

First record of Miocene crustaceans from Hormozgan Province, Southern Iran

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Abstract Four decapod crustacean species from the Middle Miocene Mishan Formation of Hormozgan Province, Southern Iran are described. Three species of leucosiid crabs represent the first fossil record for their respective genera outside the Indo-Pacific region. The oldest records for *Leucosia sensu lato*, *Phylira sensu lato*, and *Arcania* are from Middle Miocene deposits of the Indo-Pacific, and thus their paleobiogeographic distribution is extended for this lapse of time. *Harpactocarcinus miocenicus* n. sp. represents the youngest and most oriental occurrence for a typically Eocene genus, whose species are known mainly from Central Europe. This contribution represents the first formal report for Tertiary crustaceans from Iran.

Keywords Crustacea · Miocene · Paleobiogeography · Hormozgan · Iran

Kurzfassung Vier Krustazeen-Arten aus der Mitelmiozänen Mishan-Formation in der Hormozgan-Provinz, Süd-Iran sind beschrieben. Drei Arten leukosiider Krabben stellen den ersten fossilen Nachweis ihrer jeweiligen

Gattungen außerhalb der indopazifischen Region dar. Die ältesten Nachweise für *Leucosia* im weiteren Sinne, *Phylira* im weiteren Sinn und *Arcania* kommen aus mitelmiozänen Sedimenten des Indopazifiks, und daher ist ihre paläobiogeographische Verbreitung um diese Zeitspanne erweitert. *Harpactocarcinus miocenicus* n. sp. stellt das jüngste und westlichste Vorkommen einer typischerweise eozänen Gattung dar, deren Arten hauptsächlich aus Zentraleuropa bekannt sind. Dieser Beitrag stellt den ersten formalen Bericht für Tertiäre Krustazeen aus dem Iran dar.

Schlüsselwörter Krustazea · Miozän · Paläobiogeographie · Hormozgan · Iran

Introduction

The fossil record of decapod crustaceans of Iran is mainly restricted to Jurassic and Cretaceous taxa (McCobb and Hairapetian 2009; Yazdi et al. 2009). The only record for Tertiary crustaceans is that of Toraby and Yazdi (2002), who reported a Miocene portunid crab from Esfahan (central Iran). This paper is the first comprehensive description of Cenozoic crustaceans of Iran.

Several crab carapaces and appendages of *Leucosia persica* n. sp., *Phylira hormozganensis* n. sp., *Arcania* sp., and *Harpactocarcinus miocenicus* n. sp. were recovered from two localities of Hormozgan Province, southern Iran. The first locality is found north of Hunguyeh Village, 300 km northwest of Bandar Abbas (Fig. 1). The crab-bearing beds are reached by taking Bastak–Jonah–Hunguyeh Road to a 2 km pathway to the north at N27°05'8.2", E54°00'34". The second locality, near Suru Village, 30 km west of Bandar Abbas, is accessed from a 5 km pathway

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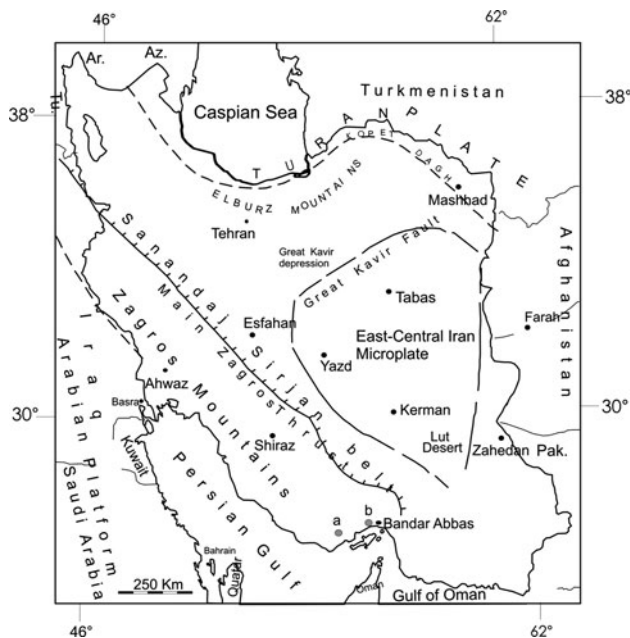


Fig. 1 Map of Iran with locality of fossil sites, a = Hunguyeh section, b = Suru section (modified from Wendt et al. 2005)

that begins at the Bandar Abbas Refinery at N27°09'20", E56°00'46" (Fig. 1).

