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New species and records of Late Miocene mollusks from southeastern Iran

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Abstract. We describe three new species of mollusks and report 11 species identifications, from Upper Miocene strata of the Dar Pahn Unit at the Makran margin of southeastern Iran. The new species are the gastropods *Bufonaria chabaharensis* sp. nov., *Cancilla makranensis* sp. nov. and the bivalve *Corbula darpahnensis* sp. nov. The new identifications include the gastropods *Protoma harrisoni* (Cox, 1936), *Protoma kayalensis* (Dey, 1961), *Neverita didyma* (Röding, 1798), *Natica vitellus* (Linnaeus, 1758), and the bivalves *Anadara blanfordi* (Newton, 1905), *Fascipecten shanganiensis* (Eames & Cox, 1958), *Pecten kilindoniensis* Eames & Cox, 1956, *Dosinia peralta* Vredenburg, 1928, *Clementia papyracea* (Gmelin, 1791), *Paratapes protolirata* (Noetling, 1901) and *Arcopaginula inflata* (Gmelin, 1791). The pectinid subgenus *Fascipecten* is raised to genus level. During the Late Miocene, seven of the species were found mainly in the northwestern part of the Indian Ocean, six had a broad Indo-West Pacific distribution. This indicates the existence of a 'Western Indian Province' within the Indo-West Pacific Ocean, as reported for the Early Miocene, although less distinct as during the Early Miocene.

Keywords. Gastropoda, Bivalvia, biodiversity hotspot, Neogene, biogeography.

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Introduction

Neogene mollusks from the northwestern Indian Ocean have been known for more than one and a half centuries (Sowerby 1840), but the fossil record of this region remains understudied and fragmentary. Western India may have the most diverse and most continuously studied faunas in the region (Forbes 1846; Dey 1961; Lyngdoh *et al.* 1999; Tiwari & Kachhara 2003; Kulkarni *et al.* 2010; Harzhauser 2014;

Halder & Bano 2015; Bose *et al.* 2024), but records from Pakistan (Newton 1905; Vredenburg 1925, 1928; Crame 1984), Oman (Harzhauser 2007; Harzhauser *et al.* 2008), and Iran (Douglas 1928; Cox 1936; Eames & Cox 1956; Hasani & Vaziri 2011; Hosseinipour & Dastanpour 2013; Harzhauser *et al.* 2017; Haskouei *et al.* 2024) are few.

The region is of particular interest, however, because it has been considered the source area for the initial colonization of the present-day Coral Triangle biodiversity hotspot in the central Indo-West Pacific Ocean (Renema *et al.* 2008; Tian *et al.* 2024). Furthermore, a study of Early Miocene gastropods from Oman and Iran led to the introduction of a Western Indian Province for faunas of that age from Oman to India, considered to have little overlap with coeval faunas in both the Mediterranean region and Indonesia (Harzhauser 2007; Harzhauser *et al.* 2017). Likewise, a study of Late Miocene gastropods from Brunei in northern Borneo, bordering the South China Sea, indicated a high level of endemicity in this area, and little overlap of species with the Java and Celebes Sea (Harzhauser *et al.* 2018).

Recently, Hadi *et al.* (2024) provided a preliminary report on a new Upper Miocene mollusk fauna from strata called the Dar Pahn Unit at the Makran Margin in southeastern Iran (Fig. 1), consisting of 18 species. Here, we identify 14 of those taxa to species level, including three new species.

Material and methods

The Iranian Makran margin is a Cenozoic accretionary wedge formed by the northward subduction of the Arabian Plate beneath the Eurasian Plate (Platt *et al.* 1985; DeMets *et al.* 2010; Burg 2018). This active tectonic setting has created a complex geological record, transitioning from deep marine to coastal environments. The Makran Accretionary Complex developed due to the convergence of the Arabian, Eurasian, and Indian plates near their Triple Junction (Byrne *et al.* 1992; Kopp *et al.* 2000; Haghipour 2014). The onshore Makran can be divided into four primary east-west trending structural zones (Dolati 2010; Burg *et al.* 2013) (Fig. 1A), each representing distinct phases in the accretionary process. From north to south, these include: (1) North Makran, comprising metamorphosed oceanic and continental terranes that form the structural backstop (McCall 1985a, 1985b); (2) Inner Makran, characterized by Middle Eocene to Middle Miocene deep-marine turbidites; (3) Outer Makran, featuring Upper Miocene shallow-marine to deltaic sequences; and (4) Coastal Makran, dominated by Late Miocene-Pleistocene shelf and coastal deposits (Burg *et al.* 2013).

Stratigraphically, the Dar Pahn Unit conformably overlies earlier Miocene units (Sabz, Darkhunish, and Band-e Chaker), represents a wedge-top "molasse" deposit, consisting of sandstones, conglomerates, and fossiliferous marls, indicating shallow marine to brackish conditions with fluvial influence (Garassino *et al.* 2024; Hadi *et al*. 2024).The Rudig section is located about 6 km south of Rudig village, 50 km east of Chabahar (Fig. 1B–C). The section has a total thickness of 100 m within the Coastal Makran area, and is composed of an alternation of sandy limestone, muddy sandstone, limey sandstone, shale and siltstone and shell beds, which form together a "Dar Pahn" unit, i.e., a formal lithological unit (McCall 1985b; Hadi *et al.* 2024). Moreover, The Upper Miocene (Tortonian) deposits of the Dar Pahn Unit are noted for their richness in well-preserved body fossils. This preservation is attributed to rapid burial and stable substrate conditions, which were occasionally disturbed by minor storm surges (Hadi *et al.* 2024; Bayet-Goll *et al.* 2025). Such environments, especially those dominated by infaunal species like *Dosinia*, provided optimal conditions for fossil preservation (Bayet-Goll *et al.* 2025). In addition, some of these fossils are preserved in life position, indicating minimal post-mortem transport and providing valuable insights into the paleoenvironment (Hadi *et al.* 2024; Vinn *et al.* 2024).

All specimens are deposited at the paleontological collection of the Geology Department of Zanjan University, Iran (GDZU).

