

Rapid Communication**Invasive portunid crabs in Libyan waters: first record of the Atlantic blue crab *Callinectes sapidus* Rathbun, 1896 and range expansion of the swimming blue crab *Portunus segnis* (Forskål, 1775)**

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OPEN ACCESS**Abstract**

The occurrence of the portunid *Callinectes sapidus* is documented for the first time from Libyan waters. The record fills a gap of knowledge concerning the distribution of this non-indigenous crab of Atlantic origin, that currently has invaded almost all the Mediterranean basin. Recent records of the Lessepsian crab *Portunus segnis*, already known from Libyan waters, ascertain furthermore its establishment within and its range expansion along the coastline of the country.

Key words: bio-invasion, non-indigenous species, Portunidae, Mediterranean Sea, citizen science

Introduction

The invasion by non-indigenous species (NIS, also known as non-native, alien, allochthonous or exotic organisms) in the Mediterranean Sea is often listed among the components of a deleterious cocktail to biodiversity, ecosystem services and public health (Coll et al. 2010; Katsanevakis et al. 2014). Much research has focused on ecological impacts, but the role of NIS for livelihoods and human well-being is less well known. Some NIS, for example, may constitute an additional biological resource and even represent a commercial value for local human populations (Katsanevakis et al. 2014).

Knowledge on NIS introduced to Libyan waters has been increasing in recent years, through the intensification of research projects but also through the enhanced contribution of citizen science (Shakman et al. 2019;

Abdulrazziq et al. 2021; Al Mabruk et al. 2021; Al Mabruk and Crocetta 2021; Mahklouf and Shakman 2021).

The Atlantic blue crab *Callinectes sapidus* Rathbun, 1896 and the lessepsian blue swimming crab *Portunus segnis* (Forskål, 1775) are listed among the worst invasive species introduced into the Mediterranean (Streftaris and Zenetos 2006). The Atlantic blue crab was first detected in the north Adriatic Sea at the end of the 1940s, introduced probably via ballast waters and/or for aquaculture purposes (Galil 2011; Nehring 2011; Mancinelli et al. 2017a; Kampouris et al. 2020). To date, this crab has been recorded from almost the entire Mediterranean basin, except for a few regions, including the coast of Libya (Falsone et al. 2020; Shaiek et al. 2021; Mancinelli et al. 2021).

The blue swimming crab, first detected in the Mediterranean in Egypt in 1898 (Galil 2011), has colonized extensive coastal areas in the eastern and central parts of the basin (Shaiek et al. 2021). The species has only recently been recorded from Libya, in 2017, west of the city of Tobruk (Shakman et al. 2017; Mahklouf and Shakman 2021) and at Farwa lagoon, west Libya (Shakman et al. 2019).

Both invasive decapods are large-sized and edible; *C. sapidus*, due to its abundance, is already exploited in many Mediterranean countries (Mancinelli et al. 2017b; Kampouris et al. 2020), while *P. segnis* is similarly being viewed with interest for human consumption purposes (Abdel Razek et al. 2006; EastMed 2010; Galil 2011; Corsini-Foka et al. 2015; Tureli and Yesilyurt 2018).

In the present study, the occurrence of *C. sapidus* is reported for the first time from Libyan waters, bridging a knowledge gap on its distribution range along the Mediterranean coastline. Furthermore, recent findings of *P. segnis* document a significant rapid expansion of its distribution along the western Libyan coast.

Materials and methods

Data on the portunid *C. sapidus* and *P. segnis* were obtained through direct liaison by the authors with professional and recreational fishers and through photos submitted to the citizen science platform for Libyan waters called “Marine Biology in Libya” (<https://www.facebook.com/MarineBiologyinLibya>). This citizen science platform focuses, since 2017, on monitoring alien marine species and on raising knowledge of fishermen, divers, other sea users and stakeholders about NIS and endangered marine species in Libyan waters. The person submitting the photos/videos of species of interest, such as NIS, on the citizen science social media platform was contacted to obtain additional data about the record (date, location, geographical coordinates, depth, fishing method and notes) and to verify its credibility for the validation of the observation.

