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Three new species of narrowly endemic snapping shrimp, genus *Alpheus* (Decapoda: Caridea: Alpheidae) from the Persian Gulf

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Abstract

Three new species of snapping shrimps of the genus *Alpheus* are described from the Persian Gulf. These belong to the *Alpheus edwardsii* species-group, which is mainly characterized by unarmed orbital hoods and the presence of dorsal and ventral notches on the palm of the major chela. *Alphus ankeri* sp. nov. shows a close affinity to *A. pacificus* Dana, 1852 and *A. heronicus* Banner & Banner, 1982 bearing no balaeniceps crests in both sexes on the dactylus of the minor chela, and the merus of the major chela of both sexes are unarmed. This species differs from the closely related species by the absence of an overhanging proximal shoulder in the major chela. The other rock crevice inhabiting species, *A. mohammadpouri* sp. nov. is diagnosed by exhibiting sexual dimorphism in its balaeniceps crests and the armed merus of the major chela. These two characters are similar to those recorded for three sandy/rubble dwelling species: *A. inopinatus* Holthuis & Gottlieb, 1958, *A. lobidens* De Haan, 1849 and *A. australiensis* Banner & Banner, 1982. This new species is distinguishable from these latter species by the shape of the minor chela and colour pattern. A coral inhabiting species *A. abumusa* sp. nov. appears to be closely related to *A. maindroni* Coutière, 1898, showing an armed merus of the major chela and the absence of spine-like seta on the ischia of the third legs. This last new species is easily discriminated from *A. maindroni* by longer antennular segments, a markedly concave frontal margin between the rostrum and orbital hood, and a different colour pattern.

Introduction

The genus *Alpheus* Fabricius, 1798 with 307 species is the most specious genus of the family Alpheidae (De Grave & Fransen, 2011; Almeida *et al.*, 2014; Bracken-Grissom *et al.*, 2014; Anker & Pachelle, 2015; Anker, 2018; Komai & Ohtomi, 2018), however, the number of species in the genus is estimated to be over 400 (Anker *et al.*, 2006). This genus has not been well studied in the Persian Gulf (Anker & De Grave, 2009). The first study on alpheids of the Persian Gulf resulted in the description of two species, namely *A. bucephaloides* Nobili, 1905, and *A. persicus* Nobili, 1905 (now considered a junior synonym of *A. malleodigitus* (Spence Bate, 1888)). Shortly afterwards, Nobili (1906) in a detailed review of the material collected by J. Bonnier and Ch. Pérez from the region added two species: *A. audouini* Coutière, 1905 (currently considered to be a synonym of *A. edwardsii* (Audouin, 1826)) and *A. alcyone* De Man, 1902. Later, Banner & Banner (1966) examined the unnamed *Alpheus* sp. of Nobili (1906) and described this as a new species, *A. nobili* Banner & Banner, 1966. Further, new records of *A. distinguendus* De Man, 1909 (now considered a junior synonym of the Japanese *A. digitalis* De Haan, 1844 (in De Hann, 1833–1850)) and an *Alpheus* sp. were recorded from Kuwait by Motoh (1975). Shortly afterwards, Basson *et al.* (1977) recorded *Alpheus dentipes* Guérin, 1832 from the Persian Gulf coast of Saudi Arabia. The caridean material collected by the Danish Expedition in Iran from 1937 to 1938 was examined by Banner & Banner (1981), and six *Alpheus* species were recorded from the Persian Gulf. However, they provided no exact locality details. These are *A. bisincisus* De Haan, 1844 (in De Hann, 1833–1850), *A. euphrosyne* De Man, 1897, *A. lobidens* De Haan, 1844 (in De Hann, 1833–1850), *A. lottini* Guérin-Meneville, 1838 (in Guérin-Meneville, 1829–1838), *A. rapax* Fabricius, 1798, and *A. parvirostris* Dana, 1852. In the 'Field Guide to Sea Shores of Kuwait', Jones (1986) later recorded *A. djeddensis* Coutière, 1897. Recently, a new species was described from Kuwait as *A. lutosus* Anker & De Grave, 2009. An updated list of caridean shrimps was provided by De Grave & Ashelby (2011), including 14 species of *Alpheus*. Three more species were recorded by Naderloo & Türkay (2012) from the Iranian coast, namely *A. edamensis* De Man, 1888, *A. macrodactylus* Ortmann, 1890 and *A. paracrinitus* Miers, 1881. Naderloo *et al.* (2013) later recorded two new records as *Alpheus* spp. from the Qeshm Island. In total, 17 species of the genus *Alpheus* were known prior to the current study from the Persian Gulf, although some of the records appear to be rather dubious. However, the actual alpheid diversity of the Persian Gulf is clearly under-studied and comprehensive sampling and a thorough taxonomic review are required. In the present study, three medium-sized new species belong to the *A. edwardsii* species group are described.

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Materials and methods

From May 2014 to June 2017, a series of surveys was carried out in Abu-Musa Island, as part of the projects 'Crustacean diversity along the Iranian coast' and 'Biodiversity of the Intertidal Region of Abu-Musa Island'. Fresh material for the present study was collected from four stations around the island by hand. Colour photographs were immediately taken in the field. The samples were preserved in 95% ethanol, and then kept in a −20°C refrigerator for long-term preservation for molecular studies. The holotypes, allotypes and paratypes are deposited in the Zoological Museum, University of Tehran (ZUTC) and some paratypes will be deposited at Naturalis Biodiversity Centre (formerly Rijksmuseum van Natuurlijke Historie) (RMNH). Holotypes were examined for morphological characters, while two paratypes (male and female) specimens were used for drawings. All the drawings were made using a camera lucida fitted on a stereomicroscope Leica MZ6.

