BioInvasions Records (2019) Volume 8, Issue 2: 392–399

Research Article

First record of *Xiphopenaeus kroyeri* Heller, 1862 (Decapoda, Penaeidae) in the Southeastern Mediterranean, Egypt

Amal Ragae Khafage* and Somaya Mahfouz Taha

National Institute of Oceanography and Fisheries, 101 Kasr Al-Ainy St., Cairo, Egypt

**Corresponding author*

E-mail: *amal_khafage@live.com*

Citation: Khafage AR, Taha SM (2019) First record of *Xiphopenaeus kroyeri* Heller, 1862 (Decapoda, Penaeidae) in the Southeastern Mediterranean, Egypt. *BioInvasions Records* 8(2): 392–399, https://doi.org/10.3391/bir.2019.8.2.20

Received: 31 January 2018

Accepted: 27 February 2019

Published: 18 April 2019

Handling editor: Kęstutis Arbačiauskas

Thematic editor: Amy Fowler

Abstract

Four hundred and forty seven specimens of a non-indigenous shrimp species were caught by local fishermen between the years 2016–2019, from Ma'deya shores, Abu Qir Bay, Alexandria, Egypt. These specimens were the Western Atlantic *Xiphopenaeus kroyeri* Heller, 1862, making this the first record for the introduction and establishment of a Western Atlantic shrimp species in Egyptian waters. Its route of introduction is hypothesized to be through ballast water from ship tanks. Due to the high population densities it achieves in this non-native location, it is now considered a component of the Egyptian shrimp commercial catch.

Key words: shrimp, seabob, Levantine Basin

Introduction

The commercial catch of shrimps in Alexandria, Southeastern Mediterranean Sea, is composed of several penaeid genera which includes two indigenous species, *Melicertus kerathurus* (Forsskål, 1775) and *Parapenaeus longirostris* (Lucas, 1846), several Lessepsian immigrants, *Penaeus semisulcatus* (De Haan, 1844), *Marsupenaeus japonicus* (Bate, 1888), *Metapenaeus monoceros* (Fabricius, 1798), *Metapenaeus stebbingi* (Nobili, 1904), *Trachysalambaria curvirostris* (Stimpson, 1860) (Holthuis 1980; Fischer et al. 1987; Bariche 2012), and two newly established species (documented in the last three decades), *Metapenaeopsis aegyptia* (Galil and Golani, 1990), *Metapenaeopsis mogiensis consobrina* (Nobili, 1904) (Galil 1997) and *Penaeus hathor* (Burkenroad, 1959) (Galil 1999).

The Mediterranean Sea has been impacted by several human activities including the construction of the Suez Canal (1869) and Aswan High Dam (1964), mariculture, commercial and recreational fishing, pollution, maritime traffic and global warming (Rilov and Galil 2009). These activities, among others, have led to the introduction of over 700 non-indigenous species (NIS) from warm Indo-Pacific waters into the Mediterranean Sea (Mamhoud et al. 2015; Galil et al. 2018), making the

Mediterranean Sea a global hotspot for bioinvasions (Galil et al. 2017). Crustaceans are the second most abundant NIS species group currently in the Mediterranean (159 species); among the crustaceans, decapods are the prevailing taxon (Zenetos et al. 2012).

The present study aims to identify new shrimp species recently observed within the Egyptian commercial shrimp catch off the coast of Alexandria, Egypt.

Materials and methods

Sample Collection

During the monthly routine sampling of shrimp catch by the National Institute of Oceanography and Fisheries (NIOF), Alexandria, Egypt, unfamiliar specimens were clearly observed among the indigenous penaeid species. They were caught from the area of Boughaz El-Ma'deya, Abu Qir Bay (Figure 1) by local fishermen. Data from 101 non-indigenous shrimp specimens were recorded between July and September 2016. Additional samples were collected and analyzed for more confirmation in October 2016 (N = 17), October 2017 (N = 118), and January and February 2019 (N = 238).