The portunid specimens were identified following Holthuis (1987) and Lai et al. (2010).

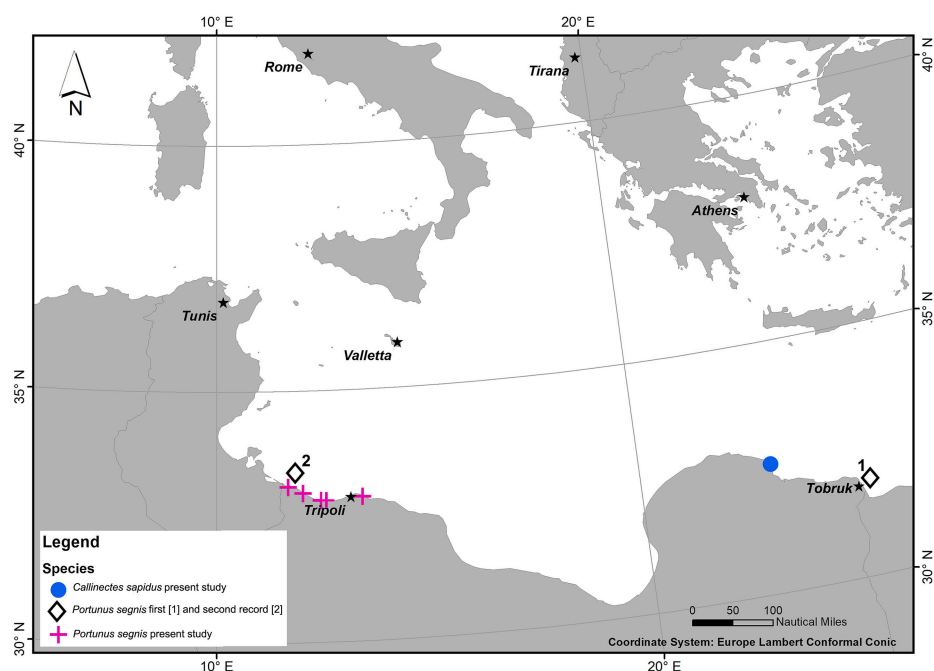


Figure 1. Locations of both published and unpublished *Callinectes sapidus* and *Portunus segnis* records along the Libyan coast ([1] Shakman et al. 2017, [2] Shakman et al. 2019).

Results

A first specimen of *C. sapidus* (specimen A) was collected on September 13th 2020 by a professional fisher using the trammel net, at the Umm-Hufayn Lagoon, east coast of Libya (32°33'42.1"N; 23°05'27.6"E) (Figure 1), at 1.25 m of depth on a prevalently sandy-muddy substrate. The specimen A (Figure 2A) was a male, carapace width 20.5 cm, carapace length 8.5 cm. The sample was deposited at the private collection of one of the authors (SAM). A second specimen of *C. sapidus* (specimen B) was an immature female (Figure 2B), collected on March 3rd 2021 at 1.5 m depth, using the same fishing technique at the same location. The sample was not retained. The Umm-Hufayn Lagoon is a coastal location described in a number of previous studies, including those by Badalamenti et al. (2011), Abdalhamid et al. (2017) and Abdulrazziq et al. (2021) (Figure 3).