Systematics

Order Decapoda Latreille, 1802
Family Alpheidae Rafinesque, 1815
Genus *Alpheus* Fabricius, 1798
Alpheus ankeri sp. nov.
(Figures 1A & B and Figure 2)

Type material: Holotype: adult male, carapace length (CL) 8.4 mm, ZUTC 6660, Qadir Park, Abu-Musa Island, Persian Gulf, Iran, 25°53′45″N 55°02′23″E, rock crevices, 10 May 2016, Coll. A. Dehghani, A. Sari, R. Naderloo and H. Ashrafi. Allotype: adult female, CL 9.1 mm, ZUTC 6661, same data as holotype. Paratypes (CL range 8–9 mm): 4 males, 5 females, ZUTC 6666, same data as holotype. Paratypes: 4 males, 2 females, ZUTC 6665, Siri Island, Persian Gulf, Iran, 25°53′48″N 54° 32′21″E, rock crevices, Coll. A. Dehghani, A. Sari and S. Ashrafi, 5 November 2016.

Type locality: Persian Gulf, Abu-Musa Island, Iran.

Description

Medium-sized species of *Alpheus* (CL range 8–9 mm). **Carapace** smooth, not setose. Rostrum small and conical, slightly longer than broad at base, tip not reaching to middle of first article of antennular peduncle; rostral carina not distinct. Orbital hoods rounded and anterior margin unarmed, slightly concave near rostrum, no projections between rostrum and orbital hoods. Pterygostomial angle rounded, not protruding (Figure 2A & B). Cardiac notch well developed.

Antennular peduncle with second segment of about 1.5 times as long as visible part of first and about twice as long as third; stylocerites with sharp point reaching to end of first article; ventromesial carina with small and broadly triangular tooth. **Antenna** with stout basicerites bearing small and acute distoventral tooth; scaphocerite with concave lateral margin and well-developed blade, latter not over-reaching strong distolateral tooth; carpocerites remarkable and reaching beyond scaphocerite (Figure 2A & B).

Mouthparts (Figure 2C) not dissected, typical for *Alpheus* in external view; third maxilliped slender, pediform; when extended markedly longer than antennular peduncle and carpocerite; antepenultimate article flattened ventromesially; penultimate and ultimate segment as illustrated, not species-specific; exopod equal to distal margin of antepenultimate segment.

Major chela (Figure 2D–F) generally similar in both sexes, not significantly larger in males; ischium short, stout; merus relatively stout, about 2.9 as long as wide, distodorsal margin curved, distomesial unarmed, with blunt distal end; carpus short, cup-shaped, with broadly rounded distal lobes; dorsal groove of major chela almost abruptly rounded, not extending posteriorly on mesial face, dorsal shoulder rounded, not overhanging, ventral shoulder rounded, slightly protruding anteriorly (Figure 2E); dactylus longer than pollex, distally rounded, not twisted, with large stout plunger; adhesive discs well developed (Figure 2D–F).

Minor chela (Figure 2G &H) not sexually dimorphic, slender than major chela; ischium very short; merus stout, about 2.5 times as long as wide, distodorsal margin ending curved; distomesial without tooth, with broad dorsal lobe; carpus short, cup-shaped; palm almost equal to length of fingers; palm surface smooth, without any grooves and crests; fingers equal in length, crossing distally, covered with scattered long setae; dactylus almost flattened dorsally; pollex thicker than dactylus; opposing surface of fingers excavate (Figure 2H).

Second pereiopod (Figure 2I) slender; merus 1.1 as long as ischium; carpus with five joints; first segment about two times as long as second; second segment two times as long as third; third and fourth segments nearly equal in length; fifth segment about two times as long as fourth (6:3:2:2:3); chela simple, as long as two distal-most carpal joints combined. Third (Figure 2J) and fourth pereiopod generally similar, relatively slender; ischium without spine-like seta; merus around five times as long as wide; merus 1.75 as long as carpus, without spine-like seta; propodus about as long as carpus but shorter than merus, inferior margin with seven spine-like setae and one distal pair near dactylus, dorsolateral side with row of long setae; dactylus conical, long and pointed, about one fourth of propodus.

Telson (Figure 2K) subrectangular, tapering distally, about 1.75 times as long proximal width, lateral margin slightly convex; dorsal surface with two pairs of postero-lateral spine-like setae, first pair at about mid-length part, second pair on about 3/4 telson length; each posterolateral angle with pair of spine-like setae, mesial about twice as long as lateral. (Figure 2K).

Uropod with bifid protopod, inner and outer lobes ending in acute tooth, exopod and endopod more or less equal in length, rounded distally; exopodal diaeresis with three small lobes separated by two notches; corner of disto-lateral margin of protopod bearing tufts of setae (Figure 2K).

Colour pattern (Figure 2A & B): Based on living specimens, female and male individuals show dimorphism. Females with carapace, abdomen, major and minor chela and uropods dark brown orange. Male carapace, abdomen, major and minor chela and uropods with pale orange and walking legs semi-transparent with red patches.

Habitat: All specimens were collected from exposed rocky shores near to high intertidal in deep crevices of the bedrock made of coarse sand where they experience short periods of dry environment during low tide.

Distribution: Presently only known from the Abu-Musa and Siri Islands, Persian Gulf, Iran.

Etymology: The species is named after Dr Arthur Anker, a well-known carcinologist for his valuable contribution to caridean taxonomy.

