Journal of the Marine Biological Association of the United Kingdom, 2013, 93(4), 999–1008.
doi:10.1017/S0025315412001361

Littoral mud shrimps (Decapoda: Gebiidea & Axiidea) of the Persian Gulf and Gulf of Oman, Iran

VAHID SEPAHVAND[1], ALIREZA SARI[1], HASSAN SALEHI[1], SEYED-MOHAMMAD-BAGHER NABAVI[2] AND SEYED-GHASEM GHORBANZADEH[3]

[1]School of Biology and Centre of Excellence in Phylogeny of Living Organisms, College of Science, University of Tehran, Tehran, Iran, [2]Department of Marine Biology, University of Marine Science and Technology, Khorramshahr, Iran, [3]Section of Marine Environment, Department of the Environment, Pardisan Natural Eco-Park, Tehran, Iran

The mud shrimps of Iran are not well known. Material for the present study was collected from 21 out of 51 intertidal localities from the Persian Gulf and Gulf of Oman, Iran. In total, 11 species were found along the Iranian coast. These were belonging to three families, including Upogebiidae (Upogebia carinicauda, U. darwinii *and* U. pseudochelata)*, Callianassidae* (Neocallichirus jousseaumei, N. calmani, Callichirus masoomi, Corallianassa coutierei, Michaelcallianassa indica, Paratrypaea bouvieri *and* Gourretia coolibah) *and Callianideidae* (Callianidea typa). *Geographical distributions of the species were considered and the results show that each species is totally dependent on a special type of habitat. Comparing different types of habitat, sandy and muddy substrates of the intertidal and shallow subtidal zone are found as the dominant habitat type for all species, but some species have a preference for boulder dominated coasts or occupy already existing holes and crevices in the boulder and bedrocks. In addition, the world distribution of each species was considered, and according to their present recorded localities, these are grouped into two distributional categories including the Indo-West Pacific region and one in a broader area of the Indo-Pacific.*

Keywords: mud shrimps, geographical distribution, Persian Gulf, Gulf of Oman, Iran

Submitted 25 July 2012; accepted 12 August 2012; first published online 27 November 2012

INTRODUCTION

The intertidal zone of the Persian Gulf and Gulf of Oman is composed of different habitats, such as mangrove, sandy-mud, muddy, sandy, rocky and muddy-sand shores dominated by mollusc shells and fragments. These diverse habitats provide suitable environment for a wide variety of burrowing organisms, especially mud shrimps. But some of these are not necessarily mud dwelling and live in habitats such as existing cavities covered with soft sediments inside boulders, within sponges and sandy-muddy areas with mollusc shells. Sometimes these organisms occupy the already existing holes and crevices in limestone (carbonate rock). These shrimps rely, as stated by Griffis & Suchanek (1991), on burrows for shelter, reproduction, and feeding. Mud shrimps spend their entire life within their burrow, except for the larval phase, which in most species is pelagic (Griffis & Suchanek, 1991). The taxonomy of mud shrimps has been subject to much controversy in the recent decade (see Tudge *et al.,* 2000; Felder & Robles, 2009; Robles *et al.,* 2009). In a recent monograph by Sakai (2011), two superfamilies Axioidea and Callianassoidea are treated and the latter is reconsidered to be composed of 51 genera, of which 25 are new taxa (including 17 gen. nov. and eight *sensu* nov.). These erected genera provide more instability and ambiguities in the taxonomy of this group.

Previously, the mud shrimp have not been studied along the Iranian coast of the Persian Gulf and Gulf of Oman. There are only three studies on the Persian Gulf including Sakai & Türkay (1995), Dworschak (2009) and a recent study by Sepahvand & Sari (2010). This latter study was part of an earlier attempt of the present extensive project on intertidal mud shrimps of Iran to discover this group along Qeshm Island, Persian Gulf, Iran. However, several studies were carried out in the adjacent regions including the Arabian Sea by Tirmizi (1970, 1974, 1977) and Tirmizi & Ghani (1978), the Red Sea by Dworschak & Pervesler (1988) and Dworschak (2003, 2007), and material of *Paratrypaea* species from the Indo-West Pacific by Dworschak (2012). Therefore, the main purpose of the present study was to consider the intertidal mud shrimps of Iranian coastal waters of the Persian Gulf and Gulf of Oman from a taxonomic point of view and to consider their zoogeographical relationships to the Indo-West Pacific region and their specific habitat types.

MATERIALS AND METHODS

In general, collecting methods follow those of Manning (1975). Sampling was carried out at 51 intertidal localities from Gwater Bay (25°08′N 48°29′E) to Arvand-Kenar (29°59′N 48°29′E) between 2008 and 2011 (Tables 1 & 2).

Corresponding author:
A. Sari
Email: sari@ut.ac.ir

Table 1. Sampling localities, habitat types and species composition of mud shrimps along the Iranian coast of the Persian Gulf and Gulf of Oman.

Station no.	Location	Latitude and longitude	Sediment type	Species
20	Bandar-Lengeh	26°32′55″N 55°01′34″E	Muddy-sand	*Michaelcallianassa indica*
21	Mahtabi	26°47′15″N 55°20′05″E	Sandy-mud with mollusc shells	*Michaelcallianassa indica* *Upogebia carinicauda*
22	Bandare-Khamir	26°51′12″N 55°34′27″E	Sandy-mud	*Michaelcallianassa indica*
23	Bandar-Abbas	27°11′24″N 56°20′42″E	Sandy-mud	*Paratrypaea bouvieri* *Michaelcallianassa indica*
25	Koohestak	26°48′12″N 57°01′06″E	Sandy-mud	*Neocallichirus calmani*
26	Ziarat-Kaleh	26°40′47″N 57°03′51″E	Sand	*Neocallichirus calmani* *Neocallichirus jousseaumei*
27	Bandar-Sirik	26°31′56″N 57°45′08″E	Sandy-mud	*Neocallichirus calmani*
28	Koohe-Mobarak	25°18′10″N 57°18′12″E	Sandy-mud with mollusc shells	*Neocallichirus jousseaumei* *Neocallichirus calmani*
31	Gorgij	25°41′46″N 57°53′19″E	Sandy with mollusc shells	*Neocallichirus calmani*
32	Seide-Bazargane (Jahla)	25°35′41″N 58°25′51″E	Sandy-mud	*Neocallichirus calmani*
33	Djod	25°26′58″N 59°30′28″E	Sandy-rocky with boulders	*Neocallichirus jousseaumei* *Neocallichirus calmani*
35	Tis (Portuguese Castle)	25°21′10″N 60°36′08″E	Sandy with boulders	*Neocallichirus jousseaumei* *Neocallichirus calmani* *Corallianassa coutierei*
36	Tis Estuary	25°21′25″N 60°36′17″E	Muddy-sand with boulders	*Neocallichirus jousseaumei*
40	Fajr Dock, Qeshm Island	26°58′27″N 56°15′07″E	Sandy-mud	*Callichirus masoomi*
42	Abshirin-Kone Laft, Qeshm Island	26°56′16″N 55°47′48″E	Sandy with boulders	*Paratrypaea bouvieri* *Gourretia coolibah* *Upogebia carinicauda* *Neocallichirus jousseaumei*
43	Basaeedou, Qeshm Island	26°39′08″N 55°15′09″E	Sandy-mud with coral gravel	*Michaelcallianassa indica* *Upogebia darwinii*
44	Dostakou, Qeshm Island	26°33′54″N 55°54′52″E	Sandy-mud with mollusc shells	*Michaelcallianassa indica*
45	Cinemadarya, Qeshm Island	26°56′07″N 56°16′31″E	Sandy with boulders	*Neocallichirus jousseaumei*
46	Salakh-Naghashe, Qeshm Island	26°43′48″N 55°50′32″E	Sandy with boulders	*Neocallichirus jousseaumei*
49	West of Zeyton Park, Qeshm Island	27°11′06″N 56°24′11″E	Layered bedrock	*Upogebia carinicauda* *Upogebia pseudochelata* *Callianidea typa*
51	West of washed oil platform	26°53′58″N 56°10′11″E	Sandy-mud with shell fragments and boulders	*Callianidea typa* *Neocallichirus jousseaumei*