A total of 22 specimens of *P. segnis* (Figure 4) were collected during the 2018–2020 period through the use of a trammel net or during SCUBA diving, from five locations sited along the western coast of Libya. More specifically, they were captured along the coastal swathe stretching for 180 km in total, from the border with Tunisia to the west and the city of Tripoli to the east, at depths ranging between 1 m and 10 m, prevalently over sandy grounds (Figure 1; Table 1). The coastal area where *P. segnis* was found, along with the entire western coastal region of Libya, is characterized by a wide continental shelf; most of the same coast is rocky, interspersed with occasional sandy areas (Shakman 2017). The western region of Libya supports a high degree of productivity as reflected in fisheries landings, but it is also vulnerable to pollution and other anthropogenic stressors to the



Figure 2. Dorsal and ventral view of *Callinectes sapidus* specimens A and B, collected at the Umm-Hufayn Lagoon, Libya, in 2020 and 2021, respectively (A. Black bar = 10 mm). Photos by H. Al Mozini.



Figure 3. Views of the Umm-Hufayn Lagoon, Libya, where *Callinectes sapidus* specimens were collected. Photos by A. Abdulghani.

marine and coastal environment (Shakman and Kinzelbach 2007; IUCN 2011; Shakman 2017). The *P. segnis* specimens were not retained; consequently, sex determination and the collection of their morphometric measurements was not possible.

Discussion

To the east of Libya, the Atlantic blue crab *Callinectes sapidus* has been recorded in Egyptian waters, in the Bardawil Lagoon, Sinai Peninsula, where



Figure 4. Specimens of *Portunus segnis* collected from various locations of western Libya (Details in Table 1). Photos by: M. Aljidi (A), R. Jarafah (B), A. Al-Mahmodi (C), M. Basha (D), H. Al Moiaoe (E), S. Al Madhoine (F).

it is abundant and even commercially exploited (Abdel Razek et al. 2016; Rady et al. 2018), at Lake Menzala, near Port Said and at Lake Edku, east of Alexandria (Shaiek et al. 2021). The subsequent records of *C. sapidus* described in the present report along the eastern coast of Libya probably

Table 1. Data on the findings of *Portunus segnis* in Libyan waters. (ID: Sample identification number; N: Number of specimens).

ID	Date	Place	Longitude	Latitude	Depth (m)	N	Gear
A	13/10/2018	Sabratha	32.81139°N	12.47194°E	10	1	Diver, hand collecting
B	5/11/2018	Zuwara	32.95750°N	12.05139°E	8	2	Trammel net
C	15/9/2020	Abukammash	33.08611°N	11.70056°E	1	2	Trammel net
D	11/11/2020	Tajurah	32.85306°N	13.45139°E	10	7	Trammel net
E	20/1/2021	Sorman	32.79556°N	12.57417°E	2	3	Diver, hand collecting
F	25/11/2020	Sabratha	32.81139°N	12.47194°E	1	7	Diver, hand collecting

constitute a natural range expansion of the species from the already invaded Egyptian waters. They may indicate furthermore that the species is establishing viable populations within the Umm-Hufayn Lagoon, an area evidently suitable to invasive alien species, as testified by the recent record of yet another NIS decapod of Atlantic origin, *Penaeus aztecus* Ives, 1891 (Abdulraziq et al. 2021).

Callinectes sapidus has been reported from estuaries and other oligo-thalassic environments (e.g. embayments contiguous to the mouth of rivers), including bays within the Ebro Delta in Spain (Prado et al. 2020), which it invades for feeding purposes (oysters, clams, gastropods). This could explain its occurrence along the eastern Libyan coast, specifically in the Jabal al Akhdar region, which is characterized by seasonal coastal runoff from non-perennial watercourses fed by precipitation levels which are higher than those for the rest of Libya.

The lessepsian blue swimming crab *Portunus segnis* has long established a presence in Mediterranean Egyptian waters (Galil 2011; Abdel Razek et al. 2006, 2016) as well as in shallow waters along extensive swathes of the Tunisian coastline (Annabi et al. 2018; Ben Abdallah-Ben Hadj Hamida et al. 2019a; Shaiek et al. 2021). Currently, blue swimming crabs, being particularly abundant in these areas, are exploited commercially, becoming an important part of the local fisheries with an increasing economic value. Indeed, the species has also become commercially important in some local markets as well as a value-added product for export to foreign markets (Ben Abdallah-Ben Hadj Hamida et al. 2019b; Ennouri et al. 2021).

