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RESEARCH ARTICLE

A review of the freshwater crabs of Turkey (Brachyura, Potamidae)

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Abstract. The present status of freshwater crabs (Decapoda, Brachyura) in Turkey is reviewed in this study, with the purpose of identifying the exact number of species, their conservation status, and their distribution. In previous records, it was reported that Turkey has nine freshwater crab species belonging to the genus *Potamon*: *Potamon bileki* Pretzmann, 1971, *P. ibericum* (Bieberstein, 1809), *P. hueceste* Pretzmann, 1962, *P. persicum* Pretzmann, 1962, *P. magnum* Pretzmann, 1962, *P. potamios* (Olivier, 1804), *P. setiger* Rathbun, 1904, *P. rhodium* Parisi, 1913, and *P. mesopotamicum* Brandis, Storch & Türkay, 1998. However, there was no detailed information on species distribution in Turkey. This review is intended to update the distribution of species in the country, and it revealed that populations of three more freshwater crab species (*P. karpathos*, *P. fluviatile* and *P. hippocrate*) also occur; thus, there are currently 12 freshwater crab species in Turkey. In addition, this review provides a distribution map and identifies possible threats to each species. This review can serve decision makers in the development of management strategies to better protect the environments of these species that are facing growing anthropogenic impacts.

Keywords: Decapoda, distribution, diversity, threat

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Introduction

Freshwater crabs are one of the macro-invertebrate groups that are of particular ecological importance in inland waters on a global scale (Dobson et al. 2007a, 2007b, Cumberlidge et al. 2009, Varadharajan and Soundarapandian 2014). In addition to the ecological significance of freshwater crabs, they are also medically important as a threat to human health (as intermediate hosts of paragonimiasis in Asia, Africa, and the Neotropics; Maleewong 2003, Blair et al. 2008, Cumberlidge et al. 2009) and as a source for medical and pharmaceutical materials (e.g., used in chitin and chitosan production; Rinaudo 2006). Furthermore, they are consumed as food (Dobson 2004, Bandral et al. 2015, Padghane et al. 2016) and are used as a food additive and fertilizer, particularly crab processing waste that is used as a feed additive (Bilgin and Fidanbaş 2011). For these reasons, there has been an increase in assessments of the freshwater crabs of the world in recent years.

In Turkey, marine crabs are considered an important fisheries product (Geldiay and Kocataş 1977, Özbek and Ustaoğlu 2006), but the importance of freshwater crabs has been ignored. For example, although freshwater crabs are widely distributed in Turkey, the exact number of species and their conservation status and distribution have not been documented

recently. Based on previous studies and observations, it can be hypothesized that there are still some unexamined locations in Turkey. Therefore, more studies should be done to identify the distribution of freshwater crabs throughout Turkey. This study reviews the present status of freshwater crabs in Turkey.

Freshwater crabs of Turkey

The only European freshwater crab genus is the Eurasian genus *Potamon* (Güner et al. 2009). In Turkey, the first records on the local populations of freshwater crabs and a revision of their taxonomy was published by Pretzmann (1962), Bott (1970), and Geldiay and Kocatas (1977). Geldiay and Kocatas (1977) reported that *P. ibericum tauricum* (Czerniavsky 1884) is distributed in the western region of Turkey, *P. potamios potamios* (Olivier 1804) is distributed in the southern and southwestern regions,. *P. p. setiger* (Bott 1970) occurs in Amik Lake, and *P. p. persicum* (Pretzmann 1962) occurs in the eastern region of Turkey. On the other hand, *Potamon fluviatile* occurs in the European part of Turkey.