In sandy and muddy substrates, spade and yabby pumps were used for collecting the specimens, but in rock and boulder dominated habitats a lever was used for lifting boulders or splitting the layered rocks to find the exposed specimens. Collected specimens were transferred to 80% ethanol, shipped to the Zoological Museum, University of Tehran (ZUTC) and after identification deposited in the crustacean collection. For comparison, additional material from the Senckenberg Museum, Frankfurt am Main (SMF) and the Naturhistorisches Museum Wien (NHMW) were studied.

In the present study, size is expressed as total length (TL in mm) from the tip of the rostrum to the end of telson and as carapace length (CL in mm) from the tip of the rostrum to the posterior median edge of carapace, measured with Vernier calipers.

The remarks are given only for main or diagnostic characters, and any characters, which show variations compared to original drawings and descriptions of the respective species.

In material examined, the stations are shown as 'S' with a relevant number according to the data presented for localities in Tables 1 and 2. The systematic account is arranged according to that proposed by Sakai (2006) and the website of the World Register of Marine Species (http://www.marinespecies.org).

Species synonymy is given only for original descriptions and recent works.

https://doi.org/10.1017/S0025315412001361 Published online by Cambridge University Press

Table 2. Sampling localities and habitat types along the Iranian coast of the Persian Gulf and Gulf of Oman with no record of mud shrimps.

Station no.	Location	Latitude and longitude	Sediment type
1	Arvand-Kenar (Yademan-Valfajr)	29°30′24″N 57°04′40″E	Muddy-sand
2	Arrvand-Kenar (fishing dock)	29°58′19″N 48°31′01″E	Boulders
3	Hendijan (Bahrekan)	30°06′24″N 49°46′23″E	Mud
4	Shah-Abdollah	30°10′41″N 50°05′51″E	Mud with shells
5	Boayrat	26°59′04″N 50°08′12″E	Sandy-mud
6	Leylatain	29°52′57″N 50°12′46″E	Sandy-mud
7	Ghale-Heydar	29°37′41″N 50°27′50″E	Sand
8	Bandare-Rig	29°28′54″N 50°34′35″E	Muddy-sand
9	Ramleh	29°14′55″N 50°40′44″E	Sandy-mud
10	Bandar-Bousher	28°54′36″N 50°48′05″E	Sandy-muddy with coral gravel
11	Bahraman	28°46′37″N 51°01′51″E	Sand
12	Damgiz	27°49′55″N 51°40′58″E	Sand
13	Delvar	28°34′41″N 51°04′41″E	Sand
14	Bandar-Dayyer	27°49′55″N 51°55′24.8″E	Sand with coral gravel
15	Bandar-Assallouyeh	27°38′52″N 52°25′18″E	Sand with algal mat
16	Khalije-Nayband	27°25′26″N 52°39′20″E	Sand
17	Bandar-Aftab	26°42′57″N 54°07′28″E	Sand with boulders
18	Bandar-Charak	26°40′50″N 54°08′27″E	Rocky with algae
19	Bandar-Kong	26°34′48″N 54°55′32″E	Rocky–sandy–muddy
24	Bandar-Kolahi	27°20′51″N 56°51′04″E	Sandy-mud
29	Bandar- Jask	29°39′12″N 57°46′37″E	Sandy with mollusc shells
30	Gabrik Dock	25°36′09″N 58°23′17″E	Sandy-muddy with mangrove forest
34	Konarak	25°22′07″N 60°24′38″E	Sand
37	Ramin	25°16′03″N 60°44′49″E	Sand
38	Passa–Bandar	25°04′08″N 61°24′53E	Sand
39	Gowater	25°10′02″N 61°29′53″E	Sand
41	Dargahan, Qeshm Island	26°59′58″N 56°59′24″E	Mud with boulders
47	Kargah, Qeshm Island	26°38′29″N 55°37′10″E	Sand
48	Doulab, Qeshm Island	26°41′02″N 55°27′48″E	Sandy-muddy with mollusc shells
50	Shib-Deraz, Qeshm Island	26°45′40″N 55°54′52″E	Rocky

RESULTS

SYSTEMATICS

Family CALLIANASSIDAE Dana, 1852
Subfamily CALLIANASSINAE Dana, 1852
Genus *Paratrypaea* Komai & Tachikawa, 2008
Species *Paratrypaea bouvieri* (Nobili, 1904)

Callianassa (*Trypaea*) *bouvieri* Nobili, 1904: 236.
Callianassa bouvieri.—Sepahvand & Sari, 2010: 45, figure 3.
Paratrypaea bouvieri.—Dworschak, 2012: 41, figure 1D; 44, figure 4; 46, figure 5A–I; 47, figure 6A–J; 47 figure 7 A, B.

MATERIAL EXAMINED

ZUTC Tha. 1025 (Abshirin-Kone Laft, Qeshm Island, S 42; 8 females (♀), 3 males (♂)), ZUTC Tha. 1035 (Bandar-Abbas, S 23; 2♀, 1♂), NHMW 6591(Egypt, 4♂, 4♀).

REMARKS

The largest specimen was TL = 24.3 mm and CL = 6.1 mm. The material of the present study agrees well with that of Dworschak & Pervesler (1988), Sakai (2005) and Komai & Tachikawa (2008) and the recent study by Dworschak (2012). Morphologically, this species is well treated and described in the two latter works. Compared to the description provided by Sakai (1999), the merus is less denticulate and the latero-medial part of the merus is composed of a long spine. The characters of the present material are also compared with Dworschak (2012) and these are in agreement with Dworschak's figures 5D, H, 6C and 7B.

HABITAT

Sandy-mud with mollusc shells.