Regional geology

The studied localities are part of Zagros Mountains folded belt. This zone is composed of large anticlines and synclines with a NW–SE trend. Late Precambrian to Middle Cambrian evaporites and volcanic rocks of Hormuz Series are the oldest stratigraphic outcrops in the area (Stöcklin and Setudehnia 1991; Aghanabati 2004). The Hormuz Series are exposed as salt plugs, which have deformed many of the Mesozoic and Cenozoic lithostratigraphic units. Paleocene to Early Miocene strata (Pabdeh, Jahrum, and Asmari Formations) can be observed in several of the anticline cores. Early Miocene to Pleistocene Fars Group (Gachsaran, Mishan, Aghajari, and Bakhtiari Formations) composes the upper strata of the anticlines. Fossil crabs, described herein, were collected from the upper part of the Mishan Formation. The Mishan Formation was first described by James and Wynd (1965) as a 710 m unit (including Guri Member) and was composed mostly of marls and limestones in the Gachsaran oilfield. The formation conformably overlies the Gachsaran Formation evaporites and underlies the Aghajari Formation sandstones and marls. Kalantari (1992) and Stöcklin and Setudehnia (1991) assigned a Late Miocene to Pliocene age to the Aghajari Formation and a Burdigalian to Langhian to the Mishan Formation, with the Guri Member having a

Burdigalian age. Lasemi and Rastegar-Lari (2006) examined several Mishan Formation sections in Fars and Bushehr Provinces, proposing a carbonate rimmed shelf sedimentary environment.

The Mishan Formation has variable thickness within the Zagros folded belt area from W-NW to E-SE. The total thickness increases from 486 m in the Hunguyeh section to 1,448 m in the Suru area (west of Bandar Abbas). However, the thickness decreases to 150 m southward to the Hormuz Strait (Motiei 1993, Fig. 80). These deposits appear to be accumulated as synorogenic strata in a narrow and long NW–SE trend basin in front of the Zagros Mountains (Mouthereau et al. 2006). Within the Hunguyeh section, the upper part of the Mishan Formation is composed of 26.7 m marly limestone (containing crabs) and 25.5 m overlying marl; within the Suru section, it changes to a 1 m marly limestone and 520 m marl (Figs. 2, 3). Contrary to the scheme of Lasemi and Rastegar-Lari (2006), these conspicuous changes in thickness confirm the

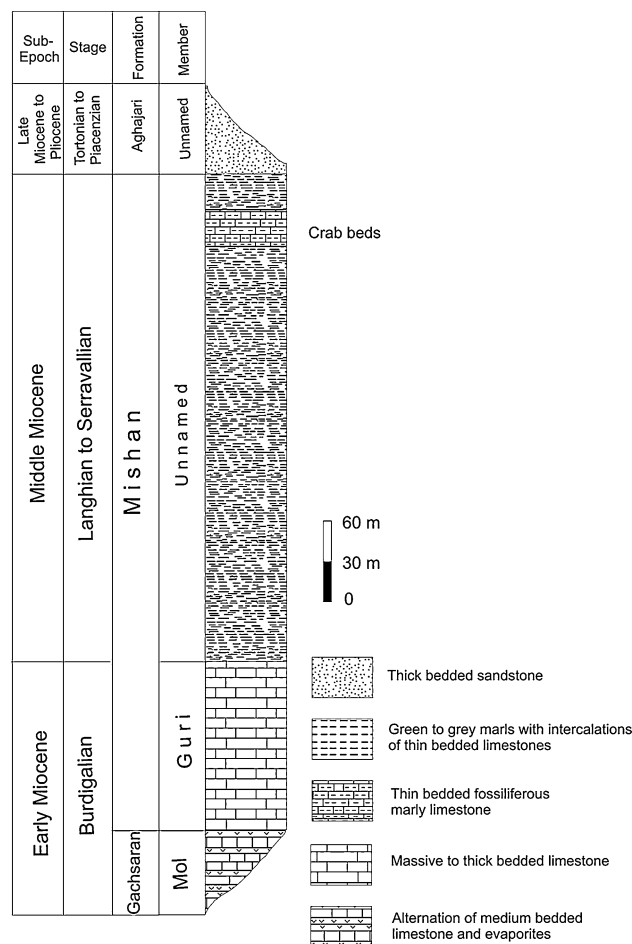


Fig. 2 Stratigraphic section of upper part of Mishan Formation at Hunguyeh area, southern Iran, with position of crustacean-bearing strata

