Preliminary study on *Acropora* (Scleractinia: Astrocoeniina: Acroporidae) of the Persian Gulf, with emphasis on the north and northeastern areas

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Abstract: Due to a lack of adequate taxonomic information on *Acropora* Oken, 1815 species in the Persian Gulf, especially those inhabiting the coasts of the northern and northeastern areas, an appraisal of the diversity of this genus required comprehensive and careful examination of a large number of specimens. To satisfy such a need, 10–15 cm pieces of more than 1100 colonies of staghorn corals were collected from the subtidal zones of different islands. The specimens were studied using both light stereo and scanning electron microscopes and were identified with regional and global keys. During the study, 9 species of *Acropora* were identified, including *A. tortuosa* (Dana, 1846) and *A. mossambica* Riegl, 1995, which are new to the Persian Gulf. Furthermore, *A. horrida* (Dana, 1846), *A. nasuta* (Dana, 1846), *A. aspera* (Dana, 1846), and *A. muricata* (Linnaeus, 1758) were identified, all of which were recorded for the first time from Iran. By adding these species to those previously reported from the area, the numbers of *Acropora* species in the study area and in the Persian Gulf reach 10 and 15, respectively.

Key words: Khark, Larak, Farur, taxonomic key, islands, Iran, coral, *Acropora*

1. Introduction

The information available on different aspects of scleractinian diversity and biology is exhaustive (Wallace, 1999; Meyer and Paulay, 2000; Veron, 2000). From a taxonomic point of view, staghorn corals, members of genus *Acropora* Oken, 1815, are amongst the most controversial taxa due to their high intraspecific diversity and interspecific similarities. Those facts are evident in the constant changes of the total diversity estimates given by several authors (see Wallace, 1999; Veron, 2000). Although recent molecular studies (van Oppen et al., 2001; Fukami et al., 2003; Wolstenholme et al., 2003, Wolstenholme, 2004; Fukami et al., 2007; Chen et al., 2009) raised some hopes in solving such problems, morphological identification is still the most preferred procedure in the taxonomical studies conducted on such a group. Wallace (1999) resolved most of the taxonomical problems of this genus, hence improving the accuracy of surveys.

Despite the numerous studies carried out on *Acropora* worldwide, the data available on scleractinian species diversity in the Persian Gulf in general and on the genus *Acropora* in particular are restricted (Spalding et al., 2001), even though the corals of the southern part of the Persian Gulf are better known than those of the northern and northeastern parts.

Coles (2003) reported 11 species of *Acropora*, including *A. clathrata* (Brook, 1891), in the Persian Gulf. In her previous monograph, which included the Persian Gulf and the Gulf of Oman, Wallace (1999) reported 13 *Acropora* species, but excluded *A. clathrata*. On the northern coast of the Persian Gulf, however, only 5 *Acropora* species, including *A. clathrata*, have been reported so far (Magsoudlou, 2008).

Due to the lack of adequate taxonomical information about the *Acropora* species of the Iranian parts of the Persian Gulf, and taking into account the importance of the genus *Acropora* from an endemicity point of view and its use as a model for studying the effects of global warming on marine taxa (Wallace and Muir, 2005), the present study was conducted to ascertain the distribution and the diversity of *Acropora* species in the area.

2. Materials and methods

On the basis of the studies performed on the scale of environmental stresses (see Kämpf and Sadrinasab, 2006; Nezlin et al., 2007), the Persian Gulf was divided into 3 distinct parts: the eastern, central, and western parts. Taking this fact into consideration, in each part, a coral-rich island was selected for sampling: these were Larak Island (26°49'N–26°53'N, 56°19'E–56°25'E), Farur Island

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(26°14′N–26°19′N, 54°29′E–54°32′E), and Khark Island (29°12′N–29°16′N, 50°16′E–50°20′E), from the eastern, central, and western parts of the Persian Gulf, respectively.

Along the coasts of these 3 islands, 40 locations were selected (Figure 1) for sampling. The geographic coordinates of each station were obtained using a Garmin Etrex GPS receiver. From the 1169 colonies, pieces of 10 to 15 cm were collected from October 2008 to December 2009. The first author carried out the underwater photography. At each station, the specimens were collected by scuba diving to the depths of 3, 6, and 9 m, along a line at least 120 m long.

The specimens were bleached in 5 ppt sodium hypochlorite and transferred to the laboratory where further studies took place. To study the gross and fine morphologies of the specimens, a Nikon SMZ 1000 stereomicroscope and a Zeiss DSM960A scanning electron microscope were used, respectively. Based on even minute morphological differences, 55 specimens representing 9 species (excluding *Acropora aspera*) were selected and shipped to the Museum of Tropical Queensland for further studies and identifications. Of these specimens, C.C. Wallace identified 45. Mostly due to their small size, 10 specimens remained unidentified. The morphological...
descriptions as well as the terminology and measuring procedures used in this study were performed on the basis of the descriptions and the nomenclature suggested by Wallace (1978), Veron and Wallace (1984), Riegl (1995), Wallace (1999), Veron (2000), and Wolstenholme et al. (2003).