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Fig. 1. Three new species of the genus *Alpheus* from Abu-Musa Island, Hormozgan, Persian Gulf, colour pattern in life. (A) *Alpheus ankeri* sp. nov., male holotype CL 8.4 mm; (B) female CL 9.1 mm; (C) *A. abumusa* sp. nov., male holotype CL 8.9 mm; (D) female CL 8.8 mm; (E) *A. mohammadpouri* sp. nov., male holotype CL 8.3 mm; (F) female CL 9.4 mm.

Remarks. *Alpheus ankeri* sp. nov. is morphologically closest to four species, namely *A. bunburius* Banner & Banner, 1982, *A. pacificus* Dana, 1852, *A. tasmanicus* Banner & Banner, 1982, and *A. heronicus* Banner & Banner, 1982. These five species are characterized by lacking a tooth on the merus of the major chela and showing no balaeniceps in both sexes.

Alpheus ankeri sp. nov. can be separated from *A. pacificus* and *A. heronicus* mainly by the absence of an overhanging shoulder in the major chela.

The new species is also easily distinguishable from *A. bunburius* by the presence of markedly shorter fingers, which are one third as long as the palm, while in *A. bunburius* the fingers are equal to the palm. *Alpheus tasmanicus* differs from *A. ankeri* sp. nov. in lacking spine-like setae on the ischium of the third legs and in addition the superior shoulder is not subrectangular in cross section.

Alpheus abumusa sp. nov.
(Figures 1C & D and Figure 3)

Type material. Holotype: adult male CL 8.9 mm, ZUTC 6662, Qadir Park, Abu-Musa Island, Persian Gulf, Iran, 25°53′45″N 55°02′23″E, in holes or canals in massive dead coral, 10 May 2016, Coll. A. Dehghani, A. Sari, R. Naderloo and H. Ashrafi.

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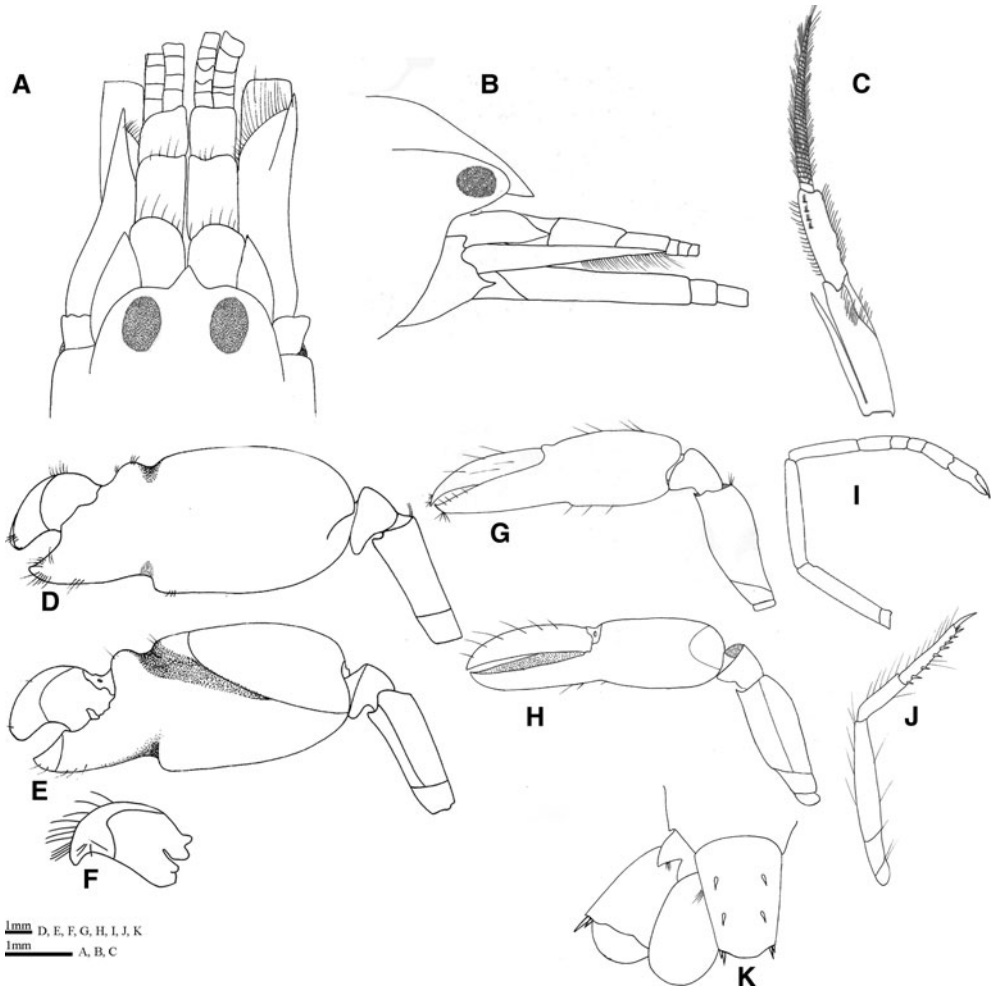

Fig. 2. *Alpheus ankeri* sp. nov., male paratype. (A) frontal region, dorsal view and (B) lateral view; (C) third maxilliped, mesial view; (D) right major chela, lateral view and (E) mesial view; (F) dactylus showing plunger in lateral view; (G) left minor chela in lateral view and (H) mesial view; (I) right second pereiopod in lateral view; (J) right third pereiopod in lateral view; (K) telson and uropods in dorsal view.

Allotypes: adult female CL 8.8 mm, ZUTC 6663 same data as holotype; Paratypes (CL range 8–9 mm): 5 males, 7 females, ZUTC 6667, same data as holotype.

Type locality: Abu-Musa Island, Persian Gulf, Iran.