WORLD DISTRIBUTION

West Indian Ocean from Madagascar to Persian Gulf, Chagos Archipelago, Indonesia, Japan, Kiribati and Fiji (see Dworschak, 2012 for detailed localities).

Subfamily CALLICHIRINAE Manning & Felder, 1991
Genus *Corallianassa* Manning, 1987
Species *Corallianassa coutierei* (Nobili, 1904)

Callianassa (*Callichirus*) *coutierei* Nobili, 1904: 237.
Glypturus coutierei.—Sakai, 2005: 141, figure 28C, D.

MATERIAL EXAMINED

ZUTC Tha. 1041 (Tis, Chabahar, Gulf of Oman S 35; 1♀).

https://doi.org/10.1017/S0025315412001361 Published online by Cambridge University Press

REMARKS
The size of this single specimen was TL = 40.3 mm and CL = 10.2 mm. The live specimens are easily recognizable by a crimson colour. The material of the present study was morphologically very close to Sakai's (1999) descriptions and drawings, but the dactylus of the large chela is stout and the propodus two times as long as broad.

HABITAT
Rocky and boulder dominated shore with muddy-sand and shell fragments.

WORLD DISTRIBUTION
Hawaii (Hanauma Bay, Oahu); Mindanao, Philippines; Tahiti; Fiji Island; Goidu, Goifurfehendu Atoll, Maldives Archipelago (de Man, 1928); Indonesia (off Seba, Savu; off Laiwui, Coast of Obi Major); Gulf of Aden (Perim; Djibouti, Aden); Tulear, south-west Madagascar (Sakai, 2005).

Genus *Michaelcallianassa* Sakai, 2002
Species *Michaelcallianassa indica* Sakai, 2002

Michaelcallianassa indica Sakai, 2002: 481.—Sepahvand & Sari, 2010: 47, figure 6.—Sakai, 2011: 450–451.

MATERIAL EXAMINED
ZUTC Tha. 1013 (Basaeedou S 43; 5♀, 3♂, 2 juveniles), 1022 (Doustakou S 44; 2♂, 2♀), 1023 (Mahtabi S 21; 10♀, 5♂), 1024 (Bandar-Lengeh S 20; 3♀, 1♂), 1045 (Bandar-Khamir S 22; 2♀) 1046 (Bandar-Abbas S 23; 1♀), SMF 25807 (Persian Gulf, holotype), NHMW 24989 (Bandar-Khamir S 22; 1♂, 1♀).

REMARKS
The largest specimen was TL= 29.2 mm and CL = 7.1 mm. The present specimens from the Persian Gulf agree well with Sakai's (2002) description except for the first pleopod of female specimens. In his work, pleopod 1 was found to be three segmented but in all the material of the present study and also the examined material deposited at the SMF, it is two segmented.

In the present study *Michaelcallianassa indica* was found intertidally on a sandy-mud substrate with shell fragments, but Sakai (2002) reported this species from subtidal waters in the Persian Gulf and Andaman Sea.

HABITAT
Sandy-mud, muddy-sand, sandy-mud with coral gravels and/or mollusc shells.

WORLD DISTRIBUTION
Persian Gulf and Andaman Sea (Sakai, 2002, 2011), Persian Gulf (Sepahvand & Sari, 2010).

Genus *Neocallichirus* Sakai, 1988
Species *Neocallichirus calmani* (Nobili, 1904)

Callianassa (*Cheramus*) *calmani* Nobili, 1904: 237.
Neocallichirus calmani.—Sakai, 2011: 455.

MATERIAL EXAMINED
ZUTC Tha. 1011 (Koohestak S 25: 4♀, 2♂), 1043 (Koohestak S 25; 3♀, 2♂), 1049 (Ziarat-Kaleh S 26; 3♀), 1019 (Bandar-Sirik S 27; 11♀, 7♂), 1005 (Koohe-Mobarak S 28; 6♀, 2♂), 1027 (Gorgij S 31; 8♀, 3♂), 1008 (Jahla S 32; 2♀, 3♂), 1028 (Djod S 33; 5♀, 2♂), 1017 (Tis S 35; 3♀, 2♂), NHMW 6780 (Red Sea, 1♀, 1♂).

REMARKS
The largest specimen was CL = 41.7 mm and TL = 13.2 mm. Dorsal and ventral margins of the ischium of the large cheliped bear some denticles. In the examined material from the studied area, the merus has seven denticles proximally. The telson is rounded and 1.2 times as broad as long. The dorsal surface bears medially a transverse row of setae and a shallow mid-dorsal depression at the posterior margin. The propodus ventrally bears some denticles.

This is one of the most common callianassid species in the Gulf of Oman. The burrow of *N. calmani* is marked by two openings on the sand flat surface with a small mound at each opening. The body colour is white with pink chelae but in the breeding season (spring) an orange or reddish ovary is visible through the translucent cuticle of females.

HABITAT
Sandy-mud with mollusc shell fragments, and sand. In both cases the lower layer of sediments (at depth of 30–50 cm) was composed of hard clay.

WORLD DISTRIBUTION
Red Sea (de Vaugelas, 1990); Philippines (Anker & Marin, 2009); Gulf of Aden, Persian Gulf and Gulf of Oman (Sakai, 2011).

Species *Neocallichirus jousseaumei* (Nobili, 1904)

Callichirus (*Cheramus*) *jousseaumei* Nobili, 1904: 236.
Neocallichirus indicus.—Sepahvand & Sari, 2010: 46 figure 4.
Neocallichirus jousseaumei.—Dworschak, 2011: 2, figures 1–4, 6F–H.

MATERIAL EXAMINED
ZUTC Tha. 1002 (Ziarat-Kaleh S 26; 3♀, 2♂), 1003 (Ziarat-Kaleh S 26; 1♂), 1032 (Koohe-Mobarak S 28; 1♂), 1035 (Djod S 33; 3♀, 1♂), 1015 (Tis S 35; 1♀, 1♂), 1016 (Tis S 35; 1♀, 2♂), 1017 (Tis S 35; 2♀), 1034 (Tis S 35; 2♀, 3♂), 1001 (Tis Estuary S 36: 2♀, 4♂), 1031 (Abshirin-Kone Laft S 42; 2♀), 1004 (Cinemadarya S 45; 4♀, 2♂), 1006 (Salakh-Naghashe S 46; 2♀), 1036 (oil platform area S 51; 1♀, 1♂), SMF 4959 (Red Sea; 1♂), NHMW 25036 (Philippines, 1♂), NHMW 24991 (Ziarat-Kaleh S 26; 1♂).

REMARKS
The largest specimen was TL = 75.3 mm and CL = 15 mm. The material of the present study agrees well with those from SMF and NHMW. The burrow of *N. jousseaumei* consists of multiple 'U' shaped parts in which ex-current openings lack mounds and these openings were not easily detectable between the sand and shell fragments. This species prefers a habitat with limestone boulders and uses mud for covering the burrow walls under the boulders. There was usually one specimen in each burrow. The colour of the live animal was whitish beige. In adult females orange coloured ovaries were visible through the transparent cuticle. This is the largest Iranian species of mud shrimp.