In the present paper, a regional taxonomic key on the *Acropora* species is also suggested, in which the characteristics of the specimens found in the present study were used for species of the northern and northeastern parts of the Persian Gulf. For the species of the southern part, the descriptions given by Wallace (1999) were used.

### 3. Results

All 1169 specimens were examined, but from those, for each species a few specimens containing most of the plasticity range of the characteristics of that species were selected for description purposes. Throughout this article, the specimens’ data are presented in the following order: sampling location; coordinates of the sampling location; location depth, sampling date, and the museum reference number. The order followed for the description of 2 or more specimens was also the same.

Whenever branch diameters are provided, they are presented in the following order: branch diameter at the base, at the midpoint, and at 5 mm below the tip of the branch.

From the northern and northeastern parts of the Persian Gulf, 9 species of *Acropora* were identified during the study. Amongst those species, 6 are reported for the first time from the area of the study, and 2 other species are new to the Persian Gulf. Although the ecological and population data collected during the sampling are not analyzed in the present paper in general, amongst the species found in this study, *A. downingi* and *A. arabensis* were the most common species, with *A. valida* next in abundance and the rest of the species being rare.

The specimens described in this article are deposited in the Zoological Museum of the University of Tehran (ZUTC) and the National Museum of Natural History (MMTT).

In the description of each species, we chose not to mention the synonyms, as they are available in detail from Wallace (1999).

#### Acropora valida (Dana, 1846); Figures 2a–2g

**Material examined:** Iran, Larak Island: 26°53′10.1″N, 56°23′58.3″E; depth 6 m; 7 October 2008; MMTT Cnid. 1024. Larak Island: 26°52′45.8″N, 56°20′26.8″E; depth 6 m; 14 October 2008; MMTT Cnid. 1319. Larak Island: 26°53′12.1″N, 56°23′32.1″E; depth 3 m; 8 October 2008; ZUTC Cnid. 1115.

**Description:** Branching pattern: Caespitose (usually for small colonies) to corymbose (usually for large colonies); main branches of large colonies sometimes grow horizontally; colony size up to 45 cm (rarely more than 55 cm) (Figure 2a); branches cylindrical to slightly tapering (Figure 2b); branch diameters: 6.5–11.9 mm, 7.3–11.7 mm, and 7.2–9.8 mm; branch length up to 29.4 mm; growth determinate or semideterminate depending on the corallum.

**Axial corallites:** Conspicuous, cylindrical, twice the size of radial corallites; outer diameter 2.0–2.6 mm; calice diameter and thickness of axial corallites walls similar (0.8–1.2 mm); round opening; most axial corallites contain 2 septa cycles; primary septa up to 2/3R, but longer in the deeper parts of the calice; secondary septa up to 1/3R, sometimes dentate; tertiary septa rarely present (Figure 2f).

**Radial corallites:** Appressed tubular with oval opening; more or less equal in size; profile length 2.0–3.3 mm; some tubular or tubo-nariform corallites (usually having thick lips) scattered along branches (Figures 2c and 2d); primary septa present up to 2/3R; directive septa prominent; secondary septa development variable in different corallites: up to 1/5R in those near the branch base, absent or partially developed in those near the branch tip.

**Coenosteum:** Broken-costate to costate on outer walls of radial corallites (Figure 2e); densely arranged lines of laterally flattened spinules on the outer edge of radial corallite walls; reticulate with simple to slightly elaborated spinules between radials (Figure 2g).

**Color:** Pale to cream brown.

**Remarks:** Comparison of the specimens of *A. valida* from this study with those described by Wallace (1999) showed that the branches were relatively thinner and shorter, and axial corallites were smaller and had thinner walls in the specimens from the study area.

#### Acropora aspera (Dana, 1846); Figures 3a–3g

**Material examined:** Iran, Farur Island: 26°17′44.1″N, 54°32′22.4″E; depth 6 m; 28 October 2009; MMTT Cnid. 1347. Khark Island: 29°16′33.8″N, 50°18′21.5″E; depth 3 m; 19 December 2009; MMTT Cnid. 1699.

**Description:** Branching pattern: Arborescent (Figure 3a); branch length up to 71.7 mm, tapering slightly towards the tip, and tapering abruptly at the tip (Figure 3b); branch diameters: 11.3–13.0 mm, 9.5–10.8 mm, and 6.8–8.4 mm; growth indeterminate.

**Axial corallites:** Conspicuous; larger than radial corallites; dome-shaped; outer diameter 2.7–4.0 mm; calice diameter 1.3–1.6 mm; both primary and secondary septa present up to 2/3R, secondary septa development variable in different corallites: up to 1/5R in those near the branch base, absent or partially developed in those near the branch tip.