However, recent records showed that there are 12 species of the genus of *Potamon* in Turkish freshwaters. These species are *P. hueceste* (Pretzmann 1962), *P. bileki* (Pretzmann 1971), *P. magnum* (Pretzmann 1962), *P. ibericum* (Bieberstein 1809), *P. potamios* (Olivier 1804), *P. persicum* (Pretzmann 1962), *P. rhodium* (Parisi 1913), *P. mesopotamicum* (Pretzmann 1962), *P. hippocrate* (Ghigi 1929), and *P. setiger* (Rathbun, 1904) (Brandis et al. 1998, Özbek & Ustaoğlu 2005, Gülle et al. 2007, Cumberlidge 2008a, 2008b, 2008c, 2008d, 2008e, 2008f, 2008g, 2008h, 2008i, Esser and Cumberlidge 2008, Güner 2009, Jesse et al. 2011). *P. bileki* and *P. hueceste* are endemic to Turkey (Cumberlidge 2008a, 2008c, Jesse et al. 2011). Table 1 shows the distribution of freshwater crab species in Turkey's provinces and other countries. In addition to these species, Turkey also has four imported freshwater crab species i.e. *Cardisoma armatum* Herklots, *Gecarcinus quadratus* Saussure, *Geosesarma bicolor* Ng & Davie, and *Perisesarma bidens* (De Haan) that have been introduced into the country through the aquarium trade (Türkmen and Karadal 2012). On the other hand, no reports have been published on the arrival of these introduced species in natural environments. Figure 1 shows the distribution of freshwater crab species in Turkey.

Figure 1. Distribution of freshwater crab species in Turkey. 1. *P. bileki*; 2. *P. hueceste*; 3. *P. ibericum*; 4. *P. magnum*; 5. *P. rhodium*; 6. *P. setiger*; 7. *P. fluviatile*; 8. *P. karpathos*; 9. *P. mesopotamicum*; 10. *P. persicum*; 11. *P. potamios*; 12. *P. hippocrate*. Figure was modified from Google Maps; Map data ©2018 Google.

Table 1
Distribution of freshwater crab species in Turkey's provinces and other countries

Species	Country	Province in Turkey
*Potamon bileki**	Turkey	Konya and Karaman
*Potamon hueceste**	Turkey	Ankara, Kayseri, Erzurum and Ağrı
Potamon ibericum	Turkey, Armenia, Azerbaijan, Bulgaria, Georgia, Greece, Iran, Turkmenistan, Ukraine, France	Canakkale, Balikesir, Bursa, Bilecik, Sakarya, Ankara, Rize, Trabzon, Samsun, Sakarya, Bursa, Istanbul and Bursa
Potamon magnum	Turkey, Iran, Iraq, Armenia, Syria	Artvin, Mus, Erzurum, Bingol, Sivas, Elazig, Sanliurfa, Adiyaman, Diyarbakir and Gaziantep
Potamon rhodium	Turkey, Greece	Mugla, Aydin, Izmir and Manisa
Potamon setiger	Turkey, Syria, Lebanon	Konya, Kahraman Maras, Gaziantep and Hatay
Potamon fluviatile	Turkey, Albania, Croatia, Greece, Italy, Macedonia, Malta, Montenegro	Kırklareli, Çanakkale, Edirne
Potamon karpathos	Turkey, Greece	Antalya and Mersin
Potamon mesopotamicum	Turkey, Iran, Iraq, Syria	Sanliurfa
Potamon persicum	Turkey, Iran, Iraq, Armenia	Sivas, Kayseri, Malatya, Elazig, Diyarbakir, Siirt, Bitlis, Van, Hakkari and Erzerum
Potamon potamios	Turkey, Greece, Cyprus, Syria, Jordan, Lebanon, Israel, Palestinian, Egypt	Muğla, Burdur, Isparta, Antalya, Mersin, Adana, and Hatay
Potamon hippocrate	Turkey, Greece	Aydin, Denizli, Izmir, Manisa and Muğla

*endemic freshwater crab species from Turkey

Distribution of *Potamon bileki* in Turkey

Potamon bileki is endemic to Turkey and restricted to the rivers of the eastern Taurus Mountains in Konya and Karaman provinces in southern Turkey (Cumberlidge 2008a, Jesse et al. 2011). In Konya province it inhabits water channels and springs in gardens in the eastern Taurus Mountains in southern Turkey, but no information is available about its habitat requirements. There is also no information on the population size or abundance of this species (Cumberlidge 2008a). *P. bileki* has an estimated extent of occurrence (EOO) of approximately 6,300 km^2, within which the expected area of habitation is less than 2,000 km^2 since it is confined to rivers and streams. *P. bileki* is recognized at only four places and six sampling sites in a restricted area of Turkey (Cumberlidge 2008a). Because of this limited distribution, future and major threats to this species include environmental loss/degradation from growing human populations and the associated agrarian and industrial impacts such as pollution, water diversion, habitat disturbance, and drainage.