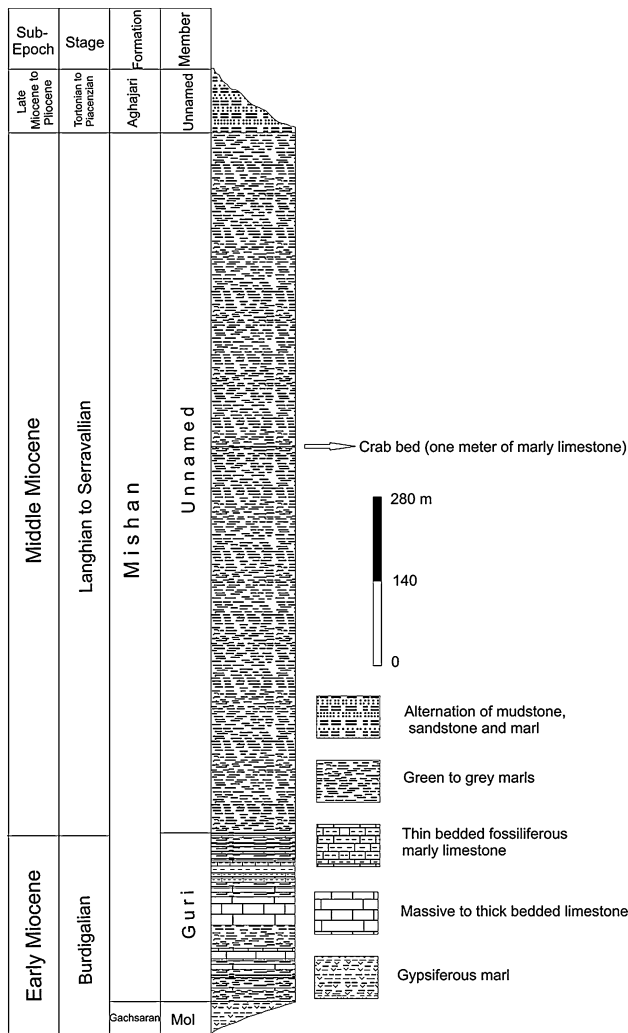


Fig. 3 Stratigraphic section of upper part of Mishan Formation at Suru area, southern Iran, with position of crustacean-bearing strata

deepening of the basin toward the Bandar Abbas area (Motiei 1993).

Crab remains were collected from the upper portion of the Mishan Formation. Crabs were collected from a 26.7 m grey to yellow marly limestone interval in the Hunguyeh section (Fig. 4a) and a 1 m pale-grey marly limestone in Suru section (Fig. 4b). In both sections, the crustaceans are associated with numerous echinoids, bivalves, and gastropods.

Material described herein is deposited at the Museum of the Hormozgan University, under acronym HUIM.

Systematic paleontology

Infraorder Brachyura Latreille, 1802
 Section Eubrachyura de Saint-Laurent, 1980
 Superfamily Leucosioidea Samouelle, 1819

Family Leucosiidae Samouelle, 1819
 Subfamily Leucosiinae Samouelle, 1819
 Genus *Leucosia* Weber, 1795

Type species: *Cancer craniolaris* Linnaeus, 1758, by subsequent designation of Holthuis (1959).

Leucosia persica n. sp. (Fig. 5a–p)

Diagnosis: Carapace small, longitudinally ovate to rhomboidal, widest at anterior third of carapace, frontal margin narrow; dorsal surface smooth, anterolateral margin inclined, with fine tubercles; posterolateral margin rimmed; posterior margin relatively wide, rimmed; male sternite 4 subtrapezoidal.

Description: Carapace elongate rhomboidal to ovate in outline, width about 85% carapace length, widest at anterior third to mid-length; orbito-frontal margin narrow, about 15% carapace width; dorsal surface glabrous, smooth, regions not defined; front strongly projected anteriorly, upturned dorsally; anterolateral margin slightly sinuous, granulate, rimmed; epibranchial angle not pronounced; posterolateral margin rimmed with scarce granules; posterior margin gently convex, rimmed, about 25% carapace width; epimeral edge invisible dorsally, finely granulate, joining posterior margin; thoracic sinus deep; anterior edge defined by nearly straight, obtusely granulated edge of pterygostomian region; male sternite 4 subtrapezoidal, 30% carapace length, male sternites 5–8 subrectangular, posteriorly deflected at lateral borders, sternites 8 subparallel to lateral margin; female fused abdominal segment tapering frontally, margins smooth, posterior margin with small projection; remainder abdominal segments rectangular, very narrow.