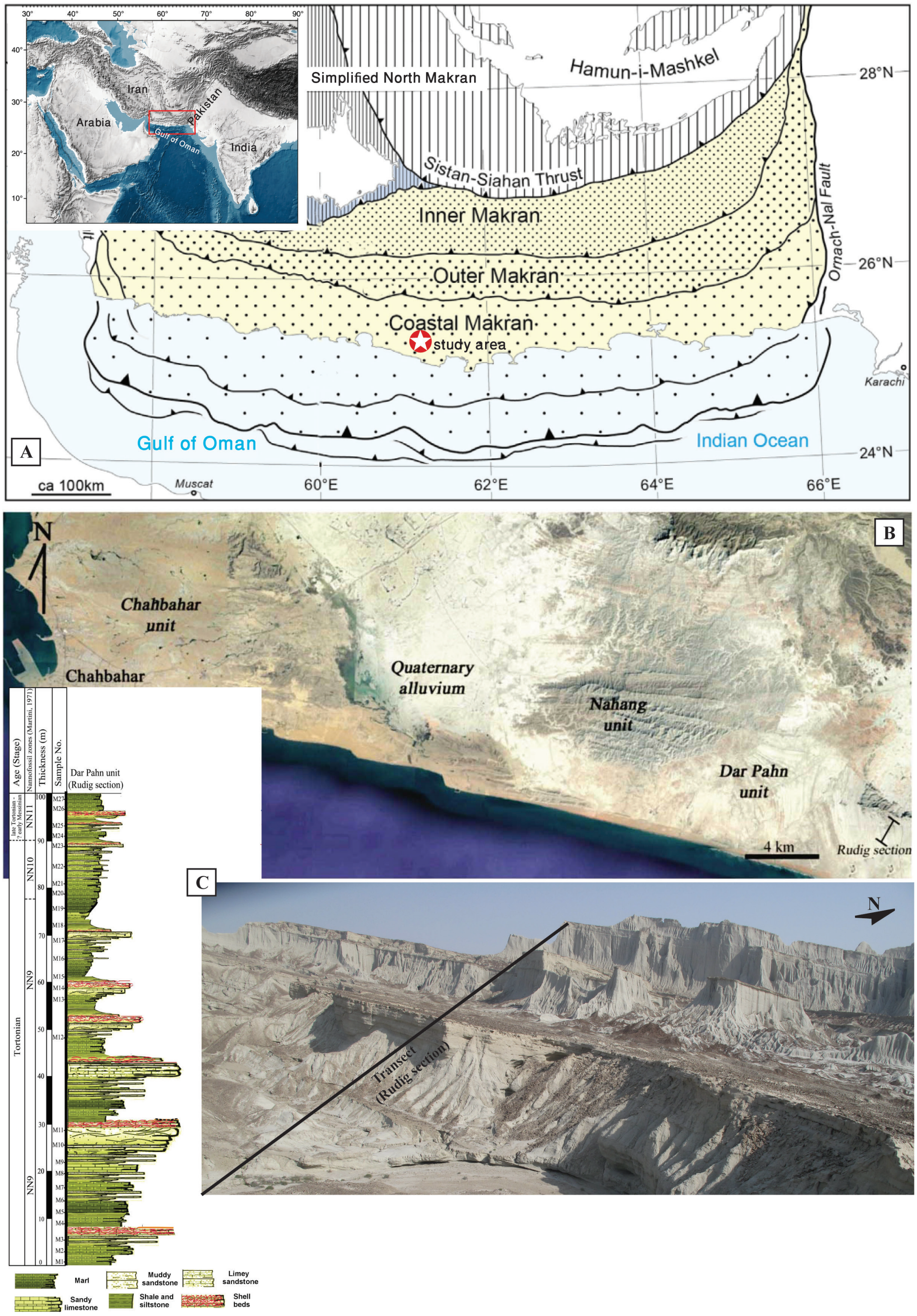

Fig. 1. Maps, lithology, and field images of the fossil locality. **A**. Simplified tectono-sedimentary map of the Makran Accretionary Complex and adjacent mountain ranges (modified from Burg 2018); star indicates the location of the Rudig section. **B**. Location of the Rudig section in the Dar Pahn Unit (lower-right); GoogleEarth@image. **C**. Outcrop view of the Dar Pahn Unit in the Rudig section, showing typical landscape of the Coastal Makran area along with the lithostratigraphic column of the Dar Pahn Unit (Bayet-Goll *et al.* 2025).

Results

Class Gastropoda Cuvier, 1795
Subclass Caenogastropoda Cox, 1960
Family Turritellidae Lovén, 1847

Genus ***Protoma*** Baird, 1870

Type species

Protoma knockeri Baird, 1870, by monotypy.

Protoma harrisoni (Cox, 1936) comb. nov.
Fig. 2A–D

Turritella harrisoni Cox, 1936: 39, pl. 8 figs 25–26, 28.

Turritella sp. – Hadi *et al*. 2024: 4, fig. 4.1a–b.

Non *Turritella harrisoni* Cox, 1936: pl. 8 figs 27, 29.
Non *Turritella angulata* Sowerby, 1840 – Crame 1984: pl. 1 fig. 1.

Material examined

IRAN – **Sistan and Baluchestan** • 10 shells; Dar Pahn Unit; , GDZU-0001 to GDZU-0010.

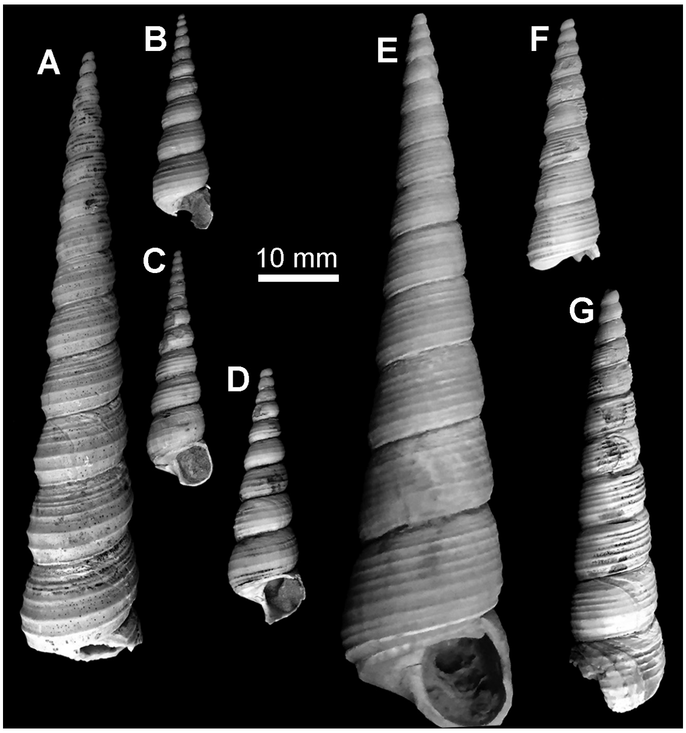

Fig. 2. Turritellidae from the Late Miocene Dar Pahn Unit in southeastern Iran. **A–D**. *Protoma harrisoni* (Cox, 1936). **A**. Large specimen with 15 whorls (GDZU-0001). **B**. Small specimens with convex whorls (GDZU-0002). **C**. Small specimens showing shape of aperture (GDZU-0003). **D**. Small specimen showing shape of growth lines (GDZU-0004). **E–G**. *Protoma kayalensis* (Dey, 1962). **E**. Large specimen showing sculpture and shape of aperture (GDZU-0011). **F**. Small specimen showing convexity of early whorls (GDZU-0012). **G**. Medium-sized specimen showing shape of growth lines (GDZU-00013).

