New records and distribution extension of *Nassarius persicus* (Martens, 1874) and *N. tadjallii* Moolenbeek, 2007 (Mollusca: Gastropoda: Nassariidae) to India

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Abstract

We report new findings of live specimens of *Nassarius persicus* (Martens, 1874) and *N. tadjallii* Moolenbeek, 2007, extending their range to the Gulf of Kachchh, Gujarat, India. The known distribution of both species was limited: *N. persicus* was distributed in the Persian Gulf, Gulf of Oman and Karachi, Pakistan; *N. tadjallii* was reported from the Persian Gulf and Gulf of Oman. We also provide comprehensive taxonomic descriptions of both species, along with additional morphological and ecological information.

Key words: intertidal mudflats, Nassariidae, new records, Gulf of Kachchh Marine Sanctuary, Gujarat, India.

Running title: New records of *Nassarius* to India from Gujarat.

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Introduction

Nassarius Duméril, 1805 (Gastropoda: Nassariidae) is the most diverse genus within the subfamily Nassariinae and limited to the Indo-West Pacific (Galindo et al., 2016; Dekker et al., 2016). However, information on the members of this genus from the Indian subcontinent, a major ecoregion of the Western Indo-Pacific, is scarce (Nerurkar et al., 2020). In this paper, for the first time, we report the occurrence of many living specimens of *Nassarius persicus* (Martens, 1874) and *Nassarius tadjallii* Moolenbeek, 2007 from the intertidal reef associated mud-flats of the Gulf of Kachchh, Gujarat, India. We also provide complete taxonomic description for both species, along with additional information about morphological characters which are previously unknown (radula and operculum) for further reference.

Nassarius persicus (Martens, 1874) was earlier reported from the Persian Gulf and the Gulf of Oman, a single record from Aden, Yemen, should be confirmed as it is out of the expected range for this species. This species is also found in Karachi, Pakistan (Cernohorsky, 1984). This species is a conspicuous member of the intertidal reef community within the Gulf of Kachchh, Gujarat. However, it was misidentified as *N. arcularia plicatus* (Röding, 1798) (Ghosh, 2008: pl. 1, figs. 5-6) and *N. olivaceus* (Bruguière, 1789) (Dave and Mankodi, 2008: fig. 1) previously.

Nassarius tadjallii Moolenbeek, 2007 is currently known only from the Persian Gulf and Gulf of Oman. This species is very similar to *N. marmoreus* (A. Adams, 1852), *N. javanus* (Schepman, 1891) and *N. thachorum* Dekker, Kool & van Gemert, 2016.

Materials and Methods

Abbreviations:

BNHS: Bombay Natural History Society, Mumbai, India;

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MNHN: Muséum national d'Histoire naturelle, Paris, France;

WoRMS: World Register of Marine Species.

Taxon sampling: Specimens of both species were found and handpicked at low tide during the present study, intertidally, up to 1 m depth, at different localities in the district Devbhumi Dwarka, Gujarat, India. Live animals were photographed in the field before collection (Figure 1). Animals were preserved in 96-98% ethanol and voucher specimens are housed in the museum of Bombay Natural History Society (BNHS).

Morphological analyses for primary identification: A stereomicroscope (Carl Zeiss ZEISS Stemi 2000C, Germany) was used to observe shell and operculum morphology for each specimen included in the study. A digital Vernier (accurate to 0.1 mm) was used for shell measurements. Shells were photographed using SX520 HS Canon digital single-lens reflex camera. For SEM imaging, radulae were mounted on carbon conducting tape and sputter coated with Au-Pd. The scanning electron microscope (SEM) images of radulae were obtained on JEOL JSM 6360A (JEOL, Japan) operating at 10 kV. Primary morphological identifications were confirmed accessing the taxonomical information from WoRMS, Moolenbeek, 2007 and Cernohorsky, 1984.

Results

Systematics

Family Nassariidae Iredale, 1916 (1835)

Subfamily Nassariinae Iredale, 1916 (1835)

Genus *Nassarius* Duméril, 1805

Type species: *Buccinum arcularia* Linnaeus, 1758 (by subsequent monotypy; Froriep, 1806).

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76 ***Nassarius persicus* (Martens, 1874)**

77 **(Figures: 1A; 2A-B, E-G & I)**

1874. *Nassa persica* v. Martens, Novit. Conch. Suppl. 5: 94, pl. 5, fig. 47.

1984. *Nassarius (Plicarcularia) persicus* (v. Martens, 1874) —Cernohorsky, Bull. Auckland. Inst. Mus. 14: p. 71, pl. 5, figs. 3-6.

2008. *Nassarius arcularia plicatus* (Röding, 1798) —Ghosh: pl. 1, figs 5-6.

2008. *Nassarius olivaceus* (Bruguière, 1789) —Dave & Mankodi: fig. 1.

78

79 **Vernacular name:** Persian Nassa.

80 **Type locality:** Persian Gulf.

81 **Examined material:** Holotype: Catalogue number 69524 (specimen in Zoological
82 Museum, Humboldt University, Berlin) (image examined from Cernohorsky, 1984: pl.
83 5, fig. 3).