The species has been recently recorded along eastern and western swathes of the Libyan coast (Shakman et al. 2017, 2019). The rapid establishment and proliferation of *P. segnis* along the western coast of Libya was expected, given the invasive nature of the species and a further imminent expansion of the species along the entire coastline of Libya is anticipated.

Sympatry is not uncommon within decapods, with sympatric species reducing the intense competitive pressure arising from their affiliated niches through adaptations (Baumart et al. 2015). Through fishing operations in the shallow coastal waters of Tunisia, the concomitant occurrence of the two invasive portunids *C. sapidus* and *P. segnis* has been recently documented (Ben Suissi et al. 2017; Mili et al. 2020). To date, along the Libyan coastline, it appears that the two allochthonous decapods occupy areas which are spatially distinct and non-overlapping, but the fact that the

two species are easily confused by fishermen as a result of their morphological similarities, makes it contingent to conduct a future comprehensive scientific survey along the same coastline in order to evaluate if the above two invaders eventually share the same habitats (Mili et al. 2020).

Considering the great ability of these species to spread, their high fecundity rate and aggressivity towards local species and physical damage to fishing gears, specific surveillance, monitoring and participatory mapping activities will be needed to evaluate the potential impact of these NIS on the environment and on local Libyan fisheries. These strategies could be useful in identifying fishery management measures and profitable market niches to make new resources commercially exploitable, as is currently the case in Tunisia, as a viable mitigation measure.

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References

- Abdalhamid AHA, Mohamed Ali S, Ali RAS, Elawad AN, Buzaid EMK (2017) Food and feeding habits of the European eel *Anguilla anguilla* (Linnaeus, 1758) in Umm Hufayan Lagoon, eastern Libya Mediterranean coast. *Bulletin de l'Institut Scientifique, Rabat, Section Sciences de la Vie* 39: 63–70
- Abdel Razeq FA, Taha SM, Ameran AA (2006) Population biology of the edible crab *Portunus pelagicus* (Linnaeus) from Bardawil Lagoon, Northern Sinai, Egypt. *Egyptian Journal of Aquatic Research* 32(1): 401–418
- Abdel Razeq FA, Ismaiel M, Ameran MAA (2016) Occurrence of the blue crab *Callinectes sapidus*, Rathbun, 1896, and its fisheries biology in Bardawil Lagoon, Sinai Peninsula, Egypt. *Egyptian Journal of Aquatic Research* 42: 223–229, <https://doi.org/10.1016/j.ejar.2016.04.005>
- Abdulrzaq AA, Abdulghani A, Ibrahim SM, Zava B, Deidun A (2021) First record of the northern brown shrimp *Penaeus aztecus* Ives, 1891 (Crustacea, Decapoda, Penaeidae) from Libyan waters. *BioInvasions Records* 10: 287–294, <https://doi.org/10.3391/bir.2021.10.2.06>
- Al Mabruk SAA, Crocetta F (2021) Filling gaps: the upside-down jellyfish *Cassiopea andromeda* (Forskål, 1775) in Libya. In: New alien Mediterranean biodiversity records (December 2021). *Mediterranean Marine Science* 22(3) (in press), <https://doi.org/10.12681/mms.26668>
- Al Mabruk SAA, Zava B, Abdulghani A, Corsini-Foka M, Deidun A (2021) The first record of the Pharaoh cardinal fish *Apogonichthyoides pharaonis* (Actinopterygii: Perciformes: Apogonidae) from Libyan waters. *Acta Ichthyologica et Piscatoria* 51: 113–118, <https://doi.org/10.3897/aiep.51.63504>
- Annabi A, Bardelli R, Vizzini S, Mancinelli G (2018) Baseline assessment of heavy metals content and trophic position of the invasive blue swimming crab *Portunus segnis* (Forskål, 1775) in the Gulf of Gabès (Tunisia). *Marine Pollution Bulletin* 136: 454–463, <https://doi.org/10.1016/j.marpolbul.2018.09.037>
- Badalamenti F, Ben Amer I, Dupuy De La Grandrive R, Foulquie M, Milazzo M, Sghaier YR, Gomei M, Limam A (2011) Scientific field survey report for the development of Marine Protected Areas in Libya. MEDPAN South Project Technical Series, 31 pp
- Baumart JS, Dalosto MM, Gonçalves AS, Palaoro AV, Santos S (2015) How to deal with a bad neighbor? Strategies of sympatric freshwater decapods (Crustacea) for coexistence. *Hydrobiologia* 762: 29–39, <https://doi.org/10.1007/s10750-015-2331-0>
- Ben Abdallah-Ben Hadj Hamida O, Ben Hadj Hamida N, Bdioui M, Missaoui H (2019a) Prolifération du crabe bleu nageur *Portunus segnis* le long du littoral Tunisien. Troisième Conférence Méditerranéenne de la Biodiversité 2019. Hammamet, Tunisie, 1-3 Novembre 2019. Book of Abstracts, p 8, https://ascob.net/files/abstract_book_biodiv2019_finale.pdf
- Ben Abdallah-Ben Hadj Hamida O, Ben Abdallah O, Ben Hadj Hamida N, Bdioui M, Ben Jarray F (2019b) Premiers resultats de l'évaluation du stock du crabe bleu *Portunus segnis*