Remarks

Cox (1936) introduced *Turritella harrisoni* for specimens from the Pliocene 'Mekran beds' near Bandar-e Jask on the western end of the Makran margin in southern Iran. He described the whorls as "convex", and among the five primary spirals, he noted "the three more posterior ones [are] weaker than the other two". This description matches only some of the specimens he illustrated, including the one he selected as holotype (Cox 1936: pl. 8 fig. 26). Two specimens (Cox 1936: pl. 8 figs 27, 29), however, show a nearly flat whorl profile and spirals of almost equal strength. These specimens are now assigned to *Protoma kayalensis* Dey, 1961 (see below).

A specimen illustrated as *Turritella angulata* from the Talar Sandstone, between Garr Koh and Chatti at the Makran margin in southwestern Pakistan (Crame 1984) also belongs to *P. harrisoni*. The actual *Turritella angulata* is an Early Miocene species from Kutch in India, and is much more angular due to a prominent keel near the base of the whorls (see Sowerby 1840: pl. 26 fig. 7, or Kulkarni *et al.* 2010: fig. 2g).

Protoma kayalensis (Dey, 1961)
Fig. 2E–G

Turritella kayalensis Dey, 1961: 59, pl. 7 fig. 18.

Protoma kayalensis – Kulkarni *et al*. 2010: 315, fig. 2(h).

Non *Turritella harrisoni* Cox, 1936: pl. 8 figs 27, 29 (misidentification).

Material examined

IRAN – **Sistan and Baluchestan** • 10 shells; Dar Pahn Unit; GDZU-0011 to GDZU-0020.

Remarks

Dey's (1961) description and illustration match the specimens reported here from the Dar Pahn Unit, with the exception that these specimens attain a height of 88 mm, whereas the incomplete specimens from India measure only 32 mm. The species was subsequently reclassified to *Protoma* by Kulkarni *et al.* (2010).

Family Naticidae Guilding, 1834

Genus ***Neverita*** Risso, 1826

Type species

Neverita josephinia Risso, 1826, by monotypy.

Neverita didyma (Röding, 1798)
Fig. 3A–D

Polinices sp. – Hadi *et al.* 2024: 6, fig. 4.3a–b.

Material examined

IRAN – **Sistan and Baluchestan** • 2 shells; Dar Pahn Unit; GDZU-0065, GDZU-0066.

Remarks

This extant species is found throughout the Indo-West Pacific Ocean, including the Persian Gulf (Niamaimandi *et al.* 2017) and has Neogene fossil occurrences ranging from India though Indonesia to Sakhalin Island (Majima 1989; Amano *et al.* 1996; Lyngdoh *et al.* 1999; Kase *et al.* 2008; Harzhauser *et al.* 2018). The species is often referred to as *Glossaulax didymia*, but Huelsken *et al.* (2012) questioned the distinction of *Glossaulax* Pilsbry, 1929, as a subgenus within *Neverita* based on molecular data.

Genus ***Natica*** Scopoli, 1777

Type species

Nerita vitellus Linnaeus, 1758, by subsequent designation.

Natica vitellus (Linnaeus, 1758)
Fig. 3E–I

Polinices sp. – Hadi *et al.* 2024: 6.

Material examined

IRAN – **Sistan and Baluchestan** • 3 shells; Dar Pahn Unit; GDZU-0067 to GDZU-0069.

Remarks

The specimens from the Dar Pahn Unit are very similar to *N. vitellus*, but appear somewhat taller. The species [including its synonym *Natica rufa* (Born, 1778)] has Neogene fossil records in the central Indo-West Pacific region, as well as in India and Japan (Mukerjee 1939; Dey 1961; Kanno *et al.* 1982; Majima 1989).

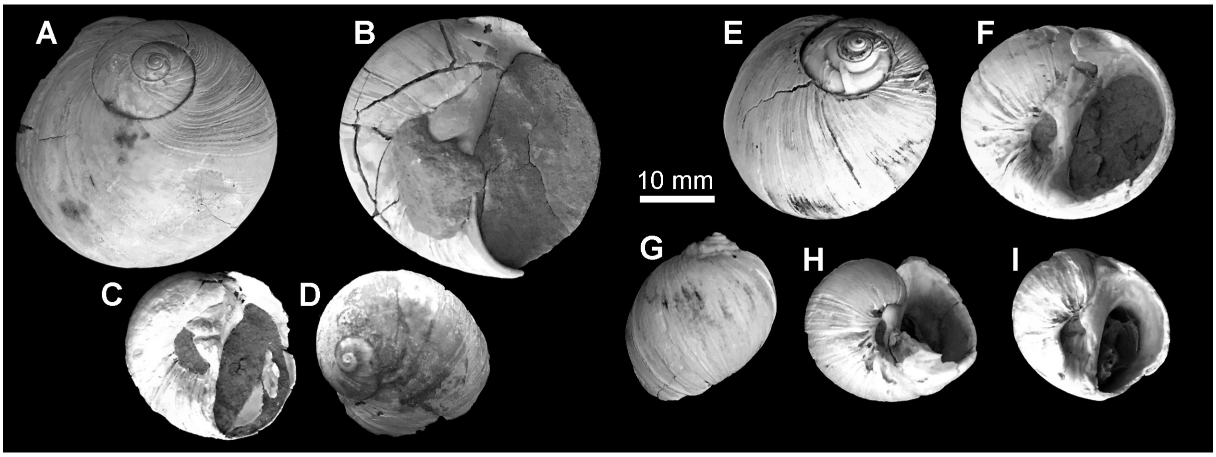

Fig. 3. Naticidae from the Late Miocene Dar Pahn Unit in southeastern Iran. **A**–**D**. *Neverita didyma* (Röding, 1798). **A–B**. Large specimen (GDZU-0065). **C–D**. Small specimen showing umbilical callus (GDZU-0066). **E–I**. *Natica vitellus* (Linnaeus, 1758). **E–F**. Large specimen showing umbilical callus (GDZU-0067). **G–H**. Smaller specimen showing large last whorl and elevation of spire (GDZU-0068). **I**. Smaller specimen showing umbilical callus (GDZU-0069).

Family Bursidae Thiele, 1925

Genus ***Bufonaria*** Schumacher, 1817

Type species

Gyrineum echinatum Link, 1807, by subsequent designation.

Bufonaria chabaharensis Kiel & Hadi sp. nov.
urn:lsid:zoobank.org:act:1203B45A-1800-4BA8-BA8F-668A684A2A53
Fig. 4A–J

Lampusia cf. *affinis* – Newton 1905: 300, pl. 17 fig. 4.
Bursa sp. – Hadi *et al.* 2024: 8, pl. 4 fig. 5.