Sample Analysis

All non-indigenous specimens underwent visual taxonomic diagnosis based upon keys of Burkenroad (1934), Pérez-Farfante (1988), Pérez-Farfante and Kensley (1997) and Carpenter (2002). The sex was examined macroscopically and sexually differentiated with the naked eye. Then morphometric study was done by measuring the total length TL and carapace length CL (to 0.1 mm accuracy) using digital Vernier caliper. The total weight TWt was recorded using digital balance (to 0.1 g accuracy). Specimens were preserved in 80% ethyl alcohol and 3% formalin. They were kept in the Collection of the Zoology Department, Faculty of Science, Alexandria University, and also in the Museum of the NIOF in Alexandria, Egypt.

Results

Description of specimens

In the present study, careful and accurate macroscopic examination showed that the observed species was *Xiphopenaeus kroyeri,* the Atlantic seabob shrimp (Figure 2). *Xiphopenaeus kroyeri* (Heller, 1862) has a closed thelycum with a single smooth broad plate of sternite XIV, and its anterolateral hood is extremely reduced. The proximal anterior sternal invagination is as broad as a sternite, forming a spacious pocket extending to the posterior thoracic ridge. The median protuberance of sternite XIII is also broad but considerably shorter (Pérez-Farfante and Kensley 1997). The seminal receptacle is a bilobed pair of invaginated sac-like sperm receptacles, whose apertures are hidden by the thelycum, and the main lobes may extend back into the first pleonic somite (Burkenroad 1934).

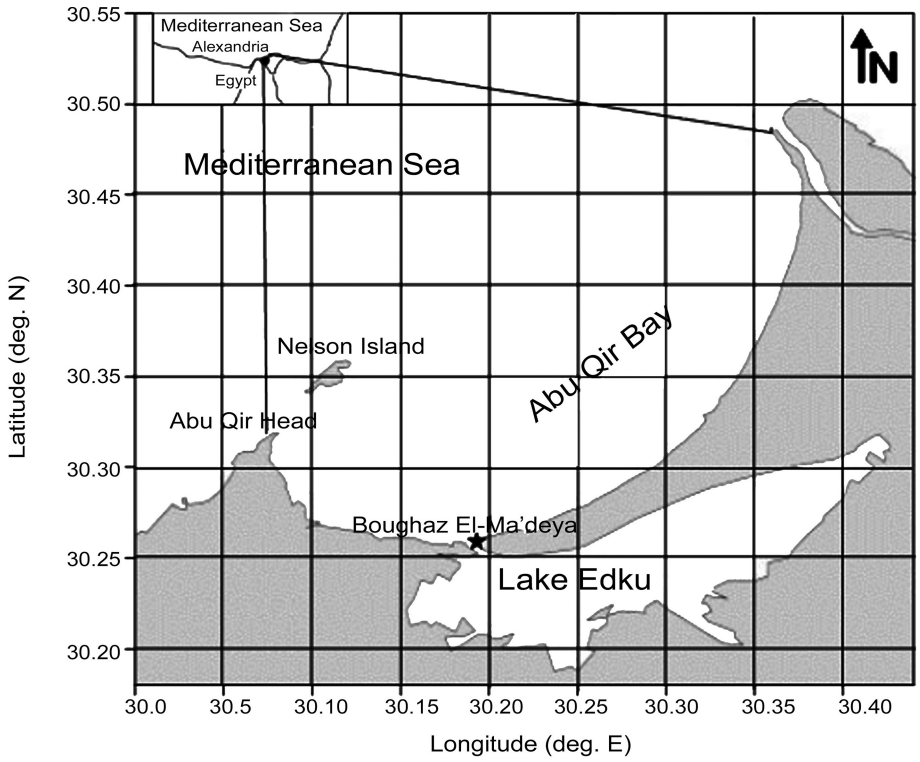

Figure 1. Sampling site, noted with a star, of *Xiphopenaeus kroyeri* collected between the years (2016–2019) in Boughaz El-Ma'deya, Abu Qir Bay, Mediterranean Sea, Egypt.