- dans la région du Golfe De Gabès. Troisième Conférence Méditerranéenne de la Biodiversité 2019. Hammamet, Tunisie, 1-3 Novembre 2019. Book of Abstracts, p 7, https://ascob.net/files/abstract_book_biodiv2019_finale.pdf
- Ben Souissi J, Abidi A, Ounifi-Ben Amor K, Chaffai A, Rifi M, Zaouali J (2017) Nouvelle invasion du Golfe de Gabès par un crabe bleu d'origine Atlantique: Première occurrence de *Callinectes sapidus* Rathbun, 1896 en Tunisie (Méditerranée Centrale). XVIIèmes Journées Tunisiennes des Sciences de la Mer. Iles Kerkennah, 18-21 décembre 2017. Book of Abstracts, p 119, <https://researchgate.net/publications>
- Coll M, Piroddi C, Steenbeek J, Kaschner K, Ben Rais Lasram F, Aguzzi J, Ballesteros E, Bianchi C.N, Corbera J, Dailianis T, Danovaro R, Estrada M, Froglija C, Galil B.S, Gasol JM, Gertwagen R, Gil J, Guilhaumon F, Kesner-Reyes K, Kitsos M-S, Koukouras A, Lampadariou N, Laxamana E, López-Fé de la Cuadra CM, Lotze HK, Martin D, Mouillot D, Oro D, Raicevich S, Rius-Barile J, Saiz-Salinas JI, San Vicente C, Somot S, Templado J, Turon X, Vafidis D, Villanueva R, Voultsiadou E (2010) The Biodiversity of the Mediterranean Sea: estimates, patterns, and threats. *PLoS ONE* 5: e11842, <https://doi.org/10.1371/journal.pone.0011842>
- Corsini-Foka M, Zenetos A, Crocetta F, Çinar ME, Koçak F, Golani D, Katsanevakis S, Tsiamis K, Cook E, Froglija C, Triandaphyllou M, Lakkis S, Kondylatos G, Tricarico E, Zuljevic A, Almeida M, Cardigos F, Çağlar S, Durucan F, Fernandes AMD, Ferrario J, Haberle I, Louizidou P, Makris J, Marić M, Micu D, Mifsud C, Nall C, Kytinou E, Poursanidis D, Spigoli D, Stasolla G, Yapici S, Roy H.E (2015) Inventory of alien and cryptogenic species of the Dodecanese (Aegean Sea, Greece): collaboration through COST action training school. *Management of Biological Invasions* 6: 351–366, <https://doi.org/10.3391/mbi.2015.6.4.04>
- EastMed (2010) Report of the Sub-Regional Technical meeting on the Lessepsian migration and its impact on Eastern Mediterranean fishery. GCP/INT/041/EC - GRE - ITA/TD-04, 140 pp
- Ennouri R, Zarrouk H, Fatnassi M, Mili S (2021) Development of the fishing and commercialization of the blue crabs in Bizerta and Ghar EL Melh lagoons: A case study of promotion opportunities of blue growth in Tunisia. *Journal of Aquaculture & Marine Biology* 10: 66–74, <https://doi.org/10.15406/jamb.2021.10.00308>
- Falsone F, Scannella D, Geraci ML, Vitale S, Sardo G, Fiorentino F (2020) Further records of *Callinectes sapidus* (Rathbun, 1896) (Decapoda, Brachyura, Portunidae) in the Strait of Sicily. *Marine Biodiversity Records* 13: 1–6, <https://doi.org/10.1186/s41200-020-00190-5>