Diagnosis

The shell is biconical, with six whorls and a strongly constricted base. A central row of spines is present, with 9 spines on the penultimate whorl and 12 spines on the last whorl. The aperture is lenticular to subcircular, with the inner lip featuring beaded spirals and little to no callus. The outer lip bears four strong spines of alternating strength: the sutural spine is long, the central spine is elongate-triangular and shorter, the spine at the basal margin is long and strong, and the spine at the base is short. The areas between the rows of spines have 3 to 6 beaded spiral cords, also alternating in strength.

Etymology

For the town of Chabahar, located in the Makran region of southeastern Iran, where the specimens were collected.

Type material

Holotype

IRAN – **Sistan and Baluchestan** • Dar Pahn Unit; GDZU-0082

Paratypes

IRAN – **Sistan and Baluchestan** • 6 shells; Dar Pahn Unit; GDZU-0083 to GDZU-0088.

Other material studied

IRAN – **Sistan and Baluchestan** • 82 shells; Dar Pahn Unit; GDZU-0089 to GDZU-0170.

Remarks

Bufonaria chabaharensis sp. nov. differs from many other species of *Bufonaria* by its strongly constricted base. Species with a similarly constricted base include *B. crumena* (Lamarck, 1816) from Neogene strata of Indonesia, and *B. margaritula* (Deshayes, 1832) from mostly Pleistocene strata in Indonesia, both of which have a lower spire and weaker spines (see Beu 2005: figs 1–5) than *B. chabaharensis*. Similarly long spines are known from *Bufonaria echinata* (Link, 1807), which today is common throughout the northern Indian Ocean, including the Red Sea and is rare in the northwestern Pacific Ocean up to southern Japan (Okutani 2000; Beu 2005). Other similar extant species include *Bufonaria subgranosa* (G.B. Sowerby II, 1836), also known from Neogene–Pleistocene strata in the central Indo-West Pacific (Tesch 1915), and *Bufonaria rana* (Linnaeus, 1758), both of which, however, have a less strongly constricted basal margin as *Bufonaria chabaharensis* (see Raven 2021).

Family Mitridae Swainson, 1831

Genus ***Cancilla*** Swainson, 1840

Type species

Tiara isabella Swainson, 1831, by subsequent designation.

Cancilla makranensis Kiel & Hadi sp. nov.
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Fig. 4K–M

Mitra sp. – Hadi *et al.* 2024: 10, pl. 5 fig. 1a–b

Non *Mitra* (*Tiara*) *aegra* Reeve, 1845 – Dey 1961: 86, pl. 4 figs 4–5.

Diagnosis

A tall, slender, mitriform shell with at least six whorls, each featuring a finely incised suture. The whorls are slightly convex, sculptured by 6 to 7 broad, flat-topped spiral bands, separated by narrow grooves. In the lower third of the final whorl, the spirals become more rounded, and the interspaces widen. The aperture is narrow and elongated, occupying slightly more than half of the shell's total height. The outer lip is thin, while the inner lip is lightly callused, with four columellar folds. The uppermost fold is the most prominent, with subsequent folds becoming progressively weaker and more oblique toward the base. A fasciole is present at the base of the siphonal column.

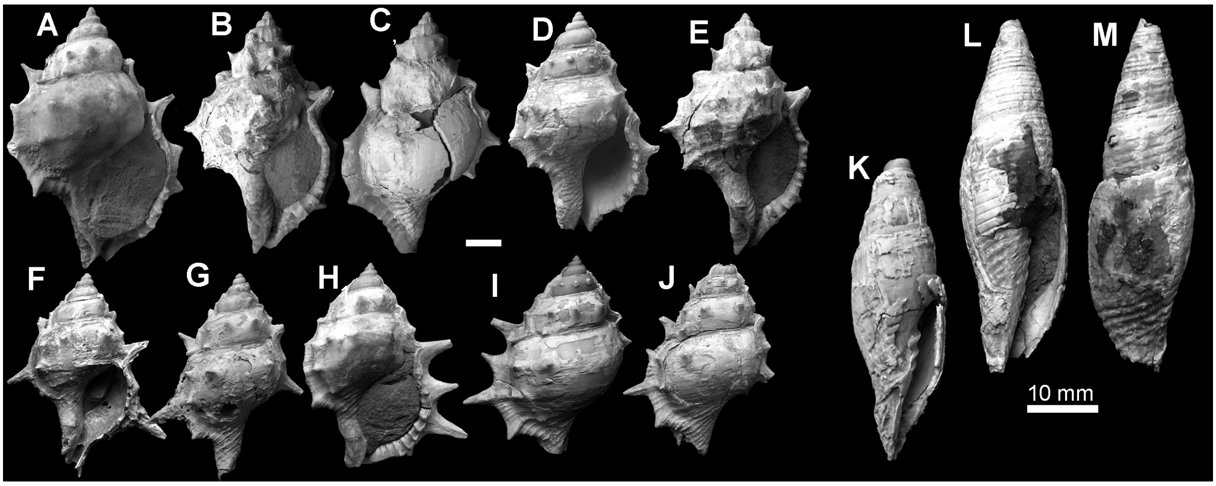

Fig. 4. Bursidae and Mitridae from the Late Miocene Dar Pahn Unit in southeastern Iran. **A–J**. The bursid *Bufonaria chabaharensis* Kiel & Hadi sp. nov. **A**. Paratype; specimen with callus on inner lip of aperture (GDZU-0083). **B–C**. Paratype; specimen with well-preserved siphonal canal (GDZU-0084). **D**. Paratype; specimen showing spiral crenulations on inner lip of aperture (GDZU-0085). **E**. Paratype; specimen showing abapical notch and spine of aperture (GDZU-0086). **F–G**. Paratype; specimen showing long spines on basal margin (GDZU-0087). **H–I**. Holotype, specimen with intact spines on outer lip but broken tip of siphonal canal (GDZU-0082). **J**. Paratype; showing spines and spiral cords on outside of outer lip (GDZU-0088). **K–M**. The mitrid *Cancilla makranensis* Kiel & Hadi sp. nov. **K**. Specimen showing fasciole and the columellar plates (lowermost barely visible; GDZU-0173). **L–M**. Holotype (GDZU-0173).

Etymology

For the Makran margin, where the specimens were collected.

Type material

Holotype

IRAN – **Sistan and Baluchestan** • Dar Pahn Unit; GDZU-0172.

Paratype

IRAN – **Sistan and Baluchestan** • 1 shell; Dar Pahn Unit; GDZU-0173.

Remarks

The image of holotype GDZU-0172 figured by Hadi *et al.* (2024) was photographed at an oblique angle and appears broader than it actually is. Similar specimens were reported by Dey (1961) as *Mitra* (*Tiara*) *aegra* from the Miocene of western India. However, the extant *Nebularia aegra* (Reeve, 1845) (cf. Fedosov *et al.* 2018) has a much lower aperture and higher spire; hence, the Miocene Indian specimens do not belong to that extant species. These Indian specimens are here considered conspecific with *Cancilla makranensis* sp. nov.