Description

Medium-sized species of *Alpheus* (CL range 8–9 mm). **Carapace** smooth, not setose. Rostrum conical, slightly longer than broad at base, tip reaching to middle of first article of antennular peduncle; rostral carina distinct, slightly rounded dorsally, and continuing to base of eyes. Orbital hoods rounded and anterior margin unarmed, slightly concave near rostrum, no projections between rostrum and orbital hoods. Pterygostomial angle rounded, not protruding (Figure 3A & B). Cardiac notch well developed.

Antennular peduncle with second segment about 1.8 times as long as visible part of first and more than twice as long as third; stylocerites with sharp point extending beyond end of first article; ventromesial carina with small and broadly triangular tooth. **Antenna** with stout basicerites bearing small and acute distoventral tooth; scaphocerite with concave lateral margin and well-developed blade, latter not over-reaching strong distolateral tooth; carpocerites remarkable and extending beyond scaphocerite (Figure 3A & B).

Mouthparts (Figure 3C) not dissected, typical for *Alpheus* in external view; third maxilliped slender, pediform; when extended markedly longer than antennular peduncle and carpocerite; antepenultimate article flattened ventromesially; penultimate and ultimate segment as illustrated, not species-specific; exopod equal to antepenultimate segment.

Major chela (Figure 3D–F) generally similar in both sexes, not significantly larger in males; ischium short, stout; merus relatively stout, about 2.9 as long as wide, distodorsal margin curved, distomesial margin bearing an acute tooth terminally; carpus short, cup-shaped, with broadly rounded distal lobes; ventral margin with deep, broad transverse groove connecting to inverse V-shaped inferior lateral palmar depression, ventral shoulder not protruding anteriorly, rounded; dactylus longer than pollex, distally rounded, not twisted, with large stout plunger; adhesive discs well developed.

Minor chela (Figure 3G & H) similar to male but different in proportions, not sexually dimorphic, slender than major chela; ischium very short; merus stout, about 2.5 times as long as wide, distodorsal margin ending curved; distomesial with subacute tooth, with broad dorsal lobe; carpus short, cup-shaped; palm almost equal to length of fingers; palm surface smooth, without any grooves and crests; fingers equal in length, crossing distally, covered with scattered long setae; dactylus almost flattened dorsally; pollex thicker than dactylus; opposing surface of fingers excavate (Figure 3H).

Second pereiopod (Figure 3I) long and slender; merus and ischium almost equal; carpus with five joints; first segment

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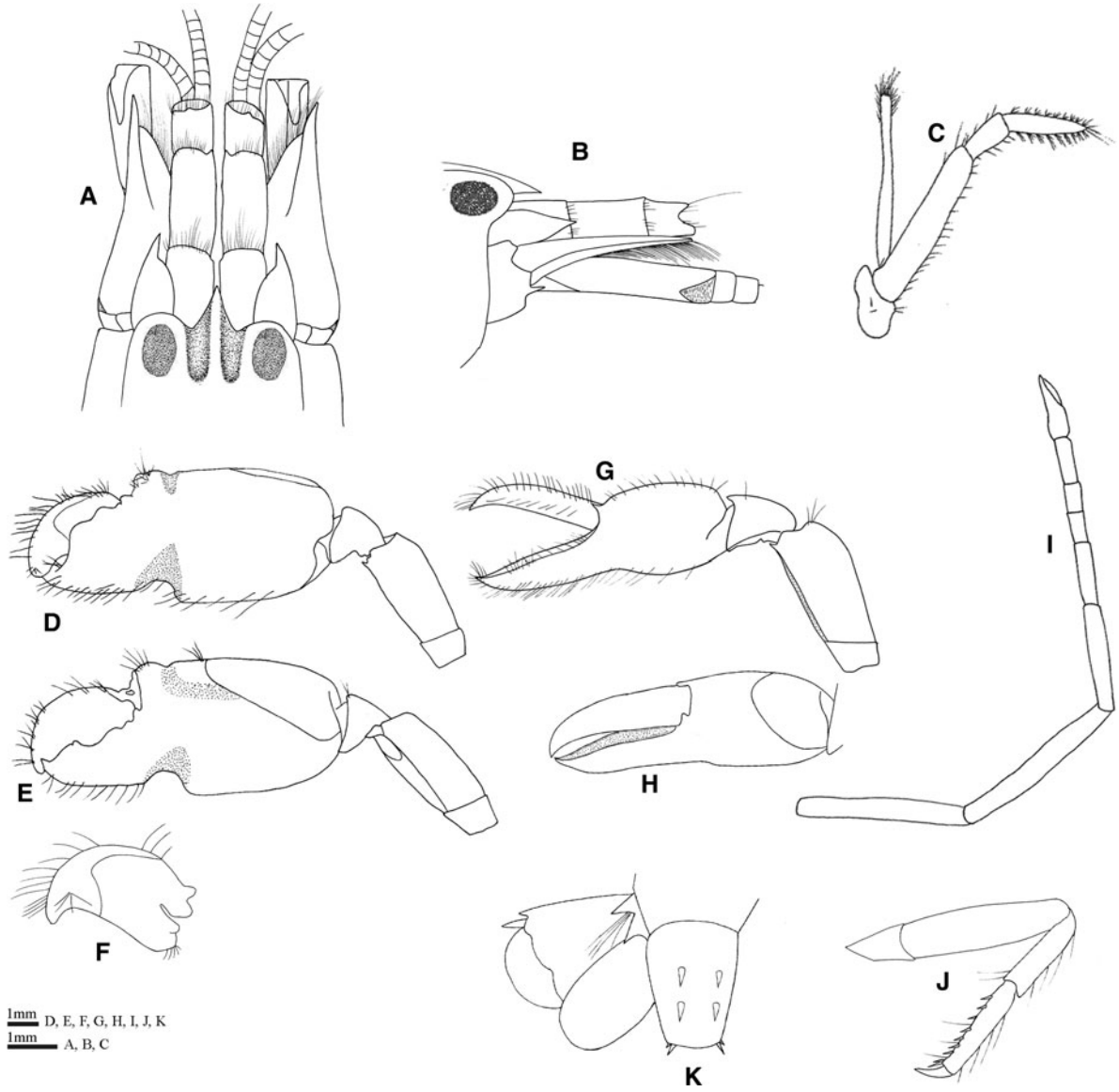