- Galil BS (2011) The Alien Crustaceans in the Mediterranean Sea: An Historical Review. In: Galil B, Clark P, Carlton J (eds), In the Wrong Place - Alien Marine Crustaceans: Distribution, Biology and Impacts. Invading Nature - Springer Series in Invasion Ecology, vol 6. Springer, Dordrecht, pp 377–401, https://doi.org/10.1007/978-94-007-0591-3_13
- Holthuis LB (1987) Vrais crabes. In: Fischer W, Bauchot M-L, Schneider M (eds), Fiches FAO d'identification des espèces pour les besoins de la pêche. (Révision 1). Méditerranée et mer Noire. Zone de pêche 37. Volume I. Végétaux et Invertébrés. Rome, FAO, pp 322–367
- IUCN (2011) Towards a representative network of Marine Protected Areas in Libya. IUCN, Gland, Switzerland and Malaga, Spain, 68 pp
- Kampouris TE, Kouroupakis E, Batjakas IE (2020) Morphometric relationships of the global invader *Callinectes sapidus* Rathbun, 1896 (Decapoda, Brachyura, Portunidae) from Papapouli Lagoon, NW Aegean Sea, Greece, with notes on its ecological preferences. *Fishes* 5: 5, <https://doi.org/10.3390/fishes5010005>
- Katsanevakis S, Wallentinus I, Zenetos A, Leppäkoski E, Çinar M.E, Öztürk B, Grabowski M, Golani D, Cardoso AC (2014) Impacts of invasive alien marine species on ecosystem services and biodiversity: a pan-European review. *Aquatic Invasions* 9: 391–423, <https://doi.org/10.3391/ai.2014.9.4.01>
- Lai JCY, Ng PKL, Davie PJF (2010) A revision of the *Portunus pelagicus* (Linnaeus, 1758) species complex (Crustacea: Brachyura: Portunidae), with the recognition of four species. *The Raffles Bulletin of Zoology* 58(2): 199–237
- Mahklouf MH, Shakman EA (2021) Invasive alien species in Libya. In: Pullaiah T, Ielmini MR (eds), Invasive Alien Species: Observations and Issues from Around the World. Volume 1: Issues and Invasions in Africa. Wiley-Blackwell, pp 173–195, <https://doi.org/10.1002/978119607045.ch6>
- Mancinelli G, Chainho P, Cilenti L, Falco S, Kapiris K, Katselis G, Ribeiro F (2017a) The Atlantic blue crab *Callinectes sapidus* in southern European coastal waters: Distribution, impact and prospective invasion management strategies. *Marine Pollution Bulletin* 119: 5–11, <https://doi.org/10.1016/j.marpolbul.2017.02.050>
- Mancinelli G, Chainho P, Cilenti L, Falco S, Kapiris K, Katselis G, Ribeiro F (2017b) On the Atlantic blue crab (*Callinectes sapidus* Rathbun, 1896) in southern European coastal waters: Time to turn a threat into a resource? *Fisheries Research* 194: 1–8, <https://doi.org/10.1016/j.fishres.2017.05.002>
- Mancinelli G, Bardelli R, Zenetos A (2021) A global occurrence database of the Atlantic blue crab *Callinectes sapidus*. *Scientific Data* 8: 111, <https://doi.org/10.1038/s41597-021-00888-w>