**Radial corallites:** Labellate; horizontal extension of the outer walls and absence of inner walls give a gutter-shaped appearance (Figures 3c and 3d); profile length 1.2–1.7 mm; subimmersed radial corallites scattered between labellate corallites; crowded; radial corallites in 2 sizes,
both with a round opening; development of septal cycles varies depending on the position of the radial corallites on the branch. In those located from the branch base to near its tip 2 complete cycles are present, but these are incomplete and poorly developed in the radial corallites located at the branch tips; primary septa up to 1/2R, except for the directives that are well developed; secondary septa, if present, a low ridge maximum 1/3R.

**Coenosteum:** Costate to broken-costate on radial corallites proper (Figure 3e); sometimes densely arranged lines of laterally flattened spinules on radial corallites; coenosteum between radial corallites reticulate with dispersed, laterally flattened, and slightly elaborated spinules (Figure 3g).

**Color:** Brown to cream-brown or greenish brown.

**Acropora horrida** (Dana, 1846); Figures 4a–4g  
**Material examined:** Iran, Farur Island: 26°17′44.1″N, 54°32′22.4″E; depth 6 m; 28 October 2009; MMTT Cnid. 1348. Larak Island: 26°52′45.8″N, 56°20′26.8″E; depth 6 m; 14 October 2008; ZUTC Cnid. 1305.

**Description:** Branching pattern: Arborescent; slightly tapering branches (Figures 4a and 4b); branch diameters: 7.9–11.3 mm, 7.2–10.5 mm, 6.0–9.4 mm; branch length up to 26.1 mm; growth indeterminate.

**Axial corallites:** Conspicuous; outer diameter 2.0–2.6 mm; calice diameter 1.2–1.6 mm; primary septa present, maximum 3/4R; sometimes dentate; secondary septa absent (Figure 4f).

**Radial corallites:** Extremely fragile; with different sizes; ragged surface (Figure 4c); profile length 2.0–4.5 mm; round opening; septa poorly developed, particularly the inner septa; primary septa up to 1/3R; outer directive septum more developed than the inner directive; secondary septa absent.

**Coenosteum:** Broken-costate to reticulate on radial corallites proper (Figure 4d); reticulate between radial corallites; simple, laterally flattened spinules scattered on and between radials (Figures 4e and 4g).

**Color:** Brown.
Remarks: Of this species, 1 specimen was sent to the Museum of Tropical Queensland, where C.C. Wallace identified it as Acropora cf. horrida. Detailed and careful examination of other specimens from the same dive and of additional specimens collected later allowed us to confirm the identification.

Comparison between the measurements of the specimen found in the present study with those described by Wallace (1999) indicated that branches of almost the same diameter were much shorter in our specimens. The other measurements more or less overlapped.

Acropora downingi Wallace, 1999; Figures 5a–5f

Material examined: Iran, Larak Island: 26°53′07.8″N, 56°23′59.0″E; depth 3 m; 7 October 2008; MMTT Cnid. 1022. Larak Island: 26°53′16.3″N, 56°21′01.3″E; depth 6 m, 11 October 2008; MMTT Cnid. 1172. Khark Island: 29°12′36.6″N, 50°19′56.5″E; depth 3 m; 14 December 2009; MMTT Cnid. 1404. Farur Island: 26°17′44.1″N, 54°32′22.4″E; depth 6 m; 28 October 2009; MMTT Cnid. 1382. Khark Island: 29°16′34.4″N, 50°18′31.7″E; depth 9 m; 20 December 2009; ZUTC Cnid. 1708.

Description: Branching pattern: Arborescent table, large, some up to 3 m in diameter (Figure 5a), both single and multilayered table forms present; some branches grow upwards; branches tapering slightly towards the tip (Figures 5b and 5c), anastomosed branches forming solid central plate; branch diameters: 5.4–14.8 mm, 4.8–13.6 mm, 4.2–9.1 mm; branch length up to 62.0 mm; growth determinate.

Axial corallites: Small cylindrical; outer diameter 0.9–2.5 mm; calice diameter 0.6–1.6 mm; round to oval opening; 1 or 2 septal cycles present (Figure 5e), primary septa 1/2R, directive septa sometimes touching; secondary septa absent or inconspicuous; septal length increasing downwards.

Radial corallites: Crowded and fragile; various sizes (Figure 5c); tubular, with oblique opening and upward sharp edges (Figure 5d); profile length 1–4 mm; some corallites immersed, especially those at the base of branches; primary septa seldom present (in most cases only directive septa present), when present maximum 1/4R.

Coenosteum: Coenosteum on radial corallites proper costate (Figure 5d), broken-costate, or linearly arranged, laterally flattened spinules; coenosteum between radials reticulate with simple spinules (Figure 5f).

Color: Brown to dark green or gray; branch tips pale or white.

Remarks: Our preliminary studies indicated that Acropora downingi has 2 forms in the study area. In one form, some branches grow upwards, unlike in the second form, which has no upright branches on the table. The latter form might have been misidentified as A. clathrata.