Distribution of *Potamon fluviatile* in Turkey

Potamon fluviatile has a distribution scattered over a vast geographical region of many countries with Mediterranean coastlines. For example, this species is distributed in Italy, the Maltese Islands, the Balkan Peninsula, Greece, and Turkey (Cumberlidge 2008b, Güner 2009). In Turkey, it inhabits four brooks (Velika, Yenice, Bulanık, and Demirköy) and two lakes (Üsküp and Hamam) in the Turkish Thrace region (Güner 2009). *P. fluviatile* population levels

have diminished significantly in the past years throughout its distribution. The declining population is frequently attributed to causes such as habitat damage, pollution, and overharvesting (Matthews and Reynolds 1995, Gherardi and Holdich 1999). For example, it is stated that the translocation of non-native crayfish species to European waters can cause severe hazards to the survival of freshwater crabs (Gherardi and Holdich 1999). In spite of the broad distribution of *P. fluviatile* (EOO, 800,000 km^2) and the comparatively large number of habitats and observations, several *P. fluviatile* habitats are disjunct and extremely fragmented, which raises concern about the future of a number of its separated subpopulations. Even though the broad distribution of *P. fluviatile* and the high number of observations suggest that this species should be regarded as one of Least Concern, it is currently considered as Near Threatened (NT) (Cumberlidge 2008b).

Distribution of *Potamon hueceste* in Turkey

Potamon hueceste is distributed in the Tigris-Euphrates river systems in eastern Turkey, in Ankara and Kayseri provinces in Central Anatolia, and in Erzurum and Ağrı provinces (Cumberlidge 2008c, Jesse et al. 2011). No research has been done on the trends or the size of this population. On the other hand, the population is thought to be steady based on the reasonably large number of areas inhabited by this species in Turkey. *P. hueceste* inhabits rivers and streams of eastern and central Anatolia. There is no data on the environmental requirements of *P. hueceste*. The main and future threats to this species are loss of habitat from human activities.

Distribution of *Potamon ibericum* in Turkey

In Turkey, *Potamon ibericum* is noted in the European part (cities of Kirklareli, Erdine, and Tekirdağ), and in the Asian part (cities of Canakkale, Bursa, Balıkesir, Sakarya, Bilecik, Ankara, Trabzon, Rize, Samsun and Istanbul) and in the northern Marmara River basin (Özbek and Ustaoğlu 2005, Cumberlidge 2008d). However, despite its extensive distribution and the high number of records from more than ten countries, there is relatively little information on the community size, abundance, or distribution of this species in most parts of its range (Cumberlidge 2008d). For example, this species has a broad and highly fragmented distribution to the middle and lower Danube River system. It is also distributed from Black Sea coastal rivers and the Caspian Sea to Caucasus rivers, northern Greece, and the islands of the northern Aegean. In the region of the Black Sea *P. ibericum* occurs in Ukraine, Bulgaria, Georgia, Crimea, Azerbaijan, and Armenia. In addition, in Turkmenistan it also occurs in the southern Caspian Sea region and in Iran (Maurakis et al. 2004, Cumberlidge 2008d). This species feeds on a range of foods including detritus, fallen leaves, filamentous algae, amphipods, mollusks, worms, insect larvae, tadpoles, frogs, and fish, and will consume any animal or plant food. Mating and spawning occur in the warm months (generally from June to October). During the first 5-7 days, hatchlings remain under the female abdomen, where they develop up to a carapace width of approximately 3.6 mm, after which they fend for themselves (Cumberlidge 2008d). In spite of the broad dispersion of *P. ibericum* (EOO, 2.5 million km^2) and the large number of populations and observations, some of its habitats are intermittent and highly discontinuous, so the danger level is high. Therefore, *P. ibericum* is considered as Near Threatened (NT) (Cumberlidge 2008d).