Etymology: Derived from the Persian Gulf and the ancient name of Iran, Persia.

Material: Holotype HUIM1, paratypes HUIM2 to HUIM9; 34 specimens from Mishan Formation, Suru section, Middle Miocene.

Measurements (in mm): Holotype HUIM1, female carapace length = 13.2, width = 9.8; paratypes HUIM2, male? carapace length = 13.1, width = 7.5; HUIM3, female carapace length = 12.8, width = 10.4; HUIM4, female carapace length = 13.3, width = 9.6; HUIM5, female carapace length = 11.8, width = 11.3; HUIM6, male carapace length = 12.7, width = 9.8; HUIM7, male carapace length = 12.1, width = 10.9; HUIM8, male? carapace length = 13.4, width = 10.2; HUIM9, male? carapace length = 13.2, width = 10.4.

Discussion: Karasawa et al. (2008) listed 18 fossil species for the genus *Leucosia sensu lato*, all of which are from the Indo-Western Pacific region (Japan, Sarawak,

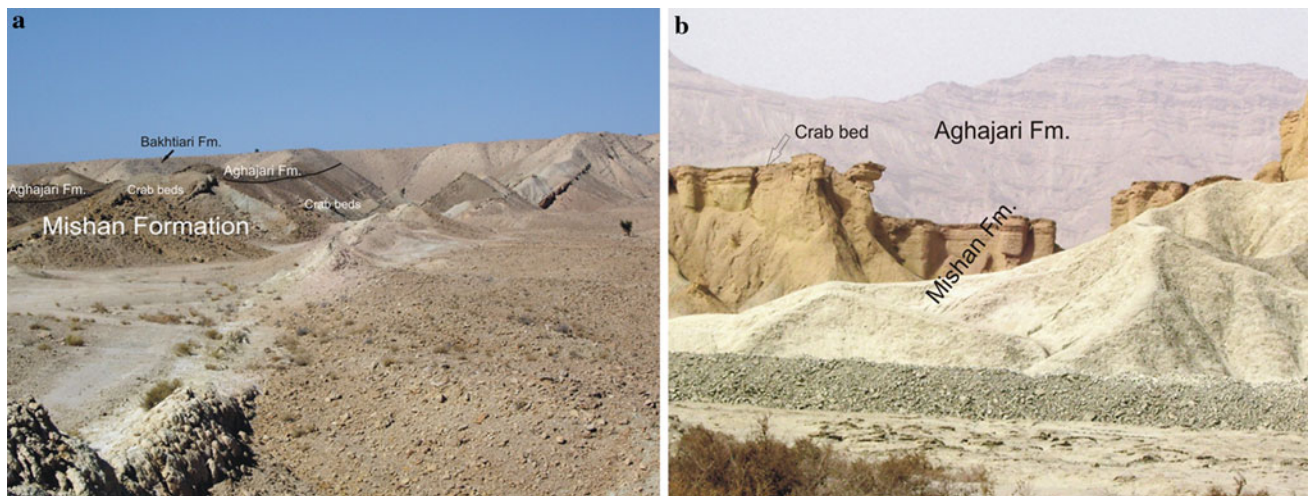


Fig. 4 Outcrops of upper part of Mishan Formation at Hunguyeh (a) and Suru (b) areas, southern Iran

Taiwan, Java, Brunei, and the Philippines). From their list, there are only four Miocene species: *Leucosia calcarata* Collins et al., 2003; *L. ovalata* Hu and Tao, 1996; *L. subrhomboidea* Hu and Tao, 1996; and *L. tricarinata* Martin, 1880. The new species differs from the above four in having a more elongated, subrhombic carapace. *Leucosia sensu lato*, in Middle Miocene deposits of Iran, represents its westernmost record, suggesting that its distribution during Miocene times was broad, with possible migration of the genus to the Paratethys Sea during the Miocene and Pliocene (Fig. 5). Galil (2003) made a review of species attributed to *Leucosia*, concluding that the genus included only four extant species, based on first male pleopod features, which are very rarely preserved in fossil specimens (Karasawa et al. 2008, p. 59). Twelve fossil species of *Leucosia sensu lato* are listed by Karasawa et al. (2008), with *L. craniolaris* (Linnaeus 1758) as the only species of *Leucosia sensu stricto* with fossil representatives. For these reasons, we consider placement of the new species in *Leucosia sensu lato* as appropriate.