Xiphopenaeus kroyeri (Figure 2) possesses the generic characteristic of an oblique longitudinal suture of the genus *Xiphopenaeus*. It appears very faint, extending from just beside the antennal spine to the mid-length of the carapace, parallel to the longitudinal body axis. The thelycum (Figure 2E) is a good representation of the genus. The petasma is symmetrical, semi-closed and produced distolaterally in a pair of broad horns, which are characterized by wide terminal expansions (Pérez-Farfante and Kensley 1997) (Figure 2F).

Table 1 shows the TL, CL and TWt of the specimens collected between the years 2016–2019. The table also shows the number of male and female in the different collected samples during the study period. The sex ratio was found to be 2.2:1 and is female biased. Moreover, the results show that the females of *X. kroyeri* are large than the males.

Color of X. kroyeri *in life*

Dense dark chromatophores are scattered on the external surface of the carapace, giving the body a grayish color. The tips of the rostrum and flagella are reddish-orange, while the pereiopods, pleopods, last abdominal segment, telson and uropods are pink to orange.

Discussion

Seabob shrimp of the genus *Xiphopenaeus* constitutes an important fishery resource along the Atlantic and Pacific coasts of Central and South America

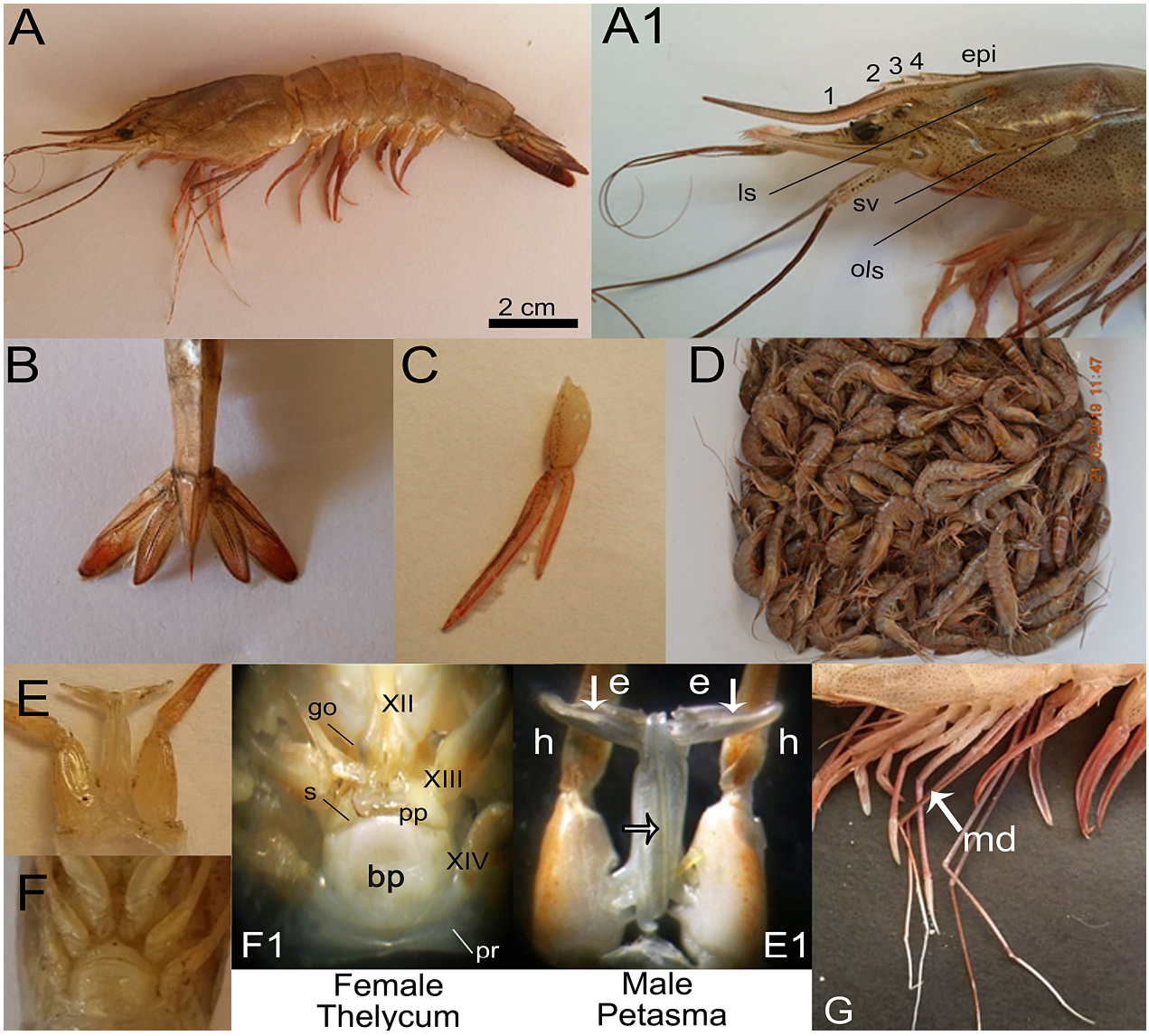

Figure 2. *Xiphopenaeus kroyeri* (Heller, 1862) collected from Abu Qir Bay, Egypt in 2016: A. lateral view; A1. lateral view of cephalothorax, 1–4 dorsal teeth + epi, (1) epigastric tooth, (ols) oblique longitudinal suture, (sv) small v-shaped; (ls) longitudinal suture; B. unarmed telson and uropods; C. Characteristic pleopod of 1–5 abdominal somites; D. Sample recently collected in February 2019 marking the establishment of the species; E and E1. Male Petasma, (h) large horns, (e) terminal expansions, white arrow showing region with cincinnuli. F and F1. Female Thelycum, (pr) posterior ridge, (bp) broad plate, (pp) proximal plate, (s) slit, (go) genital opening; G. multiarticular dactylus of fourth and fifth pereiopods. Photographs by Dr. Somaya M. Taha and Mr. Mahmoud A. Attallah.