The most similar fossil species regarding shell shape is *Mitra birmanica* Vredenburg, 1923 (Vredenburg 1923: pl. 16 fig. 5), but it is sculptured with more numerous and finer spirals. *Mitra tittabweensis* Vredenburg, 1923 (Vredenburg 1923: pl. 16 fig. 8) is less slender and has a broader aperture. Another common Miocene mitrid from the northwestern Indian Ocean region is *Scabricola sowerbyi* (d'Orbigny, 1852) [as *Mitra* (*Chrysame*) *sowerbyi* (Vredenburg 1925; Mukerjee 1939; Dey 1961) and *Nebularia sowerbyi* (Harzhauser 2014: 122, pl. 8 figs 5–6)]. This species is currently assigned to *Scabricola* Swainson, 1840 (cf. Fedosov *et al.* 2018) and differs from *Cancilla makranensis* sp. nov. mainly by having a lower spire. Also similar is *Mitra granatinaeformis* Martin, 1884, from the Miocene of Java, but has only 4–5 spiral incisions per whorl, a taller last whorl, less constricted basal margin and longer siphonal rostrum. The specimen illustrated as *Mitra granatinaeformis* by Mukerjee (1939: 65, pl. 3 fig. 25) from eastern India has four spiral incisions like the specimens from Java, but a somewhat more constricted basal margin.

Class Bivalvia Linnaeus, 1758
Family Arcidae Lamarck, 1809

Genus ***Anadara*** Gray, 1847

Type species

Arca antiquata Linnaeus, 1758, by original designation.

Anadara blanfordi (Newton, 1905)
Fig. 5

Arca blanfordi Newton, 1905: 298, pl. 16 fig. 5.

Anadara sp. – Hadi *et al.* 2024: 12, pl. 5 fig. 5a–c.

Material examined

IRAN – **Sistan and Baluchestan** • 23 shells; Dar Pahn Unit; GDZU-0314 to GDZU-0337.

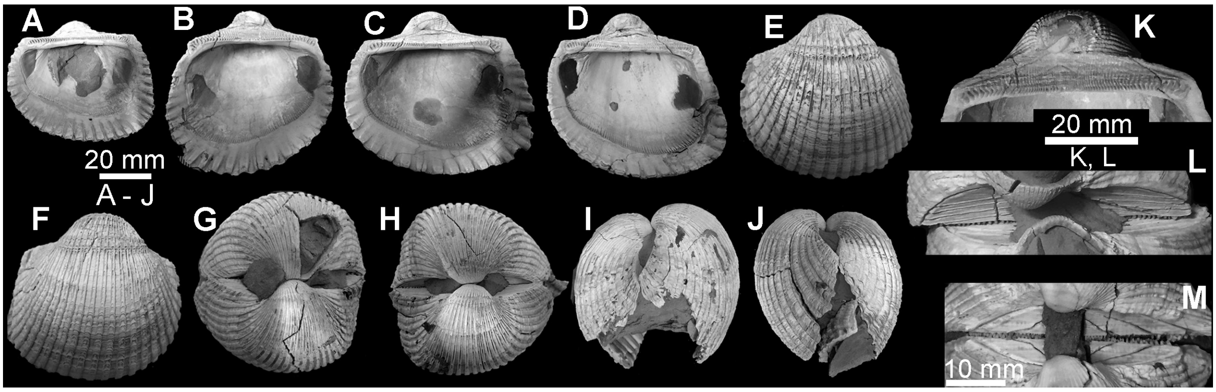

Fig. 5. The bivalve *Anadara blanfordi* (Newton, 1905) from the Late Miocene Dar Pahn Unit in southeastern Iran. **A**. Small right valve, view on interior (GDZU-0314). **B**. Left valve, view on interior (GDZU-0315). **C**. Right valve, view on interior (GDZU-0316). **D**. Right valve, view on interior (GDZU-0317). **E**. Left valve, view on exterior (GDZU-0318). **F**. Right valve, view on exterior (GDZU-0319). **G**. Articulated specimen in dorsal view (GDZU-0320). **H–J**. Articulated specimen, three views showing inflation (GDZU-0321). **K**. Right valve, close-up on dorsal area with fine crenulations and two radial incisions extending from underneath umbo (GDZU-0322). **L**. Close-up on dorsal area of articulated specimen, showing four incisions radiating from underneath umbones (GDZU-0323). **M**. Close-up on dorsal area of articulated specimen, showing three incisions radiating from underneath umbones (GDZU-0323).

Remarks

The specimens reported from "the beach off the Ormara Headland, facing the Mekran or Baluchistan coast, 130 miles west of Karachi" (Newton 1905: 293) are smaller than those reported here (45 mm vs 71 mm in length), but his description of shell outline, inflation, and the number and shape of the ribs leaves no doubt that these specimens belong to the same species.

Similar, but less inflated and smaller is *Anadara garoensis* Mukerjee, 1939, from the Miocene Garo Hills in the eastern Indian province of Meghalaya (Mukerjee 1939: 26, pl. 22 figs 2–3); it reaches only about a third of the size of *A. blanfordi* (25.8 mm vs up to 71 mm in length). Also similar is *Arca yawensis* Noetling, 1901, from the Miocene of Myanmar (Noetling 1901: 144, pl. 6 figs 4–6), which is nearly identical in outline and also very inflated. Noetling reported 29 radial ribs for this species, which falls within the range of the 28–31 present on *A. blanfordi*. However, the species can be distinguished by the difference in the size of the adductor muscle scars, described as "the posterior one much larger than the anterior one" for *A. yawensis*, whereas in *A. blanfordi* they are of subequal size (Fig. 5A–D). The Miocene *Anadara gourae* Dey, 1961, from Kerala, India, is similar to *A. blanfordi* especially regarding its outline, but it has more numerous and narrower radial ribs (Dey 1961: pl. 1 figs 4–8). The most similar extant species is *Anadara rufescens* (Reeve, 1844), an uncommon species that is, however, widely distributed in the Indo-West Pacific Ocean (Mukerjee 1939; Dey 1961).

Family Pectinidae Rafinesque, 1815

Genus ***Fascipecten*** Freneix, Karche & Salvat, 1971

Type species

Pecten vasselii Fuchs, 1878, by original designation.

Remarks

Bifurcating radial ribs as seen in *Fascipecten* do not occur among species of *Pecten*. Therefore, we elevate the subgenus *Pecten* (*Fascipecten*) to the level of genus. The type species *F. vasselii* occurs in Mio–Pliocene strata from South Africa via the Gulf of Suez to southern Pakistan (Fuchs 1878; Cox 1927; King 1954; Freneix *et al.* 1971; Crame 1984). The genus also includes *F. shanganiensis* Eames & Cox, 1958 originally described from the Late Miocene of East Africa (Eames & Cox 1956), and *F. praevasseli* Douglas 1928, from the Early Miocene of Iran (Douglas 1928). Thus, *Fascipecten* is currently restricted to the Neogene of the western Indian Ocean (Freneix *et al.* 1971).