Further taxonomic work on these growth forms is currently underway. A. clathrata was not found during the present study. Consequently, it is likely that either the reports of A. clathrata from the southern (and western) Persian Gulf (Sheppard and Sheppard, 1991; Hodgson and Carpenter, 1996; Riegl, 1999; Abdel-Moati, 2011) are a misidentification of A. downingi (see Wallace, 1999) or that A. clathrata is restricted to the southern (and western) part of the Persian Gulf, or it is an extremely rare species in this part of the Persian Gulf (see discussion).

Acropora arabensis Hodgson and Carpenter, 1996; Figures 6a–6g

Material examined: Iran, Larak Island: 26°53′16.3″N, 56°21′01.3″E; depth 6 m; 11 October 2008; MMTT Cnid. 1153. Larak Island: 26°53′16.9″N, 56°21′00.4″E; depth 9 m; 11 October 2008; MMTT Cnid. 1239. Larak Island: 26°53′12.1″N, 56°23′32.1″E; depth 3 m; 8 October 2008; MMTT Cnid. 1125. Farur Island: 26°16′52.4″N, 54°32′22.4″E; depth 6 m; 28 October 2009; MMTT Cnid. 1382. Khark Island: 29°16′34.4″N, 50°18′31.7″E; depth 9 m; 20 December 2009; ZUTC Cnid. 1708.

Description: Branching pattern: Arborescent table, large, some up to 3 m in diameter (Figure 5a), both single and multilayered table forms present; some branches grow upwards; branches tapering slightly towards the tip (Figures 5b and 5c), anastomosed branches forming solid central plate; branch diameters: 5.4–14.8 mm, 4.8–13.6 mm, 4.2–9.1 mm; branch length up to 62.0 mm; growth determinate.

Axial corallites: Small cylindrical; outer diameter 0.9–2.5 mm; calice diameter 0.6–1.6 mm; round to oval opening; 1 or 2 septal cycles present (Figure 5e), primary septa 1/2R, directive septa sometimes touching; secondary septa absent or inconspicuous; septal length increasing downwards.

Radial corallites: Crowded and fragile; various sizes (Figure 5c); tubular, with oblique opening and upward sharp edges (Figure 5d); profile length 1–4 mm; some corallites immersed, especially those at the base of branches; primary septa seldom present (in most cases only directive septa present), when present maximum 1/4R.

Coenosteum: Coenosteum on radial corallites proper costate (Figure 5d), broken-costate, or linearly arranged, laterally flattened spinules; coenosteum between radials reticulate with simple spinules (Figure 5f).

Color: Brown to dark green or gray; branch tips pale or white.
54°29′36.4″E; depth 9 m; 30 October 2009; MMTT Cnid. 1377. Khark Island: 29°13′53.5″N, 50°17′53.5″E; depth 3 m; 15 December 2009; ZUTC Cnid. 1503.

**Description:** Branching pattern: Arborescent, sometimes caespitose; colonies mostly small, up to 35 cm in diameter (Figure 6a), seldom larger colonies, up to 75 cm in diameter; most branches upright, tapering slightly towards the tip and terete (Figures 6b and 6c); branch diameters: 5.5–14.0 mm, 5.3–13.5 mm, and 4.9–11.9 mm; branch length up to 47.0 mm; growth semideterminate.

Axial corallites: Conspicuous, outer diameter 2.3–3.1 mm; calice diameter 0.7–1.6 mm; at least 1 complete septal cycle present; primary septa maximum 3/4R; directive septa well developed; secondary usually absent, when present up to 1/4R (Figure 6f).

Radial corallites: Regular and sturdy; appressed tubular to nariform (Figure 6d), gradually changing from branch tip towards its base; calice mostly oblique, sometimes dimidiate; 2 sizes; profile length 1.2–5.4 mm; outer walls extended along the branches; a few subimmersed corallites scattered on branches; dense immersed corallites at the base and between branches; at the base of branches first cycle complete, maximum septal development 1/3R, directive septa prominent, sometimes touching, particularly towards the bottom of calice; near the branches tip primary cycle mostly incomplete, directive septa present maximum 1/4R; secondary cycle usually absent (especially in radials near the branch tip) or very short.

Coenosteum: Broken-costate on radial corallites (Figure 6e); reticulate with simple, dense, laterally flattened spinules between radials (Figure 6g).

Color: Dark brown to pale brown on branches, pale or white on branch tips (Figure 6a).

**Remarks:** In general, most colonies of *A. arabensis* are arborescent in the study area, while those described in Wallace (1999) were caespitose to low arborescent. The branches were also relatively thinner and much shorter in our specimens. Conversely, axial corallites of the specimens found in these parts of the Persian Gulf were larger than those described by Wallace (1999). Differences were also observed in the coenosteum: while that of the specimens in the present study is broken-costate on the...
radial corallites and reticulate between the corallites, it is uniformly reticulate in the specimens of Wallace (1999).