Gusmão et al. (2006). *Xiphopenaeus kroyeri* (Figure 2) is one of the larger species in this genus, reaching total lengths of > 10 cm (Holthuis 1980), with females significantly larger than males (Branco et al. 1994; Grabowski et al. 2014; Grabowski et al. 2016). This large size contributes to its status as one of the top 10 commerical penaeoid shrimp species caught worldwide (D'Incao et al. 2002; Silva et al. 2013) and this is with accordance with the present study results.

It has a wide native geographical range throughout the Central Western Atlantic Ocean from Cape Hatteras, NC, USA to Southern Brazil (State of Rio Grande do Sul) (Costa et al. 2007), and it inhabits shallow coastal waters (0–30 m) with muddy and sandy soft bottoms (D'Incao 1999). Its life cycle does not demand an estuarine grow out phase, as it spends all its

Table 1. Morphometrics of the collected samples of *Xiphopenaeus kroyeri* Heller 1862, collected from Abu Qir Bay during the years 2016–2019: Carapace length CL ± SE (mm), Total Length TL ± SE (mm), Total weight TWt ± SE (g), sex differentiation and the number (N) of both sexes.

Sampling Date	Carapace length CL(mm)	Total length TL (mm)	Total weight TWt (g)	sex	N
Jul – 2016	33.2 ± 0.86	80.04 ± 1.91	3.39 ± 0.29	Male	21
	40 ± 0.52	89.53 ± 0.9	4.59 ± 1.38	Female	45
Aug – 16	37 ± 1.21	87.16 ± 1.66	3.49 ± 0.34	Male	7
	44.8 ± 1.2	100.66 ± 1.99	6.03 ± 0.52	Female	15
Sep – 16	34 ± 4	86 ± 3	3.41 ± 0.48	Male	3
	43.2 ± 1.37	98.9 ± 2.79	5.86 ± 0.50	Female	10
Oct – 16	24.3 ± 0.47	59.42 ± 1.58	1.07 ± 0.13	Male	7
	28.4 ± 1.32	65.4 ± 2.80	1.69 ± 0.19	Female	10
Oct – 2017	32.32 ± 0.88	77.92 ± 1.88	2.97 ± 0.23	Male	38
	39.86 ± 0.68	89.77 ± 1.4	4.66 ± 0.19	Female	80
Jan – 2019	35 ± 0.05	84.6 ± 0.11	3.39 ± 0.1	Male	27
	40.9 ± 0.06	92 ± 0.13	4.54 ± 0.21	Female	64
Feb – 19	37.7 ± 0.03	90.6 ± 0.12	3.88 ± 0.1	Male	46
	44.2 ± 0.05	100 ± 0.13	6.35 ± 0.19	Female	101