Subfamily Eballiinae Stimpson, 1871

Genus *Philyra* Leach, 1817

Type species: *Leucosia globus* Fabricius, 1775, by subsequent designation of H. Milne Edwards (1837).

Philyra hormozganensis n. sp. (Figs. 5q–t and 6a–c)

Diagnosis: Carapace small, rhomboidal to transversely ovate, widest at anterior third of carapace, frontal margin narrow; dorsal surface smooth, longitudinal furrows separating branchial areas from urogastric and intestinal regions; anterolateral margin rounded; posterolateral margin rounded.

Description: Carapace rhomboidal to transversely sub-oval, width about 90% carapace length, widest at mid-length to anterior third of carapace; orbito-frontal margin narrow; dorsal surface glabrous, smooth; longitudinal furrows separate undivided urogastric and cardiac regions from meso- and metabranchial regions; anterolateral margin rounded, with fine pits on lower margin; posterolateral margin slightly rounded, 60% maximum carapace length; posterior margin nearly straight, rimmed, about 23% carapace width; epimeral edge invisible dorsally; sternites 1–3 completely fused in a transverse, subrectangular crown, much wider than long; sternite 4 subrectangular, 3 times the length of fused sternites 1–3 and twice its width; remainder of sternite transversely subovate, 25% length of sternite 4; male sterno-abdominal cavity narrow, elongated, 15% maximum carapace width and 80% maximum carapace length; female sterno-abdominal cavity triangular,

Fig. 5 a–p, *Leucosia persica* n. sp., Mishan Formation, Suru section, Middle Miocene: a dorsal view of female carapace, holotype HUIM1, $\times 4.0$; b ventral view of female carapace, holotype HUIM1, $\times 4.0$; c ventral view of carapace, paratype HUIM2, $\times 4.0$; d dorsal view of female carapace, paratype HUIM3, $\times 3.5$; e ventral view of female carapace, paratype HUIM3, $\times 4.0$; f dorsal view of female carapace, paratype HUIM4, $\times 4.0$; g ventral view of female carapace, paratype HUIM4, $\times 4.0$; h dorsal view of female carapace, paratype HUIM5, $\times 4.0$; i ventral view of female carapace, paratype HUIM5, $\times 4.0$; j dorsal view of male carapace, paratype HUIM6, $\times 4.0$; k ventral view of male carapace, paratype HUIM6, $\times 4.0$; l dorsal view of male carapace, paratype HUIM7, $\times 4.0$; m right lateral view of male carapace, $\times 4.0$; n ventral view of male carapace, paratype HUIM7, $\times 4.0$; o dorsal view of carapace, paratype HUIM8, $\times 4.0$; p posterior view of carapace, paratype HUIM9, $\times 4.0$. q–t *Philyra hormozganensis* n. sp., Mishan Formation, Suru section, Middle Miocene: q dorsal view of female carapace, holotype HUIM10, $\times 5.0$; r right lateral view of female carapace, holotype HUIM10, $\times 5.0$; s ventral view of female carapace, holotype HUIM10, $\times 5.0$; t dorsal view of male carapace, paratype HUIM11, $\times 5.0$