Dworschak (2011), based on type material and numerous specimens from the Indo-Pacific—including that from

https://doi.org/10.1017/S0025315412001361 Published online by Cambridge University Press

Socotra, Yemen, and the United Arab Emirates—presented a redescription of *Neocallichirus jousseaumei* and found that *Neocallichirus indicus* is a junior synonym of the former. Material previously assigned to *N. jousseaumei* by Dworschak (1992) and Sakai (1999) turned out to belong to a different species and was described as a new species, *N. vaugelasi* Dworschak, 2011. Comparison of material from the present study with SMF 4959 from the Red Sea, and with the description and drawings provided by Dworschak (2011) for *N. jousseaumei*, revealed that they belong to this species. Material of *N. jousseaumei* were found in all localities (stations 26, 28, 33, 35, 36, 42, 45, 46 and 51) always under small boulders in sandy areas or in muddy-sand localities with shell fragments at lower depth.

There were always some red coloured parasitic copepods of the genus *Clausidium* on the carapace and chelae of the live material.

HABITAT

Sandy with boulders including a layer of hard clay under the sand to a depth of 30–50 cm.

WORLD DISTRIBUTION

Mauritius (Kensley, 1975); Kangeang Reef, Bay of Kankamaran; Djibouti, Gulf of Aden, Red Sea; Socotra and Persian Gulf (Sakai & Apel, 2002), Indonesia, Thailand, the Philippines, French Polynesia (Dworschak, 2011), Tuamotu Island, Tonaki Island, Flores, Indonesia (Sakai, 2005): Persian Gulf (Sepahvand & Sari, 2010).

Genus *Callichirus* Stimpson, 1866
Species *Callichirus masoomi* (Tirmizi, 1970)

Callianassa (Callichirus) masoomi Tirmizi, 1970: 245 figures 1 & 2. *Podocallichirus masoomi*.—Sepahvand & Sari, 2010: 47, figure 5.
Tirmizicallichirus masoomi.—Sakai, 2011: 475.

MATERIAL EXAMINED

ZUTC Tha.1012 (Fajr Dock S 40: 11♀, 9♂), NHMW 24990 (Fajr Dock S 40: 1♂).

REMARKS

The largest specimen was TL = 48.3 mm and CL = 11.8 mm. In the specimens of *C. masoomi* from Qeshm Island (station 40), the merus and ischium of the small cheliped are armed ventrally with denticles. In the original drawings and description of type material, it appears to be smooth or has been overlooked.

HABITAT

Sandy-mud.

WORLD DISTRIBUTION

Bholegi, West of Karachi, Pakistan; Ratnagiri, Bombay, India (Sankolli, 1971): Persian Gulf (Sepahvand & Sari, 2010).

Subfamily GOURRETIINAE Sakai, 1999
Genus *Gourretia* de Saint Laurent, 1973
Species *Gourretia coolibah* Poore & Griffin, 1979

Gourretia coolibah Poore & Griffin, 1979: 278.—Dworschak, 2009: 130, figures 1–34.—Sepahvand & Sari, 2010: 49, figure 7.
Paragourettia coolibah.—Sakai, 2011: 518.

MATERIAL EXAMINED

ZUTC Tha. 1032 (Abshirin-Kone Laft S 42; 1♀); NHMW 21969 (Qatar, Persian Gulf; 1♀).

REMARKS

The size of this single specimen was TL = 60.2 mm and CL = 15.1 mm. This species was reported by Dworschak (2009) from Qatar, Persian Gulf and the specimens in the present study agree well with Dworschak's drawings and material from NHMW. This species was first found in Australia by Poore & Griffin (1979). Currently, the geographical distribution of this species shows a wide gap between Western Australia and the Persian Gulf.

HABITAT

In crevices of bedrock but found in sandy habitats with shell fragments by Dworschak (2009) in Qatar.

WORLD DISTRIBUTION

Persian Gulf (Dworschak, 2009; Sepahvand & Sari, 2010) and Western Australia (Poore & Griffin, 1979).

Family CALLIANIDEIDAE Kossmann, 1880
Genus *Callianidea* H. Milne Edwards, 1837
Species *Callianidea typa* H. Milne Edwards, 1837

Callianidea typa H. Milne Edwards, 1837: 320.—Sepahvand & Sari, 2010: 48.—Sakai, 2011: 203.

MATERIAL EXAMINED

ZUTC Tha. 1027 (west of Zeyton Park S 49; 1♀, 1♂) partly damaged material, ZUTC Tha. 1052 (oil platform area S 51; 1♀), SMF 7936 (Ternate, Indonesia, 1♂).

REMARKS

The largest specimen was TL = 45.1 mm and CL = 9.8 mm. The live specimens are a crimson colour in the abdomen and the cheliped and carapace colour is ivory white.

HABITAT

Within existing crevices or cavities in calcium carbonate rocks. It is noteworthy that in the crevices of the rocks in station 49 (Table 1), this species was found sympatrically with *Upogebia carinicauda* and *U. pseudochelata* but each was found in a different boulder. There were greenish coloured parasitic copepods of the genus *Clausidium* on the chela, carapace and abdomen of material from station 51.

WORLD DISTRIBUTION

East Indian Ocean, Australia, Japan, Taiwan, Maldives and Indonesia (for more information about localities see Sakai, 2002; Komai & Tachikawa, 2008), Persian Gulf (Sepahvand & Sari 2010; Sakai, 2011).

Family UPOGEBIIDAE Borradaile, 1903
Genus *Upogebia* Leach, 1814
Species *Upogebia carinicauda* (Stimpson, 1860)

Gebia carinicauda Stimpson, 1860: 23.
Upogebia carinicauda.—Sakai, 2006: 98–101.—Sepahvand & Sari, 2010: 44, figure 2.

https://doi.org/10.1017/S0025315412001361 Published online by Cambridge University Press

MATERIAL EXAMINED
ZUTC Tha. 1029 (Mahtabi S 21; 3♀, 1♂), 1007 (Abshirin-Kone Laft S 42; 12♀, 10♂), 1009 (Abshirin-Kone Laft S 42; 3♀, 1♂), 1030 (west of Zeyton Park S 49; 2♀) and SMF 23043 (Kagoshima, Japan; 1♀, 1♂).

REMARKS
The largest specimen was TL = 41.6 mm and CL = 9.1 mm. The present material is morphologically close to the specimens from the SMF. In one of the stations, *U. carinicauda* was found in rocky (limestone) shores within holes and crevices (station 49, Qeshm Island) but in other stations (stations 21 and 42), this species was found in sandy-mud areas with shell fragments.