**Acropora mossambica** Riegl, 1995; Figures 7a–7h

**Material examined:** Iran, Larak Island: 26°52′45.8″N, 56°20′26.8″E; depth 6 m; 14 October 2008; MMTT Cnid. 1323. Larak Island: 26°53′12.1″N, 56°23′32.1″E; depth 3 m; 8 October 2008; MMTT Cnid. 1118.

**Description:** Branching pattern: Corymbose; branches very thick (Figure 7a); some secondary branches fuse to main branches at branching area, forming flattened branches; branch diameters: 10.9–13.2 mm, 8.8–13.5 mm, and 7.8–11.3 mm; branch length up to 24.2 mm.

**Axial corallites:** Size more than twice that of radials; walls thick; round to slightly oval opening; outer diameter 3.1–4.3 mm; calice diameter 1.3–1.8 mm; 1 or 2 septal cycles, poorly developed; primary septa maximum 1/3R; directive septa prominent, often touching at bottom of calice; secondary septa mostly absent, when present up to 1/5R (Figure 7g).

**Radial corallites:** Tubo-nariform, different sizes (Figures 7d and 7e); some corallites appressed, scattered on branches (Figure 7c); subimmersed and immersed radials more numerous at the base and between branches (Figure 7b); oval opening; outer walls thick, roughly 7 times thicker than the inner walls; profile length 2–3 mm; septa poorly developed; primary septa maximum 1/5R; secondary septa absent or minute.

**Coenosteum:** Costate to broken-costate on radial corallites (in most cases, costate at the tips and broken-costate at the bases of branches), sometimes densely arranged lines of laterally flattened spinules on radial corallites (Figure 7f); simple spinules between radials (Figure 7h).

**Color:** Pale to dark brown.

**Remarks:** So far, *A. mossambica* has only been reported in the literature from high-energy intertidal habitats in SE Africa (Riegl, 1995). Thus, finding this species in the Persian Gulf is noteworthy. For confirmation, a specimen of this species was sent to the Museum of Tropical Queensland, where it was identified by C.C. Wallace as *Acropora* cf. *mossambica*. Characteristics supporting the identification included the branch shape, size of axial corallites, and shape of radial corallites. Consequently, this is the first report of *A. mossambica* from the Persian Gulf. Misidentification of *A. mossambica* as similar species, e.g., *A. selago* and *A. tenuis*, both present in the area (Riegl, 1999; Wallace, 1999), was possible. However, the larger size of axial corallites together with the differences observed in the forms of radial corallites supported the identification as *A. mossambica*.

Comparison between measurements of the specimen found in the present study with those described by Riegl (1995) suggests that the axial corallites are narrower and smaller in our specimens, but very limited details for other measurements were provided by Riegl (1995).

**Acropora muricata** (Linnaeus, 1758); Figures 8a–8i

**Material examined:** Iran, Larak Island: 26°53′15.9″N, 56°21′02.3″E; depth 6 m; 11 October 2008; MMTT Cnid. 1182. Larak Island: 26°53′15.9″N, 56°21′02.3″E; depth 3 m; 11 October 2008; MMTT Cnid. 1185.

**Description:** Branching pattern: Arborescent (Figure 8a) with long branches (maximum 160 mm), slightly tapering (Figures 8b and 8c); branches relatively thick; branch diameters: 10.0–16.6 mm, 9.7–15.4 mm, and 8.8–14.1 mm; growth determinate.

**Axial corallites:** Axial corallites thicker and substantially larger than radials; outer diameter 2.5–3.2 mm; calice diameter 1.1–1.5 mm; calice usually not perfectly round; 2 complete septal cycles present (Figure 8g); primary septa up to 3/4R; secondary septa up to 2/3R.

**Radial corallites:** Two sizes, arranged spirally on branches; mostly appressed tubular, some nariform, with round to oval openings (Figures 8d and 8e); subimmersed
and immersed corallites at base of branches; profile length up to 3.6 mm; 2 septal cycles developed (Figure 8g); inner and outer septa similar in size; primary septa maximum 3/4R; secondary septa up to 2/3R.

**Coenosteum**: Similar both on and between radial corallites (Figures 8f and 8h), linear arrangement of elaborated spinules on coenosteum, some spinules forked (Figures 8h and 8i).

**Color**: Pale brown, brick red, or pale yellow.

**Remarks**: *A. muricata* has not been previously reported in this part of the Persian Gulf. In the beginning, that caused some doubts as to whether our specimens really belonged to *A. muricata*, as in some areas of the Persian Gulf *A. pharaonis* forms open arborescent colonies similar to those formed by *A. muricata*. Nevertheless, other characteristics, including the absence of branchlets in *A. muricata* and the presence of a stalk in *A. pharaonis*, help to distinguish these 2 species. A specimen was sent to the Museum of Tropical Queensland, where C.C. Wallace identified it as *Acropora cf. muricata*. Although there are literature records of *A. pharaonis* from the Persian Gulf (Coles and Fadlallah, 1991; Sheppard and Sheppard, 1991; Mostafavi et al., 2010), there is actually no formal confirmed record based on voucher skeletal specimens of *A. pharaonis* in this area. That, by itself, does not exclude the possibility of its presence in the area; however, our extensive and careful sampling did not reveal any *A. pharaonis*, either.