Fig. 3. *A. abumusa* sp. nov., male paratype. (A) frontal region, dorsal view and (B) lateral view; (C) third maxilliped, lateral view; (D) right major chela, lateral view and (E) mesial view; (F) dactylus showing plunger in lateral view; (G) left minor chela in lateral view and (H) mesial view; (I) right second pereiopod in lateral view; (J) right third pereiopod in lateral view; (K) telson and uropods in dorsal view.

about 1.5 times as long as second; second segment two times as long as third; third and fourth segments nearly equal in length; fifth segment 2.2 times as long as fourth segment (proximal to distal ratios: 4:2:1:1:2); chela simple, fingers nearly equal to palm.

Third (Figure 3J) **and fourth pereiopods** generally similar; ischium without spine-like seta; merus around five times as long as wide, without spine-like seta; carpus slightly longer than half of merus; propodus about 1.3 times as long as carpus but shorter than merus, ventral margin with seven spine-like setae and one distal pair near dactylus, dorsolateral side with row of long setae; dactylus conical, about 0.25 times as long as propodus**.**

Telson (Figure 3K) almost subrectangular, tapering distally, about 1.75 times as long as proximal width, lateral margin slightly convex; dorsal surface with two pairs of postero-lateral spine-like setae, first pair at about mid-length part, second pair on about 3/4 telson length; each posterolateral angle with pair of spine-like setae, mesial about twice as long as lateral.
Uropod (Figure 3K) with bifid protopod, inner and outer lobe ending in acute tooth, bearing tuft of long setae as illustrated, exopod and endopod more or less equal in length, rounded distally; exopodal diaeresis with three small lobes separated by two notches.

Colour pattern (Figure 1C & D): Based on live specimens, body generally translucent with brownish orange hands, hepatopancreas olive brown, abdomen with transverse broad dark green bands, fingers of major chela opaque white.

Habitat: This species characteristically is found in holes or canals in dead massive coral.

Distribution: Presently only known from the Abu-Musa Island, Persian Gulf, Iran.

Etymology: The species is named after the type locality, Abu-Musa.

Remarks. *Alpheus abumusa* sp. nov., based on the palm shape, is closely allied to *A. parvirostris* Dana, 1852, *A. bannerorum* Bruce, 1987 and *A. maindroni* Coutière, 1898. This new species differs from *A. parvirostris* by the lack of a spine on the merus of the third pereiopods, while the spine is markedly distinct in *A. parvirostris*. *Alpheus bannerorum* is readily distinguishable from *A.*

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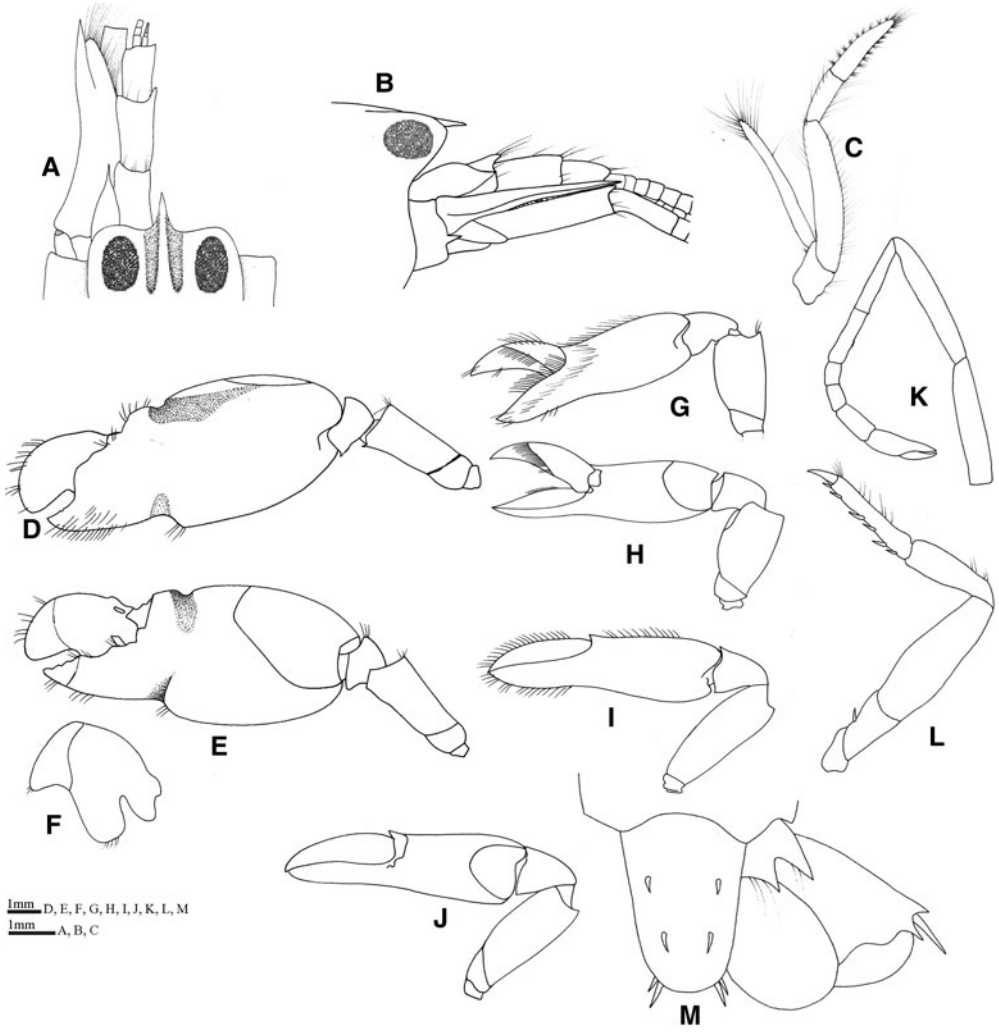