Fascipecten shanganiensis (Eames & Cox, 1958) comb. nov.
Fig. 6A–M

Pecten fasciculatus Eames & Cox, 1956: 49, pl. 15 figs 4–6 [not Hinds 1844–1845; Sandberger 1863; Millet 1866].
Pecten shanganiensis Eames & Cox, 1958: 86.

Pecten sp. – Hadi *et al.* 2024: 14, figs 6.2a–b, 9.

Material examined

IRAN – **Sistan and Baluchestan** • 17 shells; Dar Pahn Unit; GDZU-0243 to GDZU-0259.

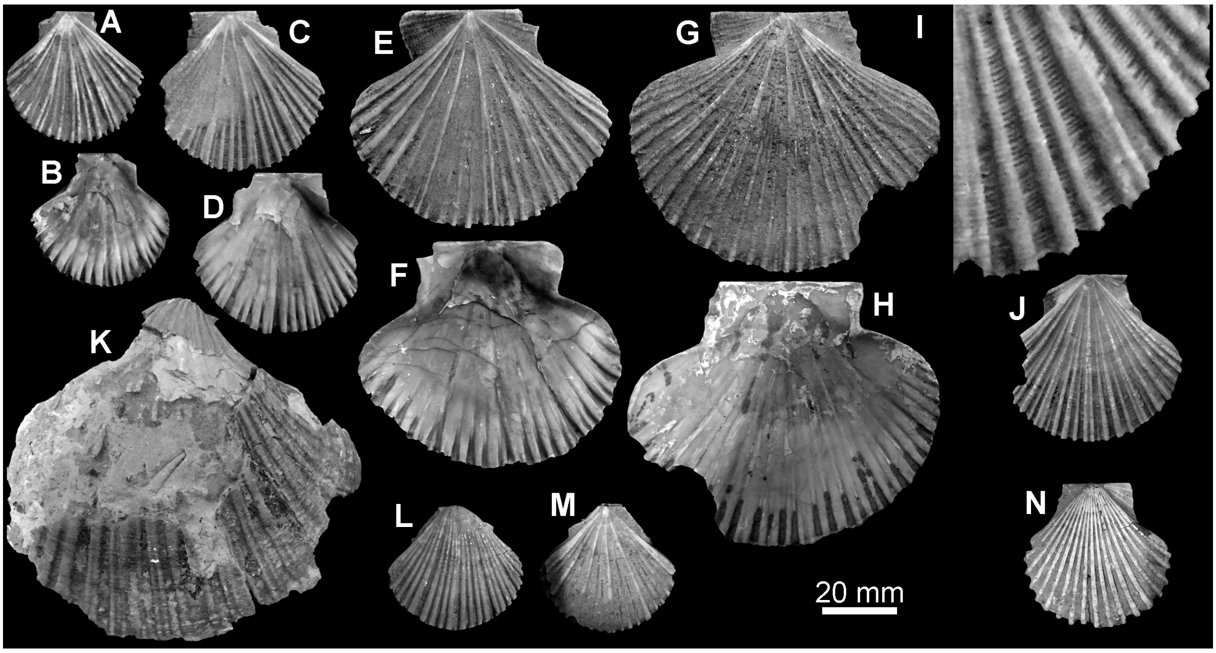

Fig. 6. Pectinidae from the Late Miocene Dar Pahn Unit in southeastern Iran. **A–M**. *Fascipecten shanganiensis* (Eames & Cox, 1958). **A–H**. Growth series of left valves, from small to large, upper images show the outside, lower images show the inside of the shells (A–B: GDZU-0243; C–D: GDZU-0244; E–F: GDZU-0245; G–H: GDZU-0246). **I**. Close-up on sculpture of same specimen as C, showing fine commarginal ribblets. **J**. Left valve of small specimen (GDZU-0250). **K**. Outside of large right valve (GDZU-0247). **L**. Outside of small right valve (GDZU-0248). **M**. Outside of small left valve (GDZU-0249). **N**. *Pecten kilindoniensis* Eames & Cox, 1956, external view of right valve (GDZU-0260).

Remarks

Identical specimens were described as *Pecten fasciculatus* from the Late Miocene of East Africa (Eames & Cox 1956). That name, however, was invalid, as no fewer than three species of the same name had been described earlier (Hinds 1844–1845; Sandberger 1863; Millet 1866) and it was thus replaced by *Pecten shanganiensis*.

Genus ***Pecten*** Müller, 1776

Type species

Ostrea maxima Linnaeus, 1758, by subsequent designation.

Pecten kilindoniensis Eames & Cox, 1956
Fig. 6N

Pecten kilindoniensis Eames & Cox, 1956: 51, pl. 15 figs 7–8.

Material examined

IRAN – **Sistan and Baluchestan** • 1 shell; Dar Pahn Unit; GDZU-0260.

Remarks

The single right valve from the Dar Pahn Unit has 18–19 narrow, regularly spaced and evenly sized radial ribs, virtually identical to those described for the left valves of *Pecten kilindoniensis*, from the Late Miocene of Mafia Island, Tanzania. It resembles that species also in size, outline, and auricle shape.

Family Veneridae Rafinesque, 1815

Genus ***Dosinia*** Scopoli, 1777

Type species

Venus concentrica Born, 1778, by monotypy.

Dosinia peralta Vredenburg, 1928
Fig. 7A–B

Dosinia peralta Vredenburg, 1928: 449, pl. 29 figs 1–6.

Dosinia sp. – Newton, 1905: 299, pl. 16 figs. 8–10.
Dosinia (*Dosinisca*) *peralta* – Borkar & Kulkarni 2019: 10, pl. 1 figs t–z.

Material examined

IRAN – **Sistan and Baluchestan** • 1 shell; Dar Pahn Unit; GDZU-0338.

Remarks

This specimen agrees well with previous illustrations and description of *D. peralta* (Vredenburg 1928; Borkar & Kulkarni 2019), although with a height of 45 mm it is somewhat larger than the maximum height of 35 mm reported by Borkar & Kulkarni (2019). A very similar species is *Dosinia boettgeri* Martin, 1879 from the Late Miocene of Java (see Leloux & Wesselingh 2009: pl. 17 figs 6–8), from which *D. peralta* differs mainly by its more acute anterodorsal margin. Another similar species is *Dosinia exasperata* from Pleistocene strata in the Philippines (Shuto 1971), which has more irregular commarginal sculpture and the sculpture is scaly on the posterodorsal margin, unseen in *D. peralta*.

Extant specimens of *Dosinia exasperata* are more roundish and have more steeply sloping antero- and posterodorsal margins.

Genus ***Clementia*** Gray, 1842

Type species

Mactra papyracea Gmelin, 1791, by subsequent designation.

Clementia papyracea (Gmelin, 1791)
Fig. 7C–E

Mactra papyracea Gmelin, 1791: 3257.
Venus non-scripta Sowerby, 1840: pl. 25 fig. 8.