HABITAT
Muddy-sand with shell fragments but also found in rocks. The mound of the ex-current opening was 1–1.5 cm in height. The burrow in sand is Y-shaped or multiple U-shaped.

WORLD DISTRIBUTION
Australia, Hong Kong, South China, India, and Japan (for more information about localities see Poore & Griffin, 1979; Sakai, 1982, 2006) and Persian Gulf (Sepahvand & Sari, 2010; Present Study).

Species *Upogebia darwinii* (Miers, 1884)

Gebiopsis darwinii Miers, 1884: 281.
Upogebia darwinii.—Sakai, 2006: 101—114, figures 15–17.

MATERIAL EXAMINED
ZUTC Tha. 1033 (Basaeedou S 43; 3♀, 3♂), SMF 26521 (Red Sea; 1♂).

REMARKS
The largest specimen was TL = 30.2 mm and CL = 7.8 mm. The specimens show variations in shape, surface texture and size of the chelae. There is a single row of about 10 tubercles on the inner surface of the dactylus of pereiopod 1. In addition, there are two small rows of tubercles at the upper and lower parts of the proximal part of this main tubercle row. The upper one consists of joined tubercles. There are also variations in the fixed finger of pereopod 1.

This species shows considerable instability in its taxonomy and there are many synonyms for it (see Sakai, 1982, 2006; Ngoc-Ho, 1990). The material of *U. darwinii* in Nobili (1906) was later assigned by Ngoc-Ho (1990) to *U. octoceras* but Sakai (2006) continued to synonymize it with *U. darwinii*.

HABITAT
The specimens were found among the ex-current canals of a single species of unknown sponges.

WORLD DISTRIBUTION
Red Sea, Kenya, Persian Gulf, Thailand, Indonesia and Australia (see Sakai, 1982, 2006; Ngoc-Ho, 1990).

Species *Upogebia pseudochelata* Tattersall, 1921

Upogebia (Upogebia) pseudochelata Tattersall, 1921: 395.
Upogebia pseudochelata.—Sakai & Apel, 2002: 286.—Sakai, 2006: 133.

MATERIAL EXAMINED
ZUTC Tha. 1026 (west of Zeyton Park S 49; 21♀, 9♂, 4 juveniles) SMF 26523 (Socotra, Yemen; 1♀, 1♂), NHMW 24987 (west of Zeyton Park S 49; 1♂, 2♀).

REMARKS
The largest specimen was TL = 24.1 mm and CL = 6 mm. Some specimens of the present study show minor variations in characters which do not completely agree with the descriptions of Tattersall (1921) and Sakai (1982), especially the rostrum appears to be longer than in described material and extends beyond the eyes. This is possibly an intrapopulational difference (V.S., personal communication with Dworschak, 2010). The anterior part of rostrum at the lateral margins bears three denticles.

In the present study, it was noteworthy that many individuals of *U. pseudochelata* were found in the west of Qeshm Island, in layered limestone living within small U-shaped cavities.

HABITAT
Layered limestone rocks with crevices.

WORLD DISTRIBUTION
Red Sea and Socotra (Sakai, 2006), Persian Gulf (Present Study).

DISCUSSION

There are few studies on mud shrimps of the Persian Gulf but there is no study on the Gulf of Oman. This survey is the first thorough study of intertidal mud shrimps of these Iranian intertidal regions. The studies by Nobili (1906), Sakai & Türkay (1995) and Dworschak (2009) mostly focused on the Arabian parts of the Persian Gulf, and Tirmizi (1970, 1974, 1977) on the Arabian Sea. A recent study by Sepahvand & Sari (2010) on the mud shrimps of Qeshm Island, Persian Gulf resulted in a first record of seven species from 11 localities in Iran. In the present study, four more new records were added to the mud shrimps fauna of the studied area and the geographical distribution of the different species were considered along the 2440 km-long Iranian coastline.

According to Sepahvand & Sari (2010), the mud shrimps of Qeshm Island, Persian Gulf include seven species namely, *Paratrypaea* (as *Callianassa*) *bouvieri*, *Michaelcallianassa indica*, *Neocallichirus jousseaumei* (as *N. indicus*), *Callichirus* (as *Podocallichirus*) *masoomi*, *Upogebia carinicauda*, *Callianidea typa* and *Gourretia coolibah*. The present study added another two, *U. darwinii* and *U. pseudochelata* to the list of species from Qeshm Island.

Among the Iranian mud shrimps of the present study, the most common species were *Neocallichirus jousseaumei* and *N. calmani*. The genus *Upogebia* with three species has the highest species richness, and the genera *Callichirus*, *Corallianassa*, *Michaelcallianassa*, *Callianidea*, *Paratrypaea* and *Gourretia* each with one species, have the lowest species richness. Most species, based on recorded localities by Sakai (2005, 2006, 2011), show an Indo-West Pacific distribution pattern.

https://doi.org/10.1017/S0025315412001361 Published online by Cambridge University Press

As far as distribution is concerned, Apel & Spiridonov (1998), Apel & Türkay (1999) and Naderloo & Sari (2007) demonstrated a biogeographical pattern and zoogeographical affinities for crabs of the Persian Gulf with adjacent regions. According to the observed distribution of the species, the 11 mud shrimps of the Persian Gulf and Gulf of Oman could be categorized into two regions as follows:

1. Four species are Indian Ocean species. *Michaelcallianassa indica* and *Gourretia coolibah* are each found in two discrete localities while *Upogebia pseudochelata*, *Callichirus masoomi* are endemic to the north-west Indian Ocean.
2. Seven species are Indo-West Pacific species. These include *Corallianassa coutierei*, *Paratrypaea bouvieri*, *Upogebia carinicauda*, *U. darwinii*, *Neocallichirus calmani* and *N. jousseaumei*. The first species in the list is also found in Hawaii and the last species is widely distributed in the region. One species, *Callianidea typa*, is also found in the wider area of the Indo-Pacific region.

For the first category, one species, *Gourretia coolibah* has a limited distribution and was found by Dworschak (2009) and in the present study from the Persian Gulf but, previously recorded by Poore & Griffin (1979) from Western Australia. The other species, *Michaelcallianassa indica* was found previously from the Persian Gulf and Andaman Sea by Sakai (2002) and from the Persian Gulf in the present study. These two species show a patchy distribution with our current knowledge on their world records.

Two families, the Callianassidae (63%) and Upogebiidae (27%) have the highest species richness among mud shrimps in the studied region. The remaining family Callianideidae shows the lowest species richness with only one representative.