Distribution of *Potamon magnum* in Turkey

In eastern Turkey *Potamon magnum* is distributed over the upper reaches of the Tigris and Euphrates rivers (in the cities of Mus, Artvin, Bingol, Erzurum, Elazig, Sivas, Sanliurfa, Diyarbakir, Adiyaman, and

Gaziantep), in western Armenia, in Iraq, and in northern Syria (Cumberlidge 2008e). *P. magnum* is evaluated as a species of Least Concern based on its comparatively broad distribution (EOO, 145,000 km^2) and the many populations and observations in four countries. No data is available on its population size or abundance. Threats are human-caused environmental loss/degradation stemming from population growth and agricultural and industrial development (Cumberlidge 2008e).

Distribution of *Potamon mesopotamicum* in Turkey

This species is seen at the Turkish-Syrian border (Sanliurfa Province), Syria (sources of Khabur River in Ras al-Ain; Nar al-Khabur) (Brandis et al. 1998, Esser and Cumberlidge 2008), and, recently, Naser (2009) extended the range of *P. mesopotamicum* to the southern regions of Iraq over 400 km to the southeast. In the Al-Huwaizah marshes, this species lives in areas of still, shallow water, on mud, or among submerged aquatic plants (*Ceratophyllum* sp.). Associated organisms include the gastropods, *Radix* sp. and *Bellamya bengalensis* as well as the atyid shrimp, *Caridina babaulti basrensis* (Naser 2009). Potential threats for the survival of *P. mesopotamicum* and other aquatic organisms in these marshes include the application of pesticides by fishers and illegal overfishing (Al-Helfi 2005). On the other hand, the conservation status of this species is not identified on the IUCN Red List.

Distribution of *Potamon persicum* in Turkey

Potamon persicum occurs broadly in four countries. The distribution of this species is Turkey (in the cities of Kayseri, Sivas, Elazig, Malatya, Siirt, Diyarbakır, Van, Bitlis, and Hakkari, and in the upper reaches of the Aras River, the southwest of Erzurum, eastern Anatolia), Armenia, and Iraq. *Potamon persicum* is distributed in the river systems of the Tigris-Euphrates and in the area from Van Lake to the mountains of Elbur, and in the south Esfahan region in Iran (Gülle et al. 2007, Cumberlidge 2008f).

P. persicum is designated as of Least Concern due to its broad distribution (EOO, 1 million km^2) and the high number of populations and observations from four countries (Cumberlidge 2008f).

Distribution of *Potamon potamios* in Turkey

This species possesses a broad, but greatly dispersed distribution and is seen from Greece (in Rhodes and Naxos) to southern Turkey, the south of Jordan and the Litani River basin, and Egypt's Sinai Peninsula. In addition, it is distributed in the following countries that border the Mediterranean Sea: Turkey (in the southern coastal provinces of Mugla, Burdur, Isparta, Antalya, Icel, Adana, and Hatay), Greece, Cyprus, Syria, Jordan, Lebanon, and Israel, and also in the Palestinian Territories and Egypt (Brandis et al. 2000, Özbek and Ustaoğlu 2005, Gülle et al. 2007, Cumberlidge 2008g, Jesse et al. 2011). In Cyprus, it stated that *P. potamios* is threatened by pesticide pollution, drought, and deforestation. Protection from these dangers will be afforded to populations inhabiting state forests on the farthest west side of Cyprus that will become a branch of the national park system in the near future (Cumberlidge 2008g). In spite of the broad distribution of *P. potamios* (EOO, 940,000 km^2) and the reasonably large number of populations and reports, several *P. potamios* populations are disconnected and extremely disjointed and at risk; thus, there is concern for the future of some *P. potamios* populations. Therefore, *P. potamios* is considered as Near Threatened (NT) (Cumberlidge 2008g).

Distribution of *Potamon rhodium* in Turkey

Potamon rhodium occurs on the Greek islands Icaria, Kos, Samos, Rhodes, and Tilos in the southern Aegean Sea. It is also occurs in some regions in

western Anatolia in Turkey neighboring to Greek islands along the coastal plain west of the Taurus Mountains in the cities of Muğla, Izmir, Aydın, and Manisa (Cumberlidge 2008h). Although there is not much data about the size or abundance of *P. rhodium,* it is thought that populations in the Rhodes Islands may be reduced. In 1935 it was reported that freshwater crabs inhabited Monolithos in Rhodes; however, reconnaissance in this region in 1963 and 1969 did not reveal any specimens (perhaps because the spring feeding this aquatic ecosystem was directed to a pipeline and the bed was completely dry). Similar conditions apply to other islands where *P. rhodium* occurs (Cumberlidge 2008h). Despite the broad distribution of *P. rhodium* (EOO, 120,000 km^2) and the moderately elevated number of populations from Greece and Turkey, many *P. rhodium* habitats (particularly those on islands) are disconnected and extremely isolated. Therefore, there is a reason for concern for the future of a number of these populations, and the species is considered as Near Threatened (NT) (Cumberlidge 2008h).