Astarte sp.? – Cossmann, 1923: 120, pl. 7 fig. 1.
Venus (*Clementina*) *papyracea* – Vredenburg 1928: 455, pl. 32.
Clementia papyracea – Mukerjee 1939: 23, pl. 1 fig. 17.
Dosinia sp. – Hadi *et al*. 2024: 14, fig. 6.2b

Material examined

IRAN – **Sistan and Baluchestan** • 6 shells; Dar Pahn Unit; GDZU-0264 to GDZU-0269.

Remarks

This is an extant species with a broad Indo-West Pacific distribution; fossil occurrences range back at least into the Early Miocene and are known across the Indo-West Pacific region (Sowerby 1840; Cossmann 1923; Vredenburg 1928; Beets 1950; Shuto 1969; Mahdi 2007; Ralte 2012), including Japan (Ogasawara 1976).

Genus ***Paratapes*** Stoliczka, 1870

Type species

Venus textile (Gmelin, 1791), by typification of replaced name.

Paratapes protolirata (Noetling, 1901)
Fig. 7F–I

Pophia [sic!] sp. – Hadi *et al.* 2024: 15, fig. 5.6a–b.

Material examined

IRAN – **Sistan and Baluchestan** • 4 shells; Dar Pahn Unit; GDZU-0277 to GDZU-0280.

Remarks

Tapes protolirata Noetling, 1901 from the Miocene of Myanmar was described as follows: "ornamentation consists of strong concentric ribs, very regular, flatly rounded, and cover the entire shell uniformly". Although the outer shell surface of the available specimens is either obscured by sediment or partially corroded, one specimen (Fig. 7G) shows indications of concentric sculpture. The drawings provided by Noetling (1901: 212, pl. 13 figs 12–13) show specimens with a somewhat straighter dorsal margin than the Iranian specimens, hence they are here only tentatively assigned to *Paratapes protolirata*.

Pullastra? *virgata* (Sowerby 1840: pl. 25 fig. 9) from the Miocene of Kutch, India, is less rectangular than typical *Venerupis* Lamarck, 1818 (= *Pullastra* Sowerby, 1826) and somewhat resembles *Paratapes*. However, that species has never been revised and was only briefly mentioned in the context of an Eocene species of *Tapes* Megerle von Mühlfeld, 1811 from northern Italy (Mayer-Eymar 1863). Popenoe & Kleinpell (1978) illustrated a similar specimen as *Paphia euglypta* (Philippi, 1847) from the Pliocene Vigo Formation in the Philippines. The three accepted extant species of *Paratapes*, differ from each other only by minute differences, but they seem to have a more gently rounded dorsal margin than *Paratapes protolirata* (i.e., Thach 2024).

Family Solecurtidae d'Orbigny, 1846

Genus ***Solecurtus*** Blainville, 1824

Type species

Solen strigilatus Linnaeus, 1758, by subsequent designation (Anton 1838).

Solecurtus sp.

Fig. 7J

Material examined

IRAN – **Sistan and Baluchestan** • 1 shell; Dar Pahn Unit; GDZU-0283.

Remarks

The fragmentary specimen shows the 'clapboard' sculpture typical of *Solecurtus*. A similar species is the Miocene *Solecurtus exsulcatus* Noetling, 1901, from Myanmar, but the single available specimen is too fragmentary for reliable identification. The Miocene *Solecurtus luzonensis* (Kanno *et al.* 1982: 77, pl. 16 fig. 9) from the Philippines seems to have a broader posterior margin.

Family Tellinidae Blainville, 1814

Genus ***Arcopaginula*** Jousseaume, 1918

Type species

Tellina inflata (Gmelin, 1791), by original designation.

Arcopaginula inflata (Gmelin, 1791)
Fig. 7K–L

Arcopaginula inflata – Kanno *et al.* 1982: pl. 15 fig. 7.

Material examined

IRAN – **Sistan and Baluchestan** • 2 shells; Dar Pahn Unit; GDZU-0339, GDZU-0340.

Remarks

This is a quite characteristic extant species, originally reported from the Red Sea (Gmelin 1791; Lamy 1918), but widely distributed in the Indo-West Pacific (Glover *et al.* 2016). The potentially oldest fossil record (at least of the genus) is from the Early Oligocene of India (Kachhara *et al.* 2012). Further fossil records of *A. inflata* are from the Neogene of the Philippines (Shuto 1971; Kanno *et al.* 1982), the Pliocene of Vanuatu (Abrard 1947), and the Pleistocene of Somalia (Abrard 1941).

Family Corbulidae Lamarck, 1818

Genus ***Corbula*** Bruguière, 1797

Type species

Corbula sulcata Lamarck, 1801, by subsequent designation (Schmidt 1818).

Corbula darpahnensis Kiel & Hadi sp. nov.
urn:lsid:zoobank.org:act:F22549C7-616F-4739-B4D4-F2141711A3EB
Fig. 7M–S

Corbula sp. – Hadi *et al.* 2024: 15, fig. 6.7a–c.

Diagnosis

The shell is elongate-oval, moderately inflated, with low, uncurved umbones. The posterior margin is acute and truncated, featuring a blunt ridge. The ventral margin exhibits a distinct angulation or curvature just posterior to the midline. The sculpture consists of fine or rough growth increments, less distinct on the left valve. There is no lunule, and the escutcheon is indistinct.

Etymology

For the Dar Pahn Unit.

Type material

Holotype

IRAN – **Sistan and Baluchestan** • Dar Pahn Unit; GDZU-0289.

Paratypes

IRAN – **Sistan and Baluchestan** • 3 shells; Dar Pahn Unit; GDZU-0290, GDZU-0291, GDZU-0293.