This reasonably high diversity is related to a long coastline and a considerable diversity of habitat types. This habitat diversity was more visible in Qeshm Island (located at the entrance of the Strait of Hormuz). The coastal area of Qeshm Island is influenced by different wave action and currents and includes several habitat types such as mangrove, sandy, muddy, rocky, coral gravel and a combination of these. The dominant species in the Gulf of Oman, continental coast of the Persian Gulf, and boulder dominated sandy-mud coasts (at Gulf of Oman and Qeshm Island) were

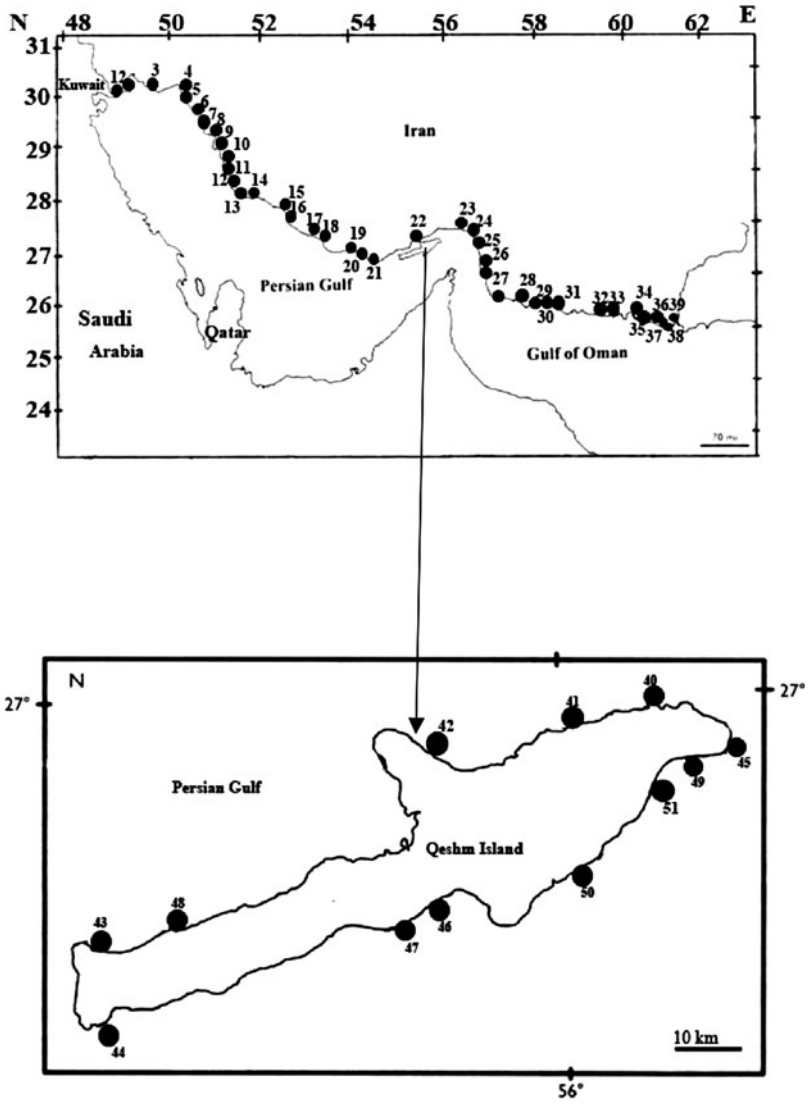

Fig. 1. (A) Sampling localities along the Persian Gulf and Gulf of Oman coastline; (B) sampling localities at Qeshm Island, Persian Gulf (for details of localities see Tables 1 and 2).

https://doi.org/10.1017/S0025315412001361 Published online by Cambridge University Press

Neocallichirus calmani, *Michaelcallianassa indica* and *N. jousseaumei*, respectively. The present study shows that mud shrimps are associated with different habitat types and were found only in 21 out of 51 stations. In ten stations (Table 1), two to four species were found sympatrically (but in different microhabitats). Despite several attempts, no mud shrimps were found along the entire coast of the north-east Persian Gulf (including Khuzestan and the eastern part of Bushehr Provinces) possibly due to the degraded nature of the habitat including dominance of very soft sediments, higher salinity or pollution (see Figure 1 and Table 2 for localities and their habitat types). The salinity on the northern coast is about 39–49‰ (Sanlaville & Prieur, 2005) while this value reaches up to 57‰ on the southern coast (John *et al.,* 1990). This is mostly due to the shallowness of the Persian Gulf. In addition, in the recent years seawater in this region is getting more saline due to the on land desalination activities by the Persian Gulf countries (Bashitialshaaer *et al.,* 2011). For the pollution, several studies revealed that the heavy metal concentrations in the northern Persian Gulf including Bushehr and Khuzestan Provinces are higher than that of other regions of the Gulf (see Diagomanolin *et al.,* 2004; Pourang *et al.,* 2005; Karbasi *et al.,* 2005; Dehghan-Madiseh *et al.,* 2009; Kazemi *et al.,* 2011). This is mainly due to oil pollution and other anthropogenic impacts.

In the rest of the Persian Gulf, and in the entire Gulf of Oman, in each, three species were found. In the present study, three species of *Upogebia* were found in the Persian Gulf but no *Upogebia* were recorded on the Iranian coast of the Gulf of Oman. This might be related to the rough wave action of the exposed shores with a scarcity of soft sediment, which is crucial for burrow construction, and lining of the burrow walls in these species. In contrast, Qeshm Island shows the highest species diversity (nine species including three species of *Upogebia*), which is mostly a reflection of the habitat diversity of the Island.

The current survey was the first study on Iranian mud shrimp and provides a basis for future studies on the ecology of these species, their burrow types and their role in sediment bioturbation of the region.

ACKNOWLEDGEMENTS

We are very grateful to Professor M. Türkay and Dr P.C. Dworschak from the Senckenberg Museum, Frankfurt and Museum of Natural History Vienna, respectively, for their help and encouragement during this study. Their hospitality during visits to their Museums by V.S. and A.S. is acknowledged. Special thanks are due to Dr C. Tudge from the American University and the Smithsonian Institution, Washington, DC for his encouragement, provision of the yabby pump for sampling, help with relevant literature and his valuable comments on the manuscript. Thanks are extended to Professor K. Sakai for his kind assistance in this study. Thanks are due to Mr R. Naderloo for help with sampling and material identification, and providing some relevant literature. Sampling would have been impossible without the help of Mr A. Kazemi. Financial help and facilities were provided by the Department of Environment and Research Council of the University of Tehran—their support is highly appreciated.

REFERENCES

Anker A. and Marin I. (2009) The alpheid shrimp genus *Leptalpheus* Williams, 1965, in the tropical western Pacific, with description of two new species (Crustacea: Decapoda: Caridea). *Raffles Bulletin of Zoology* 57, 91–107.

Apel M. and Spiridonov V.A. (1998) Taxonomy and zoogeography of the portunid crabs (Crustacea: Decapoda: Brachyura: Portunidae) of the Arabian Gulf and adjacent waters. *Fauna of Arabia* 17, 159–331.

Apel M. and Türkay M. (1999) Taxonomic composition, distribution and zoogeographic relationships of the grapsid and ocypodid crab fauna of intertidal soft bottoms in the Arabian Gulf. *Estuarine, Coastal and Shelf Science* 49 (Supplement A) 13, 1–142.