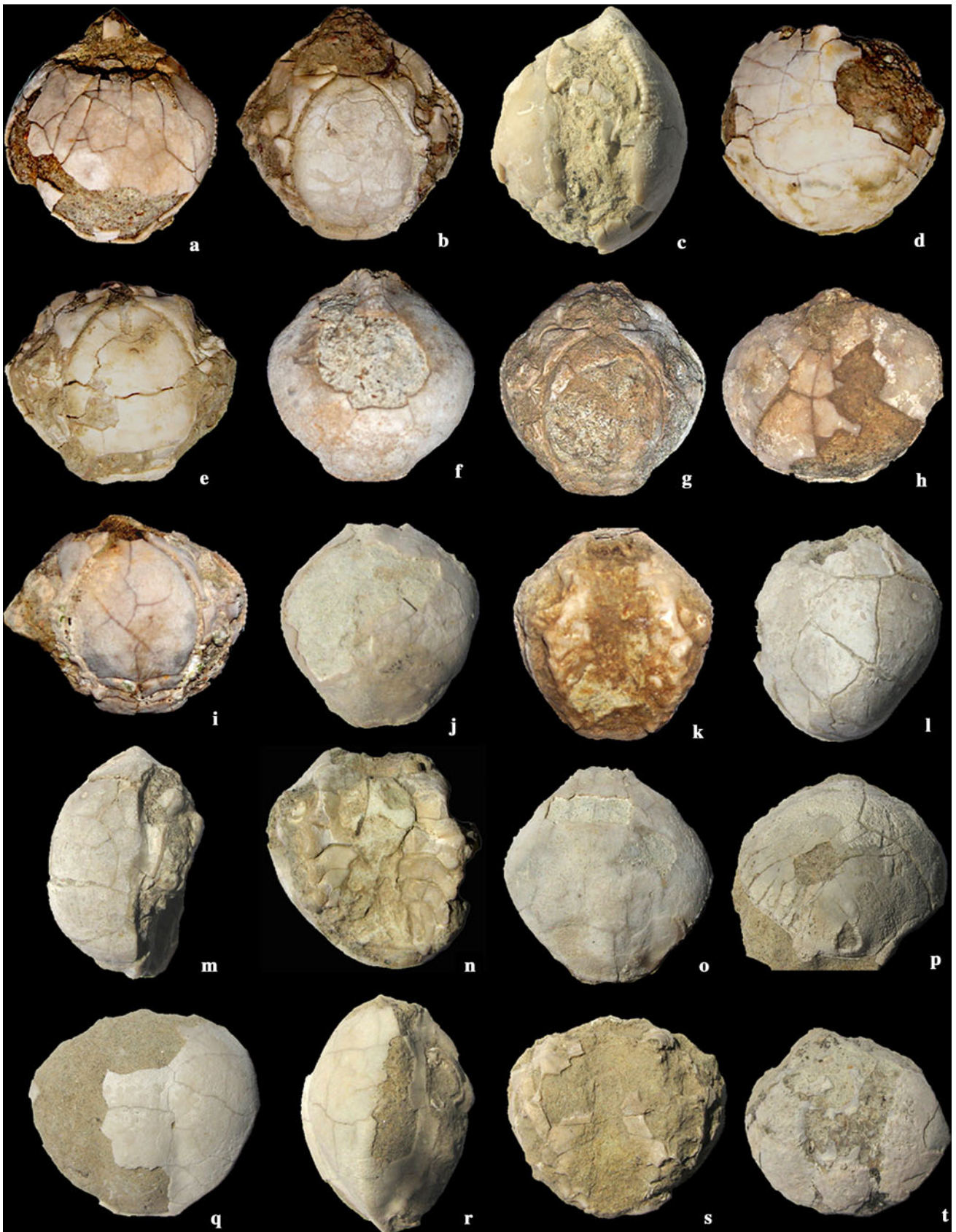




Fig. 6 *a–d*, *Philyra hormozganensis* n. sp., Mishan Formation, Suru section, Middle Miocene: *a* ventral view of male carapace, paratype HUIM11, $\times 4.5$; *b* dorsal view of male carapace, paratype HUIM12, $\times 4.5$; *c* ventral view of male carapace, paratype HUIM12, $\times 4.5$; *d* *Arcania* sp., dorsal view of carapace, hypotype HUIM13, $\times 4.0$; *e–i* *Harpactocarcinus miocenicus* n. sp., Mishan Formation, Hunguyeh

section, Middle Miocene. *e* dorsal view of female carapace, holotype HUIM14, $\times 0.7$; *f* ventral view of female carapace, holotype HUIM14, $\times 0.7$; *g* frontal view of female carapace, holotype HUIM14, \times ; *h* outer view of right chela, paratype HUIM15, $\times 1.6$; *i* internal view of distal portion of right chela, paratype HUIM16, $\times 2.0$

20% maximum carapace width at its base and 70% maximum carapace length.

Etymology: The name of the species refers to its type locality in Hormozgan Province, southern Iran.

Material: Holotype HUIM10, paratypes HUIM11 and HUIM12; 14 specimens from Mishan Formation, Suru section, Middle Miocene.

Measurements: Holotype, HUIM10, female carapace length = 14.5, width = 14.2; paratypes HUIM11, male

carapace length = 12.4, width = 12.6; HUIM12, female carapace length = 11.7, width = 12.4.