life in marine waters (Iwai 1973a, b). Like most penaeid shrimps, *X. kroyeri* is a fast growing species (Gulland and Rotschild 1984) that exhibits sexual dimorphism with females reaching maximum size after ~ 21 months versus ~ 16 months for males (Heckler et al. 2013a). In the present study, the described characters of the adult male petasma of genus *Xiphopenaeus* were in accordance with the description following Burkenroad (1934); Pérez-Farfante (1988); Pérez-Farfante and Kensley (1997) and Carpenter (2002).

Moreover, it was observed that the sex ratio is female-biased. This is in accordance with Grabowski et al. (2014), Castro et al. (2005), De Campos et al. (2011) and Heckler et al. (2013b). On the contrary, Lopes et al. (2010) found a male-biased sex ratio which according to the authors is less common for *X. kroyeri*.

Routes of Invasion

The marine biodiversity in the Mediterranean Sea has been changing for the past two centuries, and the rate of recorded marine invasive species has increased in recent years (Galil 2000; Zenetos et al. 2005; Streftaris et al. 2005; Rilov and Galil 2009). The tropicalization (Bianchi 2007), or spread of thermophilic species, in the Mediterranean has been ascribed to the interaction of the following four main factors: the Atlantic flux, lessepsian migration, human-mediated activity (i.e., maritime traffic, ballast water and aquaculture) and climate change (Otero et al. 2013; Bianchi and Morri 2003; Pancucci-Papadopoulou et al. 2005).

In the present study, the unexpected arrival of *Xiphopenaeus kroyeri* to Egyptian waters has led to several hypotheses concerning possible entry ways of the species into the Mediterranean Sea and its establishment in the Southern Levant Sea. It is most likely that the development of the shipping industry, with faster ships and larger quantities of ballast water traveling between geographically separate areas, has an increasing potential to

transport NIS to new areas. As stated by Leppäkoski et al. (2002), 3,000–4,000 species may be transported in ships' ballast water on average each day. Furthermore, Orlova (2002) mentioned that the presence of free-living stages promoted both remote dispersal by ballast water communities between regions as well as rapid colonisation of accessible habitats within and between novel localities. Recently, 14 European ballast studies recorded ~ 990 species from ballast tanks (sampled from both water and sediment), ranging from bacteria to 15 cm long fishes (Minchin and Gollasch 2002). Hence, it is likely that the main route of invasion of *Xiphopenaeus kroyeri* as larvae is through the ballast water tanks.

It is worth mentioning that recent phylogenetic research has revealed the presence of three separate species of genus *Xiphopenaeus*, two Atlantic and one Pacific. In Brazil, Gusmão et al. (2006) mentioned in their study that the collected specimens from different Atlantic and Pacific populations showed the presence of two cryptic *Xiphopenaeus* species in the Atlantic that they named *Xiphopenaeus* sp. 1 and sp. 2. Moreover, they confirmed the occurrence of a third species from the Pacific and they considered it to be *X. riveti*. Furthermore, in their most recent study, Gusmão et al. (2013) confirmed the published results in Gusmão et al. (2006) with great similarity by using an advanced methodology called geometric morphometrics. Additionally, they suggested that it is likely that *Xiphopenaeus* sp. 1 is in fact *X. kroyeri.* On the other hand, *Xiphopenaeus* sp. 2 remains to be an unidentified species.