Bashitialshaaer R.A.I., Persson K.M. and Aljaradin M. (2011) Estimated future salinity in the Arabian Gulf, the Mediterranean Sea and the Red Sea consequences of brine discharge from desalination. *International Journal of Academic Research* 3, 133–140.

Borradaile L.A. (1903) On the classification of the Thalassinidea. *Annals and Magazine of Natural History, (series 7)* 12, 534–551.

Dana J.D. (1852) Macroura. Conspectus Crustaceorum, and Conspectus of the Crustacea of the exploring expedition under Capt. C. Wilkes, U.S.N. *Proceedings of the Academy of Natural Sciences of Philadelphia* 6, 10–28.

Dehghan-Madiseh S., Savary A., Parham H. and Sabzalizadeh S. (2009) Determination of the level of contamination in Khuzestan coastal waters (Northern Persian Gulf) by using an ecological risk index. *Environmental Monitoring Assessment* 159, 521–530.

Diagomanolin V., Farhang M., Ghazi-Khansari M. and Jafarzadeh N. (2004) Heavy metals (Ni, Cr, Cu) in the Karoon waterway river, Iran. *Toxicology Letters* 151, 63–68.

Dworschak P.C. (1992) The Thalassinidea in the Museum of Natural History, Vienna; with some remarks on the biology of the species. *Annalen des Naturhistorischen Museums in Wien* 93B, 189–238.

Dworschak P.C. (2003) A new species of ghost shrimp from the Gulf of Aqaba, Red Sea (Crustacea: Decapoda: Callianassidae). *Annalen des Naturhistorischen Museums in Wien* 104B, 415–428.

Dworschak P.C. (2007) A new species of *Eucalliax* Manning and Felder, 1991 (Decapoda: Callianassidae) from the Red Sea. *Proceedings of the Biological Society of Washington* 118, 209–217.

Dworschak P.C. (2009) On a small collection of thalasssinidean shrimp (Crustacea: Decapoda) from Qatar (Persian–Arabian Gulf). *Annalen des Naturhistorischen Museums in Wien* 110 B, 129–137.

Dworschak P.C. (2011) Redescription of *Callianassa jousseaumei* Nobili, 1904, a junior subjective synonym of *Callianassa indica* De Man, 1905 with description of a new species of *Neocallichirus* (Decapoda: Axiidea: Callianassidae). *Zootaxa* 2746, 1–19.

Dworschak P.C. (2012) The identities of *Callianassa bouvieri* Nobili, 1904, *C. maldivensis* Borradaile, 1904, and *C. gravieri* Nobili, 1905 (Crustacea: Decapoda: Callianassidae): a morphometric approach. *Zootaxa* 3149, 39–56.

Dworschak P.C. and Pervesler P. (1988) Burrows of *Callianassa bouvieri* Nobili, 1904 from Safaga (Egypt, Red Sea) with some remarks on the biology of the species. *Senckenbergiana Maritima* 20, 1–17.

Felder D.L. and Robles R. (2009) Molecular phylogeny of the family Callianassidae based on preliminary analyses of two mitochondrial genes. In Martin J.W., Crandall K.A. and Felder D.L. (eds) *Decapod crustacean phylogenetics. Crustacean issues*. Volume 18. Boca Raton, London, New York: CRC Press, Taylor & Francis Group, pp. 327–342.

Griffis R. and Suchanek T.H. (1991) A model of burrow architecture and trophic modes in thalassinidean shrimp (Decapoda: Thalassinidea). *Marine Ecology Progress Series* 79, 171–183.

John V.C., Coles S.L. and Abozed A.I. (1990) Seasonal cycle of temperature, salinity and water masses of the Western Arabian Gulf. *Oceanologica Acta* 13, 273–281.

Karbasi A.R., Nabi-Bidhendi Gh.R. and Bayati I. (2005) Environmental geochemistry of heavy metals in a sediment core off Bushehr, Persian Gulf. *Iranian Journal of Environmental Health Science and Engineering* 2, 255–260.

Kazemi A., Riyahi-Bakhtiari A., Kheirabadi N., Barani H. and Haidari B. (2011) Distribution patterns of metals contamination in sediments based on type of regional development on the intertidal coastal zones of the Persian Gulf, Iran. *Bulletin of Environmental Contamination Toxicology* 88, 100–103.

Kensley B. (1975) Records of mud-prawns (genus *Callianassa*) from South Africa and Mauritius (Crustacea, Decapoda, Thalassinidea). *Annals of the South African Museum* 69, 47–58.

Komai T. and Tachikawa H. (2008) Thalassinidean shrimps (Crustacea: Deeapoda) from the Ogasawara Islands, Japan. *Natural History Research* 10, 19–52.

Kossmann R. (1880) *Zoologische Ergebnisse einer im Auftrag der königlichen Academie der Wissenschaften zu Berlin ausgeführten Reise in die Küstengebiete des Rothen Meeres. Zweite Hälfte, Erste Lieferung, 3 Malacostraca. 2. Theil: Anomura*. Leipzig: Engelmann, pp. 67–140.

Leach W.E. (1814) Crustaceology. In Brewster D. (ed.) *Edinburgh encyclopaedia*. 2nd edition. New York: Samuel Whiting and John L. Tiffany, pp. 385–737, 221 pls.

Man J.G. de (1928) The Thalassinidae and Callianassidae collected by the Siboga-Expedition with some remarks on the Laomediidae. The Decapoda of the Siboga-Expedition. Part VII. *Siboga Expeditie Monographs* 39, 1–187, pls. 1–20.

Manning R.B. (1975) Two methods for collecting decapods in shallow water. *Crustaceana* 29, 317–319.

Manning R.B. (1987) Notes on western Atlantic Callianassidae (Crustacea: Decapoda: Thalassinidea). *Proceedings of the Biological Society of Washington* 100, 386–401.

Manning R.B. and Felder D.L. (1991) Revision of the American Callianassidae (Crustacea: Decapoda: Thalassinidea). *Proceedings of the Biological Society of Washington* 104, 764–792.

Miers E.J. (1884) Crustacea (Brachyura). In *Report on the zoological collections in the Pacific Ocean during the voyage of H.M.S. 'Alert' 1881–1882. Part I. The collections from Melanesia*. 8. London: British Museum (Natural History), pp. 178–322, pls 18–32.

Milne Edwards H. (1837) Les Crustaces. In Cuvier G. (ed.) *Le Règne Animal distribué d'après son organisation, pour servir de base à l'histoire naturelle des animaux et d'introduction à l'anatomie comparée. Edition accompagnée de planches gravées par une réunion des disciples de Cuvier*. 2 volumes. Paris: Masson, pp. 1–278, pls 1–80.

Naderloo R. and Sari A. (2007) Subtidal crabs of the Iranian coast of the Persian Gulf: new collections and biogeographic considerations. *Aquatic Ecosystem Health and Management* 10, 341–349.