Discussion: In a recent review of the genus *Phylira*, Galil (2009) suggested that the genus includes only two extant species, and erected seven new genera to contain extant species previously considered as *Phylira sensu lato*, based on differences of male pleopod and other features involving maxilliped and abdominal features (Galil 2009, p. 280). Karasawa et al. (2008) listed 16 fossil species for the genus, seven of them from Miocene sediments, with a

geographic range restricted to the Indo-Western Pacific region (Taiwan, Sarawak, Japan, Java, and Sumatra). Main difference between *Phylira hormozganensis* and the other Miocene species is that *P. hormozganensis* lacks granules on the dorsal carapace surface, longitudinal furrows are weaker, and the carapace is wider. *Phylira tanakai* Karasawa, 1993, from the Pliocene of Japan, is similar to *P. hormozganensis*, however the carapace is smaller and the posterolateral margin bears scarce tubercles.

Genus *Arcania* Leach, 1817

Type species: *Cancer erinaceus* Fabricius, 1787, by monotypy.

Arcania sp. (Fig. 6d)

Description: Carapace longitudinally ovate; regions indistinct; subparallel longitudinal tubercles extend from intestinal to protogastric regions; dorsal surface of carapace granulate; antero- and posterolateral margins rounded, posterior margin narrow, slightly concave.

Material: Hypotype HUIM13; one specimen from Mishan Formation, Suru section, Middle Miocene.

Measurements (in mm): Hypotype HUIM13, carapace length = 12.2, width = 10.7.

Discussion: Most fossil species of *Arcania* are known from Pliocene and Pleistocene deposits from Taiwan and Japan (Van Straelen 1938; Kato and Karasawa 1998; Hu and Tao 1985, 2000; Kobayashi et al. 2008). The sole specimen is most similar to *Arcania cornutus* (MacGilchrist 1905), as figured by Martin (1880, pl. 1, Fig. 2) from the Miocene of Java. However, the specimen of the Miocene of Iran is too incomplete to offer detailed description and systematic identification.

Recent leucosiids from the Persian Gulf are diverse, and their affinities with the Indo-West Pacific region were discussed by Naderloo and Sari (2005), who listed the most common species of the Iranian coast. Several species of *Lucosia sensu lato*, *Phylira sensu lato*, and *Arcania* are distributed in the Persian Gulf, and the paleobiogeographic distribution for three genera in Miocene times was as wide as it is today (Fig. 7).

Superfamily Carpilioidea Ortmann, 1893

Family Zanthopsidae Via, 1959

Genus *Harpactocarcinus* A. Milne-Edwards, 1862

Type species: *Cancer punctulatus* Desmarest, 1822 (= *H. rotundatus* A. Milne Edwards, 1862).

Harpactocarcinus miocenicus n. sp. (Fig. 6e-i)

Diagnosis: Carapace of medium size, transversely ovate, wider than long; surface of carapace scabrous; orbits large;

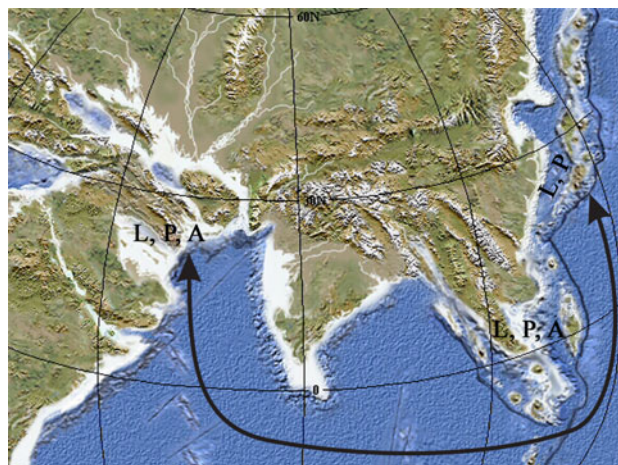


Fig. 7 Miocene paleogeographic map of Middle East to Indo-Pacific, with position of leucosiid genera reported herein and distribution of species of same genera in the Indo-Pacific region. A possible dispersion route is drawn. Modified from <http://jan.ucc.nau.edu/~rcb7/globaltext.html> and used with permission

antero- and posterolateral margin rounded; posterior margin concave; sternum wide; sternite 4 subtrapezoidal, widest element of sternum; female abdomen subtriangular elongated, widest at level of somite 2; chelae long, robust, equal.