The results of the present study show the first record of the seabob shrimp *Xiphopenaeus kroyeri* in the Mediterranean Sea and its successful establishment on the coasts of the Southern Levantine Basin for the past 3 years. It is now a part of the Egyptian commercial shrimp fishery. The mode of its introduction is likely to have been through the release of ballast waters from ship tanks. It is important to encourage further studies to assess the population size and impact on indigenous shrimp populations as well as its ecological impact on habitats and associated fauna (especially as possible novel prey items). Finally, a genetic analysis is also recommended to clear any conflict in the identification of *Xiphopenaeus kroyeri.*

Acknowledgements

The authors are grateful to all of our professors in the Faculty of Science, Alexandria University, who encouraged us to continue on the path of research. In addition, we would like to thank all of our supervisors and colleagues in the National Institute of Oceanography and Fisheries. Special thanks are due to Elzahrae M. Elmasry, Mahmoud A. Attallah, and Dr. Tarek El-Geziry (for providing the map of the sampling locations). Finally, we thank the anonymous reviewers of this manuscript for constructive comments.

References

Bariche M (2012) Field identification guide to the living marine resources of eastern and southern Mediterranean. FAO Species Identification Guide for Fishery Purposes. FAO, Rome, 610 pp

Bianchi CN (2007) Biodiversity issues for the forthcoming tropical Mediterranean Sea. *Hydrobiologia* 580: 7–21, https://doi.org/10.1007/s10750-006-0469-5

Bianchi CN, Morri C (2003) Global sea warming and "tropicalization" of the Mediterranean Sea: biogeographic and ecological aspects. *Biogeographia* 24: 319–327, https://doi.org/10.21426/B6110129

Branco J, Lunardon-Branco MJ, De Finis A (1994) The growth of *Xiphopenaeus kroyeri* (Heller, 1862) (Crustacea: Natantia: Penaeidae) from the Matinhos region, Parana state. *Brazilian Arquivos de Biologiae Tecnologia* 37(1): 1–8

Burkenroad MD (1934) The Penaeidea of Louisiana with a discussion of their world relationships. *Bulletin of the American Museum of Natural History* 68: 61–143

Carpenter KE (2002) The living marine resources of the western central Atlantic. Volume 1: Introduction, molluscs, crustaceans, hagfishes, sharks, batoid fishes, and chimaeras. FAO Species identification guide for fishery purposes and American Society of Ichthyologists and Herpetologists special publication No. 5. Rome, FAO, 600 pp

Castro RH, Fransozo A, Mantelatto FLM, Costa RC (2005) Population structure of the seabob shrimp *Xiphopenaeus kroyeri* (Heller, 1862) (Crustacea, Penaeoidea) in thelittoral of São Paulo, Brazil. *Scientia Marina* 69: 105–112, https://doi.org/10.3989/scimar.2005.69n1105

Costa RC, Fransozo A, Freire FAM, Castilho AL (2007) Abundance and ecological distribution of the "sete-barbas" shrimp *Xiphopenaeus kroyeri* (Heller, 1862) (Decapoda: Penaeoidea) in three bays of the Ubatuba region, Southeastern Brazil. *Gulf and Caribbean Research* 19: 33–41, https://doi.org/10.18785/gcr.1901.04

De Campos BR, Branco JO, D'Incao F (2011) Crescimento docamarão-sete-barbas (*Xiphopenaeus kroyeri* (Heller 1862)), na Baía de Tijucas, Tijucas, SC (Brasil). *Atlântica* 33: 201–208, https://doi.org/10.5088/atl.2011.33.2.201

D'Incao F (1999) Subordem Dendrobranchiata (camarões marinhos). In: Buckup L, Bond-Buckup G (eds), Oscamarões do Rio Grande do Sul. Porto Alegre, Editora da Universidade, pp 271–299

D'Incao FH, Valentini, LF Rodrigues (2002) Avaliação da pesca de camarões nasregiões Sudeste e Suldo Brasil. *Atlântica* 24: 103–116

Fischer W, Bauchot ML, Schneider M (1987) Fiches F.A.O. d'identification des espèces pour les besoins de la pêche "Révision" Méditerranée et Mer noire" Zone de pêche 37. Volume I et II. Vertébrés. Rome, F.A.O., 1530 pp

Galil BS (1997) Notes and news: two Lessepsian migrant decapods new to the coast of Israel. *Crustaceana* 70: 111–114, https://doi.org/10.1163/156854097X00393

Galil BS (1999) *Melicertus hathor* (Burkenroad, 1959) A Red Sea penaeid prawn new to the Mediterranean. *Crustaceana* 72(9): 1226–1228