Fig. 4. *A. mohammadpouri* sp. nov., male paratype. (A) frontal region in dorsal view and (B) lateral view; (C) third maxilliped in lateral view; (D) right major chela in lateral view and (E) mesial view; (F) dactylus showing plunger in lateral view (G) left minor chela of male in lateral view and (H) mesial view; (I) left minor chela of female in lateral view and (J) mesial view; (K) right second pereiopod in lateral view; (L) right third pereiopod in lateral view; (M) telson and uropods in dorsal view.

abumusa sp. nov. by the presence of very obvious eye-like spots on the second and third somites of abdomen (see Anker & De Grave, 2016: 345, Figure 2). The new species is more similar to *Alpheus maindroni* Coutière, 1898, than any others in the *A. edwardsii* species group. *Alpheus maindroni* Coutière, 1898, was originally described from Muscat by Coutière (1898), and was defined by short and carinate rostrum, third pereiopods with unarmed ischia, merus of major chela with a disto-mesial tooth, uropod with a distinctly bilobed transverse suture and the male minor chela with well developed balaeniceps fingers. The main diagnostic feature of *A. maindroni* is a prominently elevated area in front of the dorsal notch of the major chela (see Coutière, 1898; Banner & Banner, 1982; Anker & De Grave, 2016). Using the last characteristics, *A. abumusa* sp. nov. is easily distinguished from *A .maindroni* in bearing a short, non-elevated area in front of the dorsal notch of the major chela (see Figure 3D & E). In addition, the second major discriminating feature that separates *A. maindroni* from *A. abumusa* sp. nov. is the deep orbito-rostral grooves and prominent carina, which is feebly developed in the latter species (Table 1).

Alpheus mohammadpouri sp. nov.
(Figures 1E & F and Figure 4)

Type material. Holotype: adult male CL 8.3 mm, ZUTC 6658, Qadir Park, Abu-Musa Island, Persian Gulf, Iran, 25°53′45″N 55°02′23″E, rock crevices, Coll. A. Dehghani, R. Naderloo and A. Sari, 10 May 2016; Allotype: adult female CL 9.4 mm, ZUTC 6659, same data as holotype; Paratypes: 2 males, 3 females, ZUTC 6664, locality data same as holotype, Coll. A. Dehghani and H. Ashrafi, 10 April 2016. Paratypes: 4 males, 2 females (CL range 8–9.5 mm), ZUTC 6708, Siri Island, Persian Gulf, Iran, 25°53′48″N 54°32′21″E, rocks crevices, Coll. A. Dehghani, A. Sari and S, Ashrafi, 5 November 2016.

Type Locality: Abu-Musa Island, Persian Gulf, Iran.

Description

Medium-sized species of *Alpheus* (CL range 8–9.5 mm). **Carapace** smooth, not setose. Rostrum conical, slightly longer than broad at base, tip reaching to middle of first article of antennular peduncle; rostral carina marked, rounded dorsally, and reaches posterior to orbital hoods. Orbital hoods rounded and anterior margin unarmed, slightly concave near rostrum, no projections between rostrum and orbital hoods. Pterygostomial angle rounded, not protruding (Figure 4A & B). Cardiac notch well developed.

Antennular peduncle with second segment about 1.5 times as long as visible part of first and more than twice as long as third; stylocerites with sharp point extending end of first article; ventromesial carina with small and broadly triangular tooth. **Antenna** with stout basicerites bearing small and acute

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Table 1. Morphological discriminative features of *A. abumusa* sp. nov. compared to morphologically related species *A. maindroni*

Characters	*A. abumusa* sp. nov.	*A. maindroni* (Based on Coutière, 1898; Banner & Banner, 1982)
Rostral carina	Prominent	Carina feebly developed (only visible in lateral view)
Orbitorostral grooves	Deep	Disappearing to shallow
Scaphocerite	Acute with strong tooth, reaching to distal margin of third antennular segment	Subacute, not reaching to end of third antennular segment
Frontal margin between rostrum and orbital hood	Very concave	Extended as slight acute prominences
Ratio of second to third antennular segment	2.33	1.17
Second antennular segment	3 times as long as broad	1.5 times as long as broad
Disto-dorsal corner of minor chela	With acute tooth	With bluntly rounded projection
Colour pattern	Hepatopancreas olive brown, abdomen with transverse broad dark green bands, fingers of major chela opaque white	Thorax and abdomen with red bands

distoventral tooth; scaphocerite with concave lateral margin and well-developed blade, latter not over-reaching strong distolateral tooth; carpocerites remarkable and extending beyond scaphocerite (Figure 4A & B).

Mouthparts (Figure 4C) not dissected, typical for *Alpheus* in external view; third maxilliped slender, pediform; when extended markedly longer than antennular peduncle and carpocerite; antepenultimate article flattened ventromesially; penultimate and ultimate segment as illustrated, not species-specific; exopod equal to antepenultimate segment.