Distribution of *Potamon setiger* in Turkey

Potamon setiger occurs in southeastern Turkey (in Konya, Kahraman Maras, Gaziantep, and Hatay provinces), in Syria, and in Lebanon. It inhabits the Orontes River basin (that originates in Lebanon and runs through Syria to Turkey), the Afrin River (that runs from Turkey into northwestern Syria and to the region of Alexandretta that bounds Syria and Turkey), and the Ceyhan River in Turkey (Cumberlidge 2008i, Jesse et al. 2011). Even though the broad distribution (EOO, 68,000 km^2) and elevated number of populations of *P. setiger* suggest that this species ought to be considered of Least Concern, it is not found in any protected areas; therefore, it is evaluated as Near Threatened (NT) (Cumberlidge 2008i).

Distribution of *Potamon karpathos* in Turkey

This species is found in the Antalya and Mersin provinces of Turkey. It is also found on Karpathos Island (Greece) in the southeastern Aegean Sea (Jesse et al. 2011).

Distribution of *Potamon hippocrate* in Turkey

This species is found in the provinces of Aydin, Denizli, Izmir, Manisa, and Muğla. It is also found in a number of locations on Greek islands in the eastern Aegean Sea (Crete, Naxos, and Samos) and on Cyprus (Jesse et al. 2011).

Conclusions

1. Although there has been a worldwide increase in studies of many aspects of freshwater crab biology (e.g., food for human consumption, medical and pharmaceutical material, compositional and nutritional analyses, food additive and fertilizer, anatomy, effect of parameters on growth) (Moghal et al. 2015), studies on freshwater crabs in Turkey are largely confined to taxonomic and faunistic topics. Even so, it appears that both the taxonomy of *Potamon* and species distribution patterns within Turkey have still not been resolved with confidence. Crabs found in many freshwater sources in Turkey have still not been identified. On the other hand, Iran, which is not very far from Turkey geographically, has 14 freshwater crab species belonging to two families (Gecarcinucidae and Potamidae) (Farhadi and Harlıoğlu, 2017, unpublished data, under consideration) of which only four species (*P. ibericum*, *P. magnum*, *P. mesopotamicum*, *P. persicum*) have been reported in Turkey. The rest of Iranian freshwater crab species (*P. bilobatum*, *P. elbursi*, *P. gedrosianum*, *P.*

ilam, *P. ruttneri*, *P. strouhali*, *P. transcaspicum*, *Sodhiana blanfordi*, *S. iranica*, *S. rokitanskyi*) have not been reported in Turkey. Therefore, studies are required to investigate the habitat requirements, population structure, disease, biology, and ecology of freshwater crabs in Turkey. Studies should also be conducted to evaluate the maximum sustainable yield and economic benefits of fisheries, assay the possibility for successful aquaculture, and determine other important uses (e.g., chitin and chitosan levels).

2. Populations of freshwater crab species are under urgent, long-term threats from anthropogenic impacts affecting their habitats; for example, pollution, water diversion, habitat disturbance, drainage, and overharvesting. It is probable that stocks of these species in some areas will be in danger of destruction in the future, particularly those close to centers of human habitation.
3. Effective conservation measures for crabs require identifying species distributions and making a complete inventory of habitat requirements, assessing population levels and trends, and establishing protected areas. Indeed, most of the freshwater crabs of Turkey have been listed as Least Concern (*P. magnum, P. persicum*) or Near Threatened (*P. ibericum, P. potamios, P. rhodium, P. setiger*) on the IUCN Red List of Threatened Species (Cumberlidge et al. 2009). However, conservation strategies to protect crab populations have not been implemented in Turkey, which means that conservation policies for crab species should be prepared immediately.

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