From a morphological point of view, almost all the characteristics of our specimens overlapped those described by Wallace (1999) except in the morphology of coenosteum, which is costate on and reticulated between the radial corallites of the specimens examined by Wallace.

**Acropora nasuta** (Dana, 1846); Figures 9a–9g

**Material examined**: Iran, Larak Island: 26°53′07.8″N, 56°23′59.0″E; depth 3 m; 7 October 2008; MMTT Cnid. 1018. Larak Island: 26°52′45.8″N, 56°20′26.8″E; depth 6 m; 14 October 2008; MMTT Cnid. 1322. Larak Island: 26°53′15.0″N, 56°20′59.3″E; depth 6 m; 13 October 2008; ZUTC Cnid. 1260.

**Description**: **Branching pattern**: Corymbose, but tending to form small tables; branches cylindrical (Figure 9a), tapering abruptly at the tip (Figure 9b), slender in attachment point to the colony; colonies small; irregular branching; branch diameters: 8.9–15.2 mm, 8.0–14.2 mm, and 7.7–10.5 mm; branch length up to 54.9 mm; growth determinate.

**Axial corallites**: Cylindrical, larger than radial corallites; outer diameter 2.8–3.5 mm; calice diameter 1.1–1.3 mm; 2 complete septal cycles; primary septa maximum up to 2/3R; secondary septa 1/3R; directive septa slightly longer than the others (Figure 9f).

**Radial corallites**: Nariform to tubo-nariform (Figure 9c); round to oblique opening (Figure 9e), 2 sizes; profile length 2.2–3.0 mm; immersed corallite number increasing towards the base and between branches (Figure 9a); 1 complete septal cycle always present; primary septa up to 1/2R; lines of laterally flattened spinules usually present; secondary septa absent, or sometimes forming lines of small spinules.

**Coenosteum**: Broken costae or laterally flattened spinules in rows on radials, with spinules mostly joined by short lamellae (Figure 9d); between radials reticulate with simple spinules (Figure 9g).

**Color**: Pale brown to brown.

**Remarks**: By comparing the measurements of specimens found in the present study with those described in Wallace (1999), it was evident that the branches are both thicker and shorter, and axial corallites are larger in specimens of present study.

**Acropora tortuosa** (Dana, 1846); Figures 10a–10h

**Material examined**: Iran, Farur Island: 26°17′44.1″N, 54°32′22.4″E; depth 6 m, 28 October 2009; MMTT Cnid. 1387.
Description: Branching pattern: Arborescent (Figure 10a); branches thin and long (maximum 110 mm), slightly tapering (Figures 10b and 10c); branch diameters: 8.0–12.2 mm, 7.5–11.2 mm, and 5.0–6.6 mm; growth indeterminate.

Axial corallites: Small but slightly larger than large radial corallites; outer diameter 2.0–2.8 mm; calice diameter 1.0–1.4 mm; wall thickness about half the calice diameter; oval opening; 1 complete septal cycle present up to 3/4R; directive septa larger than the others, sometimes touching at bottom of calice; secondary septa usually absent, but if present, only developed to maximum 1/4R (Figure 10g).

Radial corallites: Arranged in rows on branches, 2 sizes, tubular, round opening; calice large compared to radial size (Figures 10b and 10d); profile length 2.05–2.83 mm; appressed and submersed corallites scattered on the bases of main branches; septa poorly developed, primary septa up to 1/4R, some septa dentate, sometimes only directive septa present; secondary septa absent.

Coenosteum: Covered with elaborate, laterally flattened spinules, both on and between radial corallites (Figures 10e, 10f, and 10h).

Color: Pale yellow or dark cream to pale brown.

Remarks: So far, Acropora tortuosa has only been recorded in the western and central Pacific Ocean (Wallace, 1999). Its presence in the Persian Gulf is therefore remarkable. For confirmation, a specimen of this species was shipped to the Museum of Tropical Queensland, where it was identified as Acropora cf. tortuosa by C.C. Wallace. Later on, with more detailed studies on the morphology and other characteristics of the colony, it became clear that the specimen was indeed Acropora tortuosa. Consequently, this is the first record of A. tortuosa from the Persian Gulf.