Ngoc-Ho N. (1990) Nine Indo-Pacific species of *Upogebia* Leach (Crustacea: Thalassinidea: Upogebiidae). *Journal of Natural History* 24, 965–985.

Nobili G. (1904) Diagnoses preliminaires de vingt-huit especes nouvelles de Stomatopodes et Decapodes Macroures de la mer Rouge. *Bulletin du Muséum National d'Histoire Naturelle, Paris* 10, 230–238.

Nobili G. (1906) Faune carcinologique de la Mer Rouge, Decapodes et Stomatopodes. *Annales des Sciences Naturelles, Zoology* 4, 1–347.

Poore G.C.B. and Griffin D.J.G. (1979) The Thalassinidea (Crustacea: Decapoda) of Australia. *Records of the Australian Museum* 32, 217–321.

Pourang N., Nikouyan A. and Dennis J.H. (2005) Trace element concentrations in fish, surficial sediments and water from northern part of the Persian Gulf. *Environmental Monitoring and Assessment* 109, 293–316.

Robles R., Tudge C.C., Dworschak P.C., Poore G.C.B. and Felder D.L. (2009) Molecular phylogeny of the Thalassinidea based on nuclear and mitochondrial genes. In Martin J.W., Crandall K.A. and Felder D.L. (eds) *Decapod crustacean phylogenetics*. Crustacean issues. Volume 18. Boca Raton, London and New York: CRC Press, Taylor & Francis Group, pp. 309–326.

Saint Laurent M. de (1973) Sur la systématique et la phylogénie des Thalassinidea: définition des familles des Callianassidae et des Upogebiidae et diagnose de cinq genres nouveaux. *Comptes Rendus Hebdomadaires de Séances de l'Académie des Sciences, Paris* 277, 513–516.

Sakai K. (1982) Revision of Upogebiidae (Decapoda, Thalassinidea) in the Indo-West Pacific region. *Researches on Crustacea, Tokyo* (Special Number 1), 1–106, pls A–G.

Sakai K. (1988) A new genus and five new species of Callianassidae (Crustacea: Decapoda: Thalassinidea) from northern Australia. *The Beagle, Records of the Northern Territory Museum of Arts and Sciences* 5, 51–69.

Sakai K. (1999) Synopsis of the family Callianassidae, with keys to subfamilies, genera and species, and the description of new taxa (Crustacea: Decapoda: Thalassinidea). *Zoologische Verhandelingen, Leiden* 326, 1–152.

Sakai K. (2002) Callianassidae (Decapoda, Thalassinidea) in the Andaman Sea, Thailand. In Bruce N.L., Berggren M. and Bussawarit S. (eds) *Proceedings of the International Workshop on the Biodiversity of Crustacea of the Andaman Sea. Phuket Marine Biological Center Special Publication* 23, pp. 461–532.

Sakai K. (2005) Callianassoidea of the world (Decapoda: Thalassinidea). *Crustaceana Monographs* 4, 1–200.

Sakai K. (2006) Upogebiidae of the world (Decapoda, Thalassinidea). *Crustaceana Monographs* 6, 1–185.

Sakai K. (2011) Axioidea of the world and a reconsideration of the Callianassoidea (Decapoda, Thalassinidea, Callianassida). *Crustaceana Monographs* 13, 1–616.

Sakai K. and Apel M. (2002) Thalassinidea (Crustacea: Decapoda) from Socotra Archipelago, Yemen, with a new species of *Lepidophthalmus*. *Fauna of Arabia* 19, 273–288.

Sakai K. and Türkay M. (1995) Two upogebiid species from the Persian–Arabian Gulf, with the description of a related new species from Taiwan (Crustacea: Decapoda: Upogebiidae). *Senkenbergiana Maritima* 25, 197–208.

Sankolli K.N. (1971) The Thalassinoidea (Crustacea, Anomura) of Maharashtra. *Journal of the Bombay Natural History Society* 68, 94–106.

Sanlaville P. and Prieur A. (2005) Asia, Middle East, coastal ecology and geomorphology. In Schwartz M.L. (ed.) *Encyclopedia of coastal science*. Dordrecht, The Netherlands: Springer, pp. 71–83.

Sepahvand V. and Sari A. (2010) Taxonomy and geographical distribution of intertidal thalassinidean shrimps (Crustacean: Decapoda) from the Qeshm Island, Persian Gulf. *Journal of Science, University of Tehran* 36, 43–52.

Stimpson W. (1860) Prodromus descriptionis animalium evertebratorum, quae in Expeditione ad Oceanum Pacificum Septentrionalem, a Republica Federata missa, Cadwaladaro Ringgold et Johanne Rodgers Ducibus, observavit et descripsit. Pars VIII. Crustacea Macrura. *Proceedings of the Academy of Natural Sciences of Philadelphia* 12, 22–47.

https://doi.org/10.1017/S0025315412001361 Published online by Cambridge University Press

Stimpson W. (1866) Descriptions of new genera and species of macrurous Crustacea from the coasts of North America. *Proceedings of the Chicago Academy of Sciences* 1, 46–48.

Tattersall W.M. (1921) Report on the Stomatopoda and macrurous Decapoda collected by Mr. Cyril Crossland in the Sudanese Red Sea. *Journal of the Linnean Society of London (Zoology)* 34, 345–398, pls 27–28.

Tirmizi N.M. (1970) A new species of *Callianassa* (Decapoda, Thalassinidea) from West Pakistan. *Crustaceana* 19, 245–250.

Tirmizi N.M. (1974) A description of *Callianassa martensi* Miers, 1884 (Decapoda, Thalassinidea) and its occurrence in the northern Arabian Sea. *Crustaceana* 26, 286–292.

Tirmizi N.M. (1977) A redescription of the holotype of *Callianassa mucronata* Strahl, 1862 (Decapoda, Thalassinidea). *Crustaceana* 32, 21–26.

Tirmizi N.M. and Ghani N. (1978) *Upogebia quddusiae* n. sp. from Pakistan (Decapoda, Thalassinidea). *Crustaceana* 35, 134–138.

Tudge C.C., Poore G.C.B. and Lemaitre R. (2000) Preliminary phylogenetic analysis of generic relationships within the Callianassidae and Ctenochelidae (Decapoda: Thalassinidea: Callianassoidea). *Journal of Crustacean Biology* 20 (Special number 2), 129–149.

and

Vaugelas J. de (1990) *Ecologie des Callianasses (Crustacea Decapoda Thalassinidea) en milieu recifal Indo-Pacifique. Consequences du remaniement sedimentaire sur la distribution des matieres humiques, des metaux traces et des radionuclides*. Université de Nice, 226 pp.

Correspondence should be addressed to:
A. Sari
School of Biology and Centre of Excellence in Phylogeny of Living Organisms
College of Science, University of Tehran, Tehran, Iran
email: sari@ut.ac.ir

https://doi.org/10.1017/S0025315412001361 Published online by Cambridge University Press