Galil BS (2000) A sea under siege – alien species in the Mediterranean. *Biological Invasions* 2: 177–186, https://doi.org/10.1023/A:1010057010476

Galil BS, Golani D (1990) Two new migrant decapods from the Eastern Mediterranean. *Crustaceana* 58: 229–236, https://doi.org/10.1163/156854090X00147

Galil B, Marchini A, Occhipinti-Ambrogi A, Ojaveer H (2017) The enlargement of the Suez Canal—Erythraean introductions and management challenges. *Management of Biological Invasions* 8: 141–152, https://doi.org/10.3391/mbi.2017.8.2.02

Galil B, Marchini A, Occhipinti-Ambrogi A (2018) East is east and West is west? Management of marine bioinvasions in the Mediterranean Sea. *Estuarine, Coastal and Shelf Science* 201: 7–16, https://doi.org/10.1016/j.ecss.2015.12.021

Grabowski RC, Simões SM, Castilho AL (2014) Population structure, sex ratio and growth of the seabob shrimp *Xiphopenaeus kroyeri* (Decapoda, Penaeidae) from coastal waters of southern Brazil. *Zookeys* 457: 253–269, https://doi.org/10.3897/zookeys.457.6682

Grabowski RC, Negreiros-Fransozo ML, Castilho AL (2016) Reproductive ecology of the seabob shrimp *Xiphopenaeus kroyeri* (Heller, 1862) in a coastal area of Southern Brazil. *Chinese Journal of Oceanology and Limnology* 34: 125–135, https://doi.org/10.1007/s00343-015-4279-3

Gulland JA, Rothschild BJ (1984) Penaeid shrimps: their biology and management. Fishing News Books, Farnham, Surrey, England, 308 pp

Gusmaõ J, Piergiorge RM, Tavares C (2013) The contribution of genetics in the study of the sea-bob shrimp populations from the Brazilian coast. *Boletim do Instituto de Pesca São Paulo* 39: 323–338, https://doi.org/10.20950/1678-2305.2013v39n3p323

Gusmaõ J, Lazoski C, Montero F, Solé-Cava AM (2006) Cryptic species and population structuring of the Atlantic and Pacific seabob shrimp species, *Xiphopenaeus kroyeri* and *X. riveti*. *Marine Biology* 149: 491– 502, https://doi.org/10.1007/s00227-005-0232-x

Heckler GS, Simões SM, Lopes M, Zara FJ, Costa RC (2013a) Biologia Populacional e Reprodutiva do camarão sete-barbas na baía de Santos, São Paulo. *Boletim do Instituto de Pesca São Paulo* 39: 283–297, https://doi.org/10.20950/1678-2305.2013v39n3p283

Heckler GS, Simões SM, Santos APF, Fransozo A, Costa RC (2013b) Population dynamics of the seabob shrimp *Xiphopenaeus kroyeri* (Dendrobranchiata, Penaeidae) in south-eastern Brazil. *African Journal of Marine Science* 35: 17–24, https://doi.org/10.2989/1814232X.2013.769901

Holthuis LB (1980) Shrimps and prawns of the world. An annotated catalogue of species of interest to fisheries. *FAO Fisheries Synopsis* 125(1): 1–271

Iwai M (1973a) Pesquisa e estudo biológico dos camarões de valor comercial. *Publicação Especial do Instituto Oceanográfico de São Paulo* 3: 501–534

Iwai M (1973b) Pesca exploratória e estudo biológico sobre o camarão na costa Centro/Sul do Brasil com o Navio Oceanográfico "Prof. W. Besnard" em 1969-1971.SUDELPA / IOUSP, São Paulo, 71 pp

Lopes JBBS, Vasques RO'R, Guimarães FJ, Cetra M, Couto ECG (2010) Proporção sexual do camarão sete-barbas *Xiphopenaeus kroyeri* na costa de Ilhéus, Bahia, Brasil. *Boletim do Instituto de Pesca* 36(4): 251–262