- Mili S, Ennouri R, Ghanem R, Rifi M, Jaziri S, Shaiek M, Ben Souissi J (2020) Additional and unusual records of blue crabs *Portunus segnis* and *Callinectes sapidus* from the northeastern Tunisian waters (Central Mediterranean Sea). *Journal of New Sciences* 14(2): 303–311
- Nehring S (2011) Invasion History and Success of the American Blue Crab *Callinectes sapidus* in European and Adjacent Waters. In: Galil B, Clark P, Carlton J (eds), *In the Wrong Place - Alien Marine Crustaceans: Distribution, Biology and Impacts*. Invading Nature - Springer Series in Invasion Ecology, vol 6. Springer, Dordrecht, pp 607–624, https://doi.org/10.1007/978-94-007-0591-3_21
- Prado P, Peñas A, Ibáñez C, Cabanes P, Jornet L, Álvarez N, Caiola N (2020) Prey size and species preferences in the invasive blue crab, *Callinectes sapidus*: Potential effects in marine and freshwater ecosystems. *Estuarine, Coastal and Shelf Science* 245: 106997, <https://doi.org/10.1016/j.ecss.2020.106997>
- Rady A, Sallam WS, Abdou NEI, El-Sayed AAM (2018) Food and feeding habits of the blue crab, *Callinectes sapidus* (Crustacea: Decapoda: Portunidae) with special reference to the gastric mill structure. *Egyptian Journal of Aquatic Biology and Fisheries* 22: 417–431, <https://doi.org/10.21608/ejabf.2018.23925>
- Shaiek M, El Zrelli R, Crocetta F, Mansour L, Rabaoui L (2021) On the occurrence of three exotic decapods, *Callinectes sapidus* (Portunidae), *Portunus segnis* (Portunidae), and *Trachysalambria palaestinensis* (Penaeidae), in northern Tunisia, with updates on the distribution of the two invasive portunids in the Mediterranean Sea. *BioInvasions Records* 10: 158–169, <https://doi.org/10.3391/bir.2021.10.1.17>
- Shakman E (2017) National monitoring programme for biodiversity in Libya. Contract n° 09_EcAp MED II SPA/RAC_2016, SPA/RAC, Tunis, 60 pp
- Shakman E, Kinzelbach R (2007) Commercial fishery and fish species composition in coastal waters of Libya. *Rostocker Meeresbiologische Beiträge* 18: 63–78
- Shakman EA, Ben Abdalha A, Talha F, Al-Faturi A, Bariche M (2017) First records of seven marine organisms of different origins from Libya (Mediterranean Sea). *BioInvasions Records* 6: 377–382, <https://doi.org/10.3391/bir.2017.6.4.13>
- Shakman E, Eteayb K, Taboni I, Ben Abdalha A (2019) Status of marine alien species along the Libyan coast. *Journal of the Black Sea/Mediterranean Environment* 25: 188–209
- Streftaris N, Zenetos A (2006) Alien marine species in the Mediterranean - the 100 ‘Worst Invasives’ and their impact. *Mediterranean Marine Science* 7: 87–118, <https://doi.org/10.12681/mms.180>
- Tureli C, Yesilyurt I (2018) Reproductive biology of blue swimming crab, *Portunus segnis* (Forskål, 1775) in Yumurtalık Cove, Northeastern Mediterranean, Turkey. *Mediterranean Marine Science* 18: 424–432, <https://doi.org/10.12681/mms.13789>