Morphologically, the specimens of A. tortuosa from the Persian Gulf were very similar to those described by Wallace (1999), except that the branches were a little longer and the walls of axial corallites were thinner in the Persian Gulf specimens.
4. Discussion

Because of the high morphological plasticity of staghorn corals (Todd, 2008), differences in the estimates of species diversity in these corals might be expected in any given area. Such differences, however, should be within a reasonable range. A number of studies carried out on the corals of the southern part of the Persian Gulf (Riegl, 1999; Wallace, 1999; Coles, 2003) showed that between 11 and 13 *Acropora* species inhabit the area. That number for the northern and northeastern parts was only 5, which included *Acropora clathrata* (Maghsoudlou, 2008, 2011), before this study. In the present study, 9 staghorn corals were found, excluding *Acropora clathrata* and *A. pharaonis*, which have frequently been reported (Maghsoudlou, 2008, 2011; Mostafavi et al., 2010) from Iranian coasts of the Persian Gulf. If the records of *A. pharaonis* were deemed valid, the number of *Acropora* species of the northern and northeastern parts of the Persian Gulf would reach at least 10. It should also be mentioned that from our specimens, C.C. Wallace identified *A. horrida*, *A. mossambica*, *A. muricata*, and *A. tortuosa* as ‘confer’ (cf.). The provisional identifications were caused by the small sizes of those specimens. More and closer examination of specimens from the same dives and of additional specimens collected later on allowed us to confirm the identification.

Nevertheless, taking into account the reports of other species from the southern part of the Persian Gulf, namely *A. valenciennesi* (Milne-Edwards and Haime, 1860) (Sheppard and Sheppard, 1991; Wallace, 1999), *A. yongei* (Veron and Wallace, 1984, *A. selago* (Studer, 1878), *A. divaricata* (Dana, 1846) (Wallace, 1999), *A. tenuis* (Dana, 1846), and *A. florida* (Dana, 1846) (Riegl, 1999), the total number of species of *Acropora* for the Persian Gulf would be at least 16.

*Acropora* is not only the richest but also the most abundant coral genus in the Persian Gulf, so much so that in some places along Larak Island the coverage by this genus is 100% (Rahmani, 2012). Fossil records suggest that *Acropora* has been the dominant coral on this island at least since the Pleistocene (Samimi-Namin and Riegl, 2012). Regardless of the number of *Acropora* ancestral species in the Europe-Western Indian Ocean region during the Miocene (which were responsible for the diversity and dominance of the modern *Acropora* of the Indo-Pacific during the Plio-Pleistocene), *Acropora* species of the Indo-Pacific are derived from their ancestral line(s) coming from the Europe-Western Indian Ocean region that diversified and dispersed during the Late Oligocene to the Miocene (Wallace and Rosen, 2006). Evidence for *Acropora* dominance in the Western Indian Ocean can be found in the Larak outcrops, too (Samimi-Namin and Riegl, 2012). Considering the repetitious (Riegl, 1999, 2002) and periodical (Shinn, 1976) mass mortalities among the *Acropora* species and their 15–20 years of succession cycles in the Persian Gulf, and also keeping the young nature of the Persian Gulf in mind (Wallace and Muir, 2005) (water began entering the Gulf only 12,500 years ago (Lambeck, 1996)), evaluations of ecological factors in addition to evolutionary and historical factors are necessary in order to study the reasons behind the relatively high diversity and abundance of *Acropora* in the Persian Gulf.

However, in this part of the Persian Gulf, *A. downingi* and *A. arabensis* are abundant, and *A. valida* is observed to a lesser extent than the former 2 species (Maghsoudlou, 2008; Rahmani, 2012).

Except these 3 species, the rest can be defined as rare species, accounting for only about 5% of the *Acropora* coverage (Rahmani, 2012). None of these corals, however, are listed as vulnerable (Askari, 2012), and no or very few special protection measures have been applied to conserve these species.

The necessity of conservation actions on behalf of the coral reefs in this area is obvious considering the severe conditions the Persian Gulf ecology must bear, especially its temperature, salinity (Coles, 1988; Coles and Fadlallah, 1991; Coles 1992; Riegl, 1999; Coles, 2003), and red tides, as well as anthropological activities including wars, offshore oil drilling, tanker traffic, ballast water discharge, the construction of several artificial islands, development of coastal areas, and destruction of coral reefs by divers. The need to conserve the corals of the Persian Gulf is even more urgent considering the continuous trend of global warming and the fact that the Persian Gulf is a breeding ground for warmth-tolerant species of the future.

As mentioned earlier, *A. clathrata* was not observed during the present work. This species has been reported as a common and dominant species by Maghsoudlou (2008, 2011). Such an abundant, common, and dominant species could hardly be missed in an intensive sampling program. Consequently, it seems that either *A. clathrata* does not exist in these parts of the Persian Gulf, or it occurs at a very low density (see remarks on *A. downingi*). However, the authors believe that the reports of *A. clathrata* in this area were, in fact, the result of a misidentification/confusion between the 2 forms of *A. downingi*. Further studies are necessary to definitely confirm the presence or absence of *A. clathrata* in the Persian Gulf.

Coles (2003) suggested that the coral species of the Persian Gulf are a small sample of a larger fauna of the Indo-Pacific area and maintained that the Acroporidae account for 16% of the total coral species of the Persian Gulf. This study changed that proportion in the Persian Gulf to 25%. This value is much closer to the proportion of Acroporidae species to all corals species of the Indo-Pacific (30%). The 5% difference could be the result of the environmental stresses in the Persian Gulf.
A review on the Acropora species of the area shows that the Persian Gulf shares coral species with both the eastern and western parts of the Indian Ocean. Biogeographical analyses of the corals of the Persian Gulf, however, point to the similarities with those elements of the Red Sea fauna (Sheppard and Sheppard, 1991). Nevertheless, when only Acropora species are considered, the results are different, clustering the Persian Gulf with Hawaii and the East Pacific (Wallace, 1999). Repeating the biogeographical analyses with the new data and new records has not changed the outcome (Rahmani, 2012).