Leppäkoski E, Gollasch S, Olenin S (2002) Alien Species in European Waters. In: Leppäkoski E, Gollasch S, Olenin S (eds), Invasive Aquatic Species of Europe. Distribution, Impacts and Management. Springer, Dordrecht, 583 pp, https://doi.org/10.1007/978-94-015-9956-6_1

Mahmoud H, Teh LSL, Khalfallah M, Pauly D (2015) Reconstruction of marine fisheries statistics in the Egyptian Mediterranean Sea, 1950-2010. Fisheries Centre Working Paper #2015-85, University of British Columbia, Vancouver, 16 pp

Minchin D, Gollasch S (2002) Vectors — How Exotics Get Around. In: Leppäkoski E, Gollasch S, Olenin S (eds), Invasive Aquatic Species of Europe. Distribution, Impacts and Management. Springer, Dordrecht, 583 pp, https://doi.org/10.1007/978-94-015-9956-6_20

Otero M, Cebrian E, Francour P, Galil B, Savini D (2013) Monitoring Marine Invasive Species in Mediterranean Marine Protected Areas (MPAs): A strategy and practical guide for managers. IUCN, Malaga, Spain, 136 pp

Orlova MI (2002) *Dreissena* (*D.*) *polymorpha*: Evolutionary Origin and Biological Peculiarities as Prerequisites of Invasion Success. In: Leppäkoski E, Gollasch S, Olenin S (eds), Invasive Aquatic Species of Europe. Distribution, Impacts and Management. Springer, Dordrecht, pp 127–134, https://doi.org/10.1007/978-94-015-9956-6_14

Pancucci-Papadopoulou MA, Zenetos A, Corsini-Foka M, Politou C-Y (2005) Update of marine alien species in Hellenic waters. *Mediterranean Marine Science* 6: 147–158, https://doi.org/10.12681/mms.188

Pérez-Farfante I (1988) Illustrated key to penaeoid shrimps of commerce in the Americas. NOAA Technical Report NMFS 64: i–iv, 1–32

Pérez-Farfante I, Kensley B (1997) Penaeoid and Sergestoid Shrimps and Prawns of the World. Keys and diagnoses for the families and genera. *Mémoires du Muséum National d'Histoire Naturelle, Paris* V. 175, 233 pp

Streftaris N, Zenetos A, Papathanassiou E (2005) Globalisation in marine ecosystems: the story of non-indigenous marine species across European seas. *Oceanography and Marine Biology: An Annual Review* 43: 419–453

Silva CNS, Broadhurst MK, Medeiros RP, Dias JH (2013) Resolving environmental issues in the southern Brazilian artisanal penaeid-trawl fishery through adaptive co-management. *Marine Policy* 42: 133–141, https://doi.org/10.1016/j.marpol.2013.02.002

Rilov G, Galil BS (2009) Marine bioinvasions in the Mediterranean Sea – history, distribution and ecology. In: Rilov G, Crooks JA (eds), Biological Invasions in Marine Ecosystems. Springer, Berlin, pp 549–576, https://doi.org/10.1007/978-3-540-79236-9_31

Zenetos A, Çinar ME, Pancucci-Papadopoulou MA, Harmelin JG, Furnari G, Andaloro F, Bellou N, Streftaris N, Zibrowius H (2005) Annotated list of marine alien spieces in the Mediterranean with records of the worst invasive spieces. *Mediterranean Marine Science* 6: 63–118, https://doi.org/10.12681/mms.186

Zenetos A, Gofas S, Morri C, Rosso A, Violanti D, Garcia Raso J, Cinar M, Almogi-Labin A, Ates A, Azzurro E, Ballesteros E, Bianchi C, Bilecenoglu M, Gambi M, Giangrande A, Gravili C, Hyams-Kaphzan O, Karachle P, Katsanevakis S, Lipej L, Mastrototaro F, Mineur F, Pancucci-Papadopoulou M, Ramos Espla A, Salas C, San Martin G, Sfriso A, Streftaris N, Verlaque M (2012) Alien species in the Mediterranean Sea by 2012. A contribution to the application of European Union's Marine Strategy Framework Directive (MSFD). Part 2. Introduction trends and pathways. *Mediterranean Marine Science* 13(2): 328–352