Major chela (Figure 4D–F) generally similar in both sexes, not significantly larger in males; ischium short, stout; merus relatively stout, about 2.6 as long as wide, distodorsal margin curved, distomesial with acute tooth; carpus short, cup-shaped, with broadly rounded distal lobes; dorsal groove of major chela almost abruptly rounded, not extending posteriorly on mesial face, dorsal shoulder rounded, not overhanging, ventral shoulder rounded, slightly protruding anteriorly (Figure 4E); dactylus longer than pollex, distally rounded, not twisted, with large stout plunger; adhesive discs well developed (Figure 4D–F).

Minor chela (Figure 4G–J) sexually dimorphic, more slender than major chela; ischium very short; merus stout, about 3.5 times as long as wide, distodorsal margin ending curved; distomesial without tooth, with broad dorsal lobe; carpus short, cup-shaped; palm almost equal to length of fingers; palm surface smooth, without any grooves and crests; fingers equal in length, crossing distally, covered with scattered long setae; dactylus almost flattened dorsally; pollex thicker than dactylus; opposing surface of fingers excavate.

Second pereiopod (Figure 4K) slender; merus longer than ischium; carpus with five joints, ratio of segments approximately equal to 3.5:2.5:1:1:2; chela simple, fingers slightly shorter than palm.

Third (Figure 4L) and **fourth pereiopods** generally similar, relatively slender; ischium with spine-like seta; merus around 4.5 times as long as wide; carpus about half as long as merus, without spine-like seta; propodus 1.2 times as long as carpus but shorter than merus, inferior margin with five spine-like setae and one distal pair, dorsolaterally with row of short setae; dactylus, simple, conical, about 1/4 of propodus length.

Telson (Figure 4M) almost subrectangular, tapering distally, about 2.2 times as long as proximal width, lateral margin slightly convex; dorsal surface with two pairs of postero-lateral spine-like setae, first pair at about mid-length part, second pair on about 3/4 telson length; each posterolateral angle with pair of spine-like setae, mesial about twice as long as lateral.

Uropod (Figure 4M) with bifid protopod, inner and outer lobe ending in acute tooth, exopod and endopod more or less equal in length, rounded distally; exopodal diaeresis sinuous.

Colour pattern: Based on living material, females and males show dimorphism in colour pattern. In females the carapace, abdomen, walking legs and uropods are dark brown with evenly scattered green chromatophores; major and minor chela brown mesially with white patches on mesial surface, finger tips of major chelae white; antennular and antennal peduncle transparent; margin of uropods and telson with transverse white band proximally (Figure 1E). Males with carapace surface dark brown; abdomen and walking legs semi-transparent with blue chromatophores; uropods and telson, dark blue with intense blue chromatophores, anterior margin of uropods and telson with transverse white band; major and minor chela brown mesially with light patches on mesial surface, fingertips of major chela light; antennular and antennal peduncle transparent (Figure 1F).

Habitat: This species was found in crevices of massive rocks and all specimens were collected in the same habitat as *A. ankeri* sp. nov.

Distribution: Presently only known from the Abu-Musa and Siri Islands, Persian Gulf, Iran.

Etymology: The species is named in honour of Alireza Mohammadpour for his encouragement and support of AD.

Remarks. The alcohol-preserved specimens of *A. mohammadpouri* sp. nov. which are now bleached show close similarity to *A. inopinatus*, *A. lobidens* and *A. australiensis* Banner & Banner, 1982, more than any other species in the *A. edwardsii* group. But this new species is easily differentiated from these related species by its particular colour pattern, which is easily recognized in the field. But this is not the case when one works with preserved material only. The major morphological discriminating feature that separates *A. mohammadpouri* sp.

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Table 2. Morphological features for distinguishing *Alpheus mohammadpouri* sp. nov. from the closest species

Characters	*A. mohammadpouri* sp. nov.	*A. inopinatus* Holthuis & Gottlieb 1958	*A. lobidens* De Haan, 1849 (in De Haan, 1833–1850)	*A. australiensis* Banner & Banner, 1982
Rostrum	Tip reaching to middle of first antennular segment	Tip reaching past middle of first antennular segment	Tip reaching past middle of first antennular segment	Tip reaching past middle of first antennular segment
Rostral carina	Marked but slightly sharp dorsally and reaches posterior to orbital hoods	Sharp, slightly depressed between eyes and terminating at base of eyes	Rounded	Rounded, extending posteriorly to base of eyes
Superior surface of palm of small chelae	Not a saddle	With defined saddle	With defined saddle	Not a saddle to shallow saddle
Distomesial tooth of merus of major chela	Armed	Unarmed	Usually armed	Unarmed
Small chela of female	Not balaeniceps	Not balaeniceps	Not balaeniceps	Sub-balaeniceps
Depression extending on lateral surface of minor chela	Not distinct	Distinct	Distinct	Not distinct
Fingers of minor chela	Excavate	Not excavate	Not excavate	Not excavate
Colour pattern	Females: Brown with green chromatophores. Males: semi-transparent with blue chromatophores	Inadequate information	Greeny-brown, olive green, or smoky-grey, anterior part of abdomen often white, with, or without longitudinal stripes. Telson and uropods apically blackish. Legs dull pinkish	Dark olive green and not transversely banded
Habitat	Exposed rocky shores near to high intertidal, in deep fissure or crevice in the rocks	Under rock, low tide	Muddy intertidal, estuaries, mangroves, rocky/cobble intertidal	Estuarine, under rocks, muddy, sandy-muddy
Geographic range	Persian Gulf	Mediterranean coast and the west of Pakistan	Throughout the Indo-Pacific area from Persian Gulf to Hawaii	Australia

nov. from *A. inopinatus* is the absence of sculpturing on the palm of the minor chela. In *A. inopinatus*, the superior surface of the palm is marked with a defined saddle and strong tooth flanking the dactylar articulation medially. While *A. mohammadpouri* sp. nov. shows no sculpturing on the palm of the minor chela. *Alpheus australiensis* is distinct from this new species by the presence of sub-balaeniceps in female individuals compared with females of the new species which lack balaeniceps. Another diagnostic character is the presence of a disto-mesial tooth on the merus of the major chela, while this is absent in *A. australiensis*. The new species is distinguished from *A. lobidens* using two main characteristics: (1) superior surface of the palm of the minor chela lacking saddle in *A. mohammadpouri* sp. nov, and (2) fingers of minor chela are clearly excavate in the new species (Table 2).