This study indicates that in the area investigated, the number of Acropora species is higher than the previously reported number. We believe that the real Acropora species diversity may still be higher and that this assumption could be extended to the other coral genera. A number of the Iranian islands surveyed in the present study where the Acropora diversity is relatively high, such as Larak, are located at the beginning of a migratory corridor formed by the currents entering the Persian Gulf from the Indian Ocean via the Gulf of Oman. Consequently, all of the coral species found in the Persian Gulf once entered through this corridor. Therefore, we surmise that at least some of the species observed in the southern Persian Gulf and not yet found in the northern and northeastern parts of it, e.g., A. valenciennesi, A. divaricata, A. selago, A. yongei (Wallace, 1999), A. tenuis, and A. florida (Riegl, 1999), are either too uncommon to be easily found or have become locally extinct due to one of the recent devastating events (such as red tide). More studies are necessary to obtain a more accurate estimate of the diversity of the corals of the Persian Gulf in general, and that of Acropora in particular.

**Taxonomic key to the Acropora of the Persian Gulf**

### A: Colony and growth form

- **A.**1) Table and growth determinate ...................................... B
- **A.**2) Corymbose to caespitose and growth determinate or semi-determinate ........................................... C
- **A.**3) Other growth forms ............................................. H

### B: Colony and radial corallites characters

- **B.**1) Colony flat; sometimes with upward branches; radial corallites tubular with sharp-pointed outer walls extending along the branches .................. A. downingi
- **B.**2) Sturdy and intertwining branches form stalk; branchlets present ...................... A. pharaonis

### C: Radial corallites' shape

- **C.**1) Nariform or tubo-nariform ..................................... D
- **C.**2) Appressed .......................................................... F
- **C.**3) Cochleariform .................................................... G

### D: Colony and axial corallites characters

- **D.**1) Corymbose; axial corallites large (outer diameter 2.8–4.3 mm) ............................................. E
- **D.**2) Caespitose-corymbose; axial corallites smaller than former (outer diameter 1.8–3.0 mm); axial corallites' primary septa 1/2R, secondary septa up to 1/4R ........................................... A. divaricata

### E: Colony, axial, and radial corallites' characters

- **E.**1) Axial corallites' outer diameter 2.8–3.5 mm; axial primary and secondary septa 2/3R and 1/3R, respectively; radial corallites mostly nariform ........................................... A. nasuta
- **E.**2) Branches growing horizontally, forming plate; axial corallites larger than former (outer diameter 3.1–4.3 mm); axial primary and secondary septa 1/3R and 1/5R, respectively; radial corallites mostly tubo-nariform .............. A. mossambica

### F: Colony, axial, and radial corallites' characters

- **F.**1) Corymbose to caespitose; growth determinate; axial corallites' primary septa 2/3R; axial secondary septa up to 1/3R; tertiary septa rarely present; radial corallites' profile length 2.0–3.3 mm; radial primary and secondary septa 2/3 and 1/3R, respectively ........................................... A. valida
- **F.**2) Caespitose; growth semideterminate; axial corallites' primary and secondary septa 3/4 and 1/4R, respectively; radial outer walls extended along the branches ...................... A. arabensis

### G: Branches' and axial and radial corallites' characters

- **G.**1) Branch length up to 90 mm; axial corallites' outer diameter 1.8–3.4 mm; radial primary septa 2/3R ........................................................... A. tenuis
- **G.**2) Branches shorter than former (up to 40 mm); axial corallites' outer diameter smaller than H.1 above (up to 1.1–2.4 mm); radial corallites crowded, radial primary septa 1/3R ...... A. selago

### H: Radial corallites' shape

- **H.**1) Tubular or appressed tubular ................................. I
- **H.**2) Cochleariform .................................................... A. yongei
- **H.**3) Labellate .......................................................... A. aspera

### I: Branches' appearance and radial corallites' characters

- **I.**1) Extremely fragile; branches with ragged appearance .................................................. A. horrida
- **I.**2) Branches and radial corallites unlike the former ................................................................. J

### J: Axial and radial corallites' characters

- **J.**1) Axial corallite outer diameter 2.0–2.8 mm; axial secondary septa absent or 1/4R; round opening; radial primary septa up to 1/4R, secondary septa absent ........................................... A. tortuosa
- **J.**2) Axial corallites larger than those of A. tortuosa (outer diameter 2.5–3.2 mm); axial secondary septa up to 2/3R; oval opening; radial corallites' septa well developed, primary and secondary septa up to 3/4 and 2/3R, respectively ............................................................... A. muricata
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