab. *Pseudodontopsis euphraticus* is reported from Tigris near Bagdad (Mousson 1874) and marshes near Qurna and Shatt Al-Arab (Ahmed 1975; Plaziat and Younis 2005), burrowing in the bottom muds. *Anodonta vescoiana* (Fig. 33.3) is present over the Tigris and Euphrates basin (Mousson 1874; Falkner 1994), with the recent records from the lake Hammar wetlands near the coast

Fig. 33.3 *Anodonta vescoiana*. Assad dam near Halawa (leg. J. Boessneck & A. von den Driesch 1985). Shell set with a colony of *Dreissena siouffi* by which the *Anodonta* possibly died. Length of the shell is 13.8 cm (Photo by G. Falkner)

(Abdul-Sahib and Abdul-Sahib 2009; Plaziat and Younis 2005). This species, less frequent than other unionid species, is indicative for the lacustrine environment (Plaziat and Younis 2005).

The most common mussel in Tigris and Euphrates basins is the Asian clam *Corbicula fluminea*, which is native to southern and eastern Asia. The taxonomic status of this species is still unclear, and according to Korniushin's (2004) molecular analysis, *C. fluminea* and *C. fluminalis*, which in the past have often been confused with each other, are parthenogenetic clones of the same species. In this list, we consider them as morphotypes, rather than as separate species. Both the morphotypes of Asian clams occurred in Tigris and Euphrates catchment: *C. fluminea* (Mousson 1874; Ahmed 1975; Al-Fanharawi and Ibrahim 2014) and *C. fluminalis* (Ahmed 1975; Plaziat and Younis 2005). This species dominates in running waters reaching an abundance of 572.7 ind./m^2 in the lower part of Euphrates (Al-Fanharawi and Ibrahim 2014), as well as in many lakes and marshes (Plaziat and Younis 2005).

The family Dreissenidae includes *Dreissena siouffi*, endemic of Euphrates River (Falkner 1994; Schütt and Şeşen 2007). Recently, this species was found in the upper part of Euphrates in the Birecik dam area in Turkey (Ekin et al. 2008). The invasive zebra mussel (*Dreissena polymorpha*) has been reported from the upper part of Euphrates, causing technical and economic damage in Atatürk dam and hydropower plants built on the Euphrates River since 1997 (Bobat et al. 2004).

33.5 Major Threats to Molluscan Fauna

There are multiple drivers of threat to freshwater molluscs in the Mesopotamian plain: (1) water abstraction for domestic supplies and agriculture, (2) the large dams in the upper reaches of the Euphrates and Tigris Rivers in Turkey and Syria, and on the Karun and Karkheh Rivers in Iran (Partow 2001), strongly impacting downstream water use (Beaumont 1996), and (3) the projects of draining of the lower basin marshes (Seddon et al. 2014). The draining of the lower basin marshes in the second half of the twentieth century and particularly in the 1990s after the second Gulf War 1991 made the iconic Iraqi marshlands almost disappear: for example, once 120 km long Lake Hammar practically disappeared between 1992 and 1994 (Munro and Touron 1997). The loss of wetlands consequently led to negative impact on the freshwater mollusc populations. Moreover, this fauna is highly susceptible to climatic changes. The climate change in the Eastern Mediterranean region is predicted to become dryer and warmer, with a particular increase in the frequency of hot summer days and high temperature events (Seddon et al. 2014). Possibly, these changes will lead to salinisation and eutrophication of the waters in the marshes affecting mollusc assemblages. This process is significantly impaired by the impact of invasive species and habitat alteration.

The mollusc assemblage in the Tigris and Euphrates basin is threated by the alarming number of invasive species, which impacts autochthonous species. About

29% of Iraqi mollusc fauna (seven gastropod and one species of Bivalvia) is non-native, which is probably one of the largest shares of non-native species in the fauna of the molluscs of one country. The first invasive gastropod species *Bellamya bengalensis* has been introduced from India to Iraq between 1929 and 1939 (Pallary 1939), followed by the findings of *Physa acuta* in the 1950s (Najim 1959). The recent invaders include the New Zealand species *Potamopyrgus antipodarum* (Naser and Son 2009), hydrobiid *Ecrobia grimmi* (Haase and Wilke 2010) possibly introduced from Caspian Sea and the North American cryptic invader *Ferrissia californica* possibly introduced via Europe (Marrone et al. 2014).

The characteristic of the mollusc fauna of Mesopotamian plain is that most species are common. Only five species known from the type localities can be considered as possibly locally endemic (Table 33.1), indicating that this region does not belong to the hot spots of gastropod diversity at the global scale (Strong et al. 2008).

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