Description: Carapace of medium size, transversely ovate, 20% wider than long, widest at mid-length; dorsal surface scabrous, regions not clearly defined; orbito-frontal margin half maximum carapace width; orbits large, transversely ovate, width 15% maximum carapace width; outer orbital spine small, subtriangular; anterolateral margin rounded, 50% maximum carapace length, no spines or tubercles present; posterolateral margin smooth, inclined 45° respect to posterior margin; posterior margin slightly concave, 40% maximum carapace width; epimeral suture clear, subrhombic; female sternum wide; fused sternites 1 and 2 form a wide, short triangle; sternite 3 transversely subrhombic; sternite 4 subtrapezoidal, widest element of sternum at level of episternites; sternite 3 subrectangular, slightly narrower than sternite 4, but 30% its length; remainder of sternites completely covered by abdomen; telson subtriangular, slightly rounded, 20% maximum carapace length and 30% its maximum width; abdominal somite 6 subrectangular, slightly wider than telson but 50% its length; somites 5 to 2 also rectangular, gradually decreasing in width and length towards posterior margin; third maxillipeds long and wide, 30% maximum carapace length; coxa subrectangular; endognath ischium wide, subrectangular elongate, twice as long as basis, semicircular at distal edge; merus slightly wider than ischium, subtrapezoidal; exognath ischium 50% width of endognath ischium, elongate, subrectangular, inclined at distal edge;

coxae of chelipeds semicircular; right chela elongated, lower margin rimmed, maximum height at distal edge of palm; fixed finger subtriangular, 30% length of chela, with 3 to 4 strong teeth on occlusal surface; dactylus robust, slightly curved, its height 50% maximum chela height and 30% its length, with median longitudinal furrow.

Etymology: Species name refers to its importance as the first Miocene species for the genus.

Material: Holotype HUIM14, paratypes HUIM15 and HUIM16; three specimens from Mishan Formation, Hunguyeh section, Middle Miocene.

Measurements (in mm): Holotype carapace length = 56, width = 68; paratypes right chela length = 42, height = 21; distal fragment of right chela length = 28, height = 20.

Discussion: *Harpactocarcinus miocenicus* n. sp. from the Miocene of Iran resembles *Harpactocarcinus* spp. in carapace shape and chelipeds, except for no anterolateral spines observed on *H. miocenicus*. Anterolateral spines of *Harpactocarcinus* spp. appear to be very delicate, therefore it is possible that the anterolateral spines on *H. miocenicus* are broken and worn. Even with the lack of anterolateral spines observed on *H. miocenicus*, the transversely subovate carapace shape, large orbits, poorly defined carapace regions, wide sternum, wide female abdomen, and long, robust chelipeds, as seen in *H. miocenicus*, are typical of *Harpactocarcinus* spp. Schweitzer et al. (2007) listed eight species included in *Harpactocarcinus*: *H. punctulatus* (Desmarest 1822); *H. macrodactylus* (H. Milne Edwards in d'Archiac 1850); *H. ovalis* A. Milne Edwards, 1862; *H. jacquoti* A. Milne Edwards, 1865; *H. multidentatus*, Stubblefield, 1946; *H. istriensis* Bachmayer and Nosan, 1959; *H. wilkeningi* (Bachmayer and Mundlos 1968); *H. dalmatius* Schweitzer, Shirk, Čosović, Okan, Feldmann, and Hoşgör, 2007; and *H. yozgatensis* Schweitzer, Shirk, Čosović, Okan, Feldmann, and Hoşgör, 2007, all from Eocene strata, except for a doubtful Oligocene age for *H. wilkeningi*. Differences amongst these species is based upon the length/width ratio of the carapace, the number of anterolateral spines, and the relative size of the front, orbits, and frontal and orbital spines, among other features (Schweitzer et al. 2005, p. 667; 2007, table 1). Geographically, the closest species to *H. miocenicus* are *H. yozgatensis* (Central Turkey) and *H. multidentatus* (Somalia). These species differ from *H. miocenicus* by less ovate carapaces, larger orbits, a densely punctuate dorsal carapace, and not rounded posterolateral margin. Stratigraphically, the closest species to *H. miocenicus* is *H. wilkeningi*, questionably referred to Oligocene strata from Germany (Bachmayer and Mundlos 1968). This species is most

similar to *H. miocenicus*, except that it has a subrhombic to subovate carapace shape and dorsal punctate surface.

Harpactocarcinus miocenicus represents the youngest occurrence of the genus, suggesting its extinction by Late Miocene times. However, unexpected presence of leucosiid genera herein reported, typical of the Indo-Pacific region, may indicate that the distribution of *Harpactocarcinus* was wider than is presently known.

Future studies on Paleogene and Neogene crustaceans from Iran will reveal important information on the distribution and evolution of decapod crustaceans from the Tethyan Realm.

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