Discussion

The genus *Alpheus* was divided by Coutière (1905) into seven groups. These are *A. macrocheles*, *A. sulcatus*, *A. obesomanus*, *A. diadema*, *A. brevirostris*, *A. crinitus*, *A. edwardsii*. All of these are found in the Persian Gulf. In addition to 17 previously recorded species, there is evidence for 17 species of this genus and eight species of *Synalpheus* from the region (current authors and H. Ashrafi unpublished data). During an ongoing project on decapod diversity of the Persian Gulf and Gulf of Oman by the authors, the new species were found in Abu-Musa Island rocky habitat in an area of about 250 m^2 and a few specimens in similar habitat in Siri Island. The three species described herein, belong to the *A. edwardsii* heterogeneous group which is defined mainly by (1) lack of orbital teeth, (2) presence of two grooves on the major chela (Banner & Banner, 1982); (3) minor chela with balaeniceps only in males, (4) third legs with unarmed merus and simple dactylus; (5) rostral carina marked and slightly sharp dorsally and reaching posterior to orbital hoods and (6) ventro-mesial margin bearing an acute tooth terminally. In a study by Williams *et al.* (2001), two unrelated clades of snapping shrimps based on the unique shape of the double-notched major chela were reported. In their study, clade 1 or clade E belong to the *Alpheus edwardsii* group. In members of this species group, the dorsal notch of the major chela extends posteriorly onto the mesial face (Anker & De Grave, 2009). The clade 2 or clade L of the Williams *et al.* (2001) study belongs to *Alpheus leviusculus* group with a dorsal notch on the major chela which is abruptly rounded and not extended posteriorly on the mesial face (see Williams *et al.*, 2001, Figure 1). Only four species of clade 2 were recorded from the Indo-west Pacific including *A. leviusculus* Dana, 1852, *A. parvirostris* Dana, 1852, *A. maindroni* Coutière, 1898 and *A. bannerorum* Bruce, 1987. In the present study *A. ankeri* sp. nov. and *A. mohammadpouri* sp. nov., bearing a particular dorsal notch, agree with clade 2 of Williams *et al.* (2001). Apart from *A. parvirostris*, which is also found on coral branches, the other species, including the new species, are considered as rock-dwelling.

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In summary, the Persian Gulf as a socio-economically important region in the Middle East is under-studied from an environmental and faunistic point of view. Apart from recent attempts to conduct some marine surveys in surrounding countries (Oman, Qatar, UAE, Saudi Arabia, Kuwait and Iraq), there is a huge gap in our knowledge from this region and there is a need for thorough biodiversity investigations. In the last decade, a series of crustacean collections has been conducted by the School of Biology, at the University of Tehran. This has resulted in higher records for Decapoda (more than 400 species) based on comparative studies, mostly on crabs (Naderloo, 2017). Other reports concern high diversity of caridean shrimp (De Grave & Ashelby, 2011; Naderloo & Türkay, 2012). The need for such taxonomic studies is rising in the region. Recently, Ansari & Maghsoodlou (2016) studied the reproductive biology of a mis-identified species from the Gulf of Oman, Iran (wrongly referred to the Arabian Sea) as *Alpheus* cf. *burukovskyi* Anker & Pachelle, 2015, which is a Pacific species in Panama. The material appears to belong to *Alpheus* sp., but no material was available for further examination. The Persian Gulf is currently facing many environmental constraints (Riegl & Purkis, 2012) and there is an urgent need for evaluations of environmental conditions (Feary *et al*., 2013). Some recent examples of environmental problems include increased oil tanker traffic, spilled-oil pollution, and higher temperatures and salinity compared with nearby open waters. Therefore, there is a need for increased biodiversity monitoring and urgent evaluation of the conservation status of species in the region. Abu-Musa Island is located with several others, such as Kish and Siri Islands, and all are under threat of quick development for tourism and oil exploration. Abu-Musa Island shows very low habitat diversity being composed of only sand, rock and coral; high intertidal species diversity was observed in only one location, namely Qadir Park, in which a 250 m^2 bedrock is dominated by a great diversity of different species, mostly crustaceans. This remote island has so far yielded 30 alpheid shrimps including members of the genera *Alpheus*, *Synalpheus*, *Salmoneus*, *Arete* and *Athanas*. This high α-diversity is remarkable in such a small locality and could represent many endemic sympatric species. Here, we refer to this as 'narrow endemism' in which each species occupies a microhabitat. The current study describes just three new *Alpheus* species from this island but unpublished data indicate a further 14 *Alpheus* and eight *Synalpheus* species from this island; mainly from the Qadir Park coast in the bedrock habitat with crevices. This high diversity demands more attention for the conservation of species in this region. Luckily, the island is currently protected from sampling and tourism activity but due to the short distances to other close islands with less protection, any conservation plans should include a larger area for protection. Further molecular taxonomic studies are planned to shed more light on the knowledge of biodiversity of alpheid shrimps of this region.

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