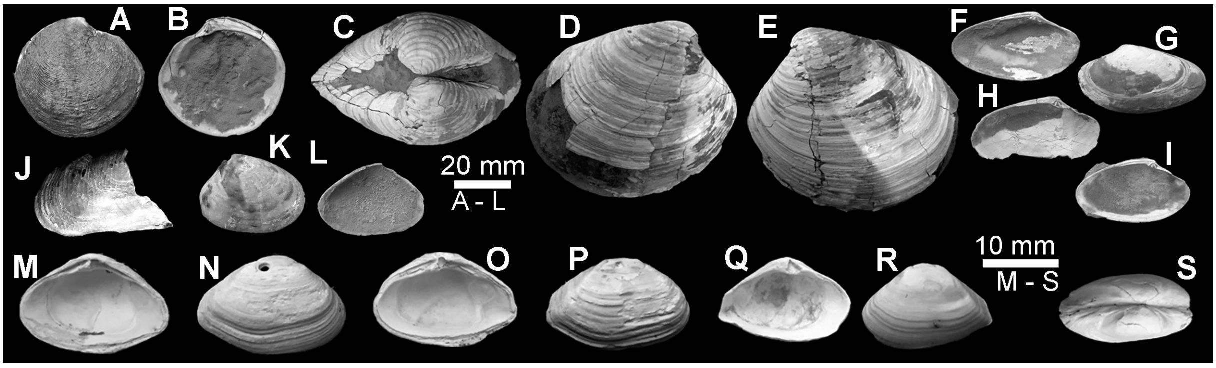

Fig. 7. Imparidentia from the Late Miocene Dar Pahn Unit in southeastern Iran. **A–B**. *Dosinia peralta* Vredenburg, 1928, complete right valve with adhering sediment (GDZU-0338). **C–E**. *Clementia papyracea* (Gmelin, 1791), articulated specimen (GDZU-0264). **F–I**. *Paratapes protolirata* (Noetling, 1901). **F–G**. Complete left valves (GDZU-0277). **H**. Left valves with broken ventral margin (GDZU-0278). **I**. Complete left valve (GDZU-0279). **J**. *Solecurtus* sp., fragment, posterior margin of right valve showing clapboard pattern (GDZU-0283). **K–L**. *Arcopaginula inflata* (Gmelin, 1791), left valve with damaged hinge area (GDZU-0339). **M–S**. *Corbula darpahnensis* Kiel & Hadi sp. nov. **M**. Paratype, left valve, interior view (GDZU-0290). **N**. Paratype, right valve, exterior view (GDZU-0291). **O–P**. Paratype, left valve, specimen with rather strong commarginal sculpture (GDZU-0292). **Q–R**. Holotype; a complete left valve showing hinge dentition, pallial line, and posterior ridge (GDZU-0289). **S**. Paratype, articulated shell, dorsal view (GDZU-0293).

Table 1. List of identified mollusks from the Late Miocene Dar Pahn Unit, their geologic ranges and Miocene distributions. *Unchanged record from Hadi *et al*. (2024). **includes *Bullia* sp. reported by Hadi *et al*. (2024). ***the material of Hadi *et al*. (2024) includes two different 'turrid' species, both poorly preserved and currently impossible to assign to any genus.

Species	Age range	Neogene distribution
Protoma harrisoni (Cox, 1936)	Late Miocene–Pliocene	Makran margin of Iran and Pakistan
Protoma kayalensis (Dey, 1961)	Late Miocene	Iran and India
Thylacodes sp.*		
Tibia sp.**		
Neverita didyma (Röding, 1798)	Miocene–Recent	Iran to Sakhalin Island
Natica vitellus (Linnaeus, 1758)	Miocene–Recent	Iran to Japan
Bufonaria chabaharensis Kiel & Hadi sp. nov.	Late Miocene	Makran margin of Iran
Cancilla makranensis Kiel & Hadi sp. nov.	Late Miocene	Makran margin of Iran
Conus sp.*		
Turridae (2 species)***		
Architectonica sp.*		
Anadara blanfordi (Newton, 1905)	Late Miocene	Makran margin of Iran and Pakistan
Ostrea sp.*		
Anomia sp.*		
Fascipecten shanganiensis (Eames & Cox, 1958)	Late Miocene	South Africa to Iran
Pecten kilindoniensis Eames & Cox, 1956	Late Miocene	Tanzania and Iran
Tagelus sp.*		
Dosinia peralta Vredenburg, 1928	Miocene	Iran and India
Clementia papyracea (Gmelin, 1791)	Miocene–Recent	Indo-West Pacific region
Paratapes protolirata (Noetling, 1901)	Miocene	Iran to Myanmar
Solecurtus sp.*		
Arcopaginula inflata (Gmelin, 1791)	Miocene–Recent	Iran and the Philippines
Corbula darpahnensis Kiel & Hadi sp. nov.	Late Miocene	Makran margin of Iran

Other material examined

IRAN – **Sistan and Baluchestan** • 20 shells; Dar Pahn Unit; GDZU-0294 to GDZU-0313.

Remarks

Corbula darpahnensis sp. nov. differs from the Late Miocene "*Corbula harpa* d'Arch." from Myanmar (Noetling 1901) by being elongate rather than triangular; the original *C. harpa* is from the Early Eocene Ranikot Group in Pakistan (d'Archiac & Haime 1853) and is also triangular in outline. Two similarly elongate species are the Miocene *Corbula tunicosulcata* Vredenburg, 1928, and the Pliocene *Corbula mekranica* Vredenburg, 1928, both of which have more regular concentric ornament and a more acute posterior margin (Vredenburg 1928). Also more triangular is the accordingly named *Corbula trigonalis* Sowerby, 1840 from the Miocene of India (Sowerby 1840: pl. 25 fig. 4), which also has a much sharper posterior ridge (see Halder & Bano 2015: fig. 5). Sowerby also reported *C. rugosa* Lamarck, 1806 from the Miocene of India (Sowerby 1840: pl. 25 fig. 5), but that specimen was later included in *Corbula tunicosulcata* (Vredenburg 1928).

Similar regarding shell outline and the low umbo is *Corbula socialis* Martin, 1879, from the Miocene of Java, but that species typically has distinct, blunt commarginal ribs, unlike the specimens from the Dar Pahn Unit. Two further species with a similar outline but distinct commarginal ribs are *C. scaphoides* Hinds, 1843 and *C. laterugata* Cossmann, 1923 from the Pliocene of southeastern India (Cossmann 1923). Also similar is *Corbula njalindungensis* Martin, 1922, from the Middle Miocene of Java. It is rather variable and includes relatively smooth forms and some that are of only moderate inflation (see Leloux & Wesselingh 2009: pls 28–30), but typically has a much more distinct and elevated umbo.

Discussion

An updated list of molluscan species from the Dar Pahn Unit in southeastern Iran is provided in Table 1. Of the 14 taxa identifiable to species level, seven were restricted to the northwestern Indian Ocean from Iran to the Indian west coast during the Late Miocene, one ranged as far east as Myanmar, and six had a broad Indo-West Pacific distribution. Thus, the Late Miocene Dar Pahn fauna indicates a continuation of the Early Miocene "Western Indian Province" (cf. Harzhauser 2007; Harzhauser *et al.* 2017) into the Late Miocene, albeit with a slightly increased number of cosmopolitan Indo-West Pacific taxa. These cosmopolitan taxa would be interesting candidates for more detailed investigations of the origin and dispersal of Indo-West Pacific species (i.e., Renema *et al.* 2008; Tian *et al.* 2024). However, the fauna of the Dar Pahn Unit and the Neogene Makran margin in general is still understudied. Many early studies from this region were based on fortuitous collections (i.e., Newton 1905; Cox 1936; Crame 1984), and of the about 24 species known from the Dar Pahn Unit, ten could not be identified to species level, and three are here described as new. Being positioned at the crossroads between the Mediterranean Sea and the Indian Ocean, further work in this area would certainly improve our understanding of the biogeography of the Tethyan region during the later Cenozoic.

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