84 **Other material:** BNHS NASSA 303, 1 ex., adult, 1.iv.2014, Poshitra, Devbhumi
85 Dwarka, Gujarat, India, 22°24'12.9"N, 69°12'05.8"E, coll. Deepak Apte, shell length
86 21.0 mm, shell width 13.1 mm. BNHS NASSA 304 (Figs. 2A-B), 1 ex., adult,
87 1.iv.2014, Poshitra, Devbhumi Dwarka, Gujarat, India, 22°24'12.9"N, 69°12'05.8"E,
88 coll. Deepak Apte, shell height 21.6 mm, shell width 13.5 mm. BNHS NASSA 305, 1
89 ex., adult, 1.iv.2014, Poshitra, Devbhumi Dwarka, Gujarat, India, 22°24'12.9"N,
90 69°12'05.8"E, coll. Deepak Apte, shell height 23.0 mm, shell width 14.4 mm. BNHS
91 NASSA 325, 1 ex., adult, 15.i.2015, Narara, Devbhumi Dwarka, Gujarat, India,
92 22°28'09.6"N, 69°43'22.6"E, coll. Sayali Nerurkar, shell height 22.3 mm, shell width
93 13.3 mm. BNHS NASSA 326, 1 ex., adult, 15.i.2015, Narara, Devbhumi Dwarka,
94 Gujarat, India, 22°28'09.6"N, 69°43'22.6"E, coll. Sayali Nerurkar, shell height 22.2

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mm, shell width 14.3 mm. BNHS NASSA 304 was used for dissecting radula and studying other morphological characters.

Diagnosis

Shell: Shell up to 23 mm in length (20.8 mm in holotype), elongate-ovate, with high, conical spire (Figs. 2A-B); very thin periostracum clearly visible in the live animal. Protoconch of 3 glassy-white whorls (Figs. 2E-F). Teleoconch of 6.5-7.25 weakly convex whorls, sculptured with strong axial ribs. Axial ribs are angulate and weakly constricted by a sharp, subsutural spiral line, to form weak nodes at the suture (same as that of holotype); ribs numbering from 12-14 on the penultimate and 12-19 on the body whorl, ribs becoming moderately obsolete in the center of the body whorl; only body whorl sculptured with very weak spiral striae, 3-4 basal spiral threads more prominent, siphonal fasciole with cords. Colour of shell is yellowish to olive green in live animals while dry shells look straw-yellow or pale grey. A creamy, pale colored spiral band is clearly visible on the shell with a nebulous darker band in the background of dorsal side of body whorl. The body whorl ends with four to five shallow axial ribs followed by a strong varix. Colour of varix is same as that of the shell. Aperture white, ovate, narrow, with 3 brown bands interiorly; outer lip thickened, edge slightly turned backwards; interior of outer lip with 7-8 lirate denticles (same as that of holotype). Columella heavily calloused, white, columellar shield large and extending up to body whorl suture; columella plicate with one strong plication at the base and 5-8 small folds. Anterior or siphonal canal short, distinct, wide and marked with 4-5 oblique basal cords. Posterior or anal canal distinct, deep, “U” shaped and marked by an intense posterior columellar ridge.

Operculum (Fig. 2G): Operculum corneous, yellowish to light brown in colour, serrate at the margins. Roughly trapezoidal in shape with curved bases, simple,

flattened with terminal basal nucleus which is slightly turned to left. Information on operculum of holotype is not available.

Radula (Fig. 2K): Approximately 62-70 rows of teeth, rachidian teeth with concave crescentic base, cutting edge is fringed with 11 or 12 sharp pointed, conical denticles with symmetrical arrangement. Corners of rachidian plate wide and smooth. Accessory intermediate lateral plates present in between each rachidian tooth and left lateral and right lateral tooth, respectively. Lateral teeth with two arched, narrow, elongated and pointed hook-like cusps, basal cusp is shorter than the upper cusp; the inner cutting edge of the basal cusp (between the two cusps) is finely serrate. The outer edge of the basal cusp (below the basal spur) is serrate with small five to six sharp, pointed denticles. Basal spur is somewhat flat with a small bump.

Global distribution (Fig. 3): SAUDI ARABIA, Persian Gulf: Al Khobar; Ain-as-saih near Al Khobar; Ras Mishab; Tarut Bay; Saihat; Dammam. BAHRAIN: Al Manamah; Zallaq, Sheiks beach. KUWAIT: Failakah I.; Injifa shore; Kuwait Bay. UNITED ARAB EMIRATES: Trucial Coast, Sharjah. OMAN: Mina al Fahal; Masirah I.; 18 km S. E. of Muscat (mangrove/muddy flats); Marsis, Masirah I.; 2 km N. of Sur Masirah, Masirah I.; Sur Masirah beach, Masirah I.; Dawwah beach, Masirah I.; S.E. end of Bar Al Hikman Peninsula; Al Sawadi Resort, Muscat; Muscat; As Seeb, 3 miles offshore (40 m depth); Bandar Jissah. PAKISTAN: Karachi. (GBIF Occurrences https://www.gbif.org/species/10492859, Cernohorsky, 1984 and M. Al-Kandari, P.G. Oliver, W. Chen et al., 2020).

Localities within India: Previously none.

New localities within India (Fig. 3): Narara and Poshitra, both localities in the Gulf of Kachchh, District Devbhumi Dwarka, Gujarat.

Habitat: Intertidal, up to 1 m depth, within degraded reef-flat with coral sand and silt.

147 **Remarks:** *Nassarius persicus* occur abundantly in its habitat and observed to be a
148 dominant member of the intertidal fauna in intertidal reef-flats of Poshitra, Gujarat. It
149 is a new record for India and a valuable addition to the fauna of Gulf of Kachchh
150 Marine Sanctuary, Gujarat. Formerly, this species was misidentified (Ghosh, 2008;
151 Dave & Mankodi, 2008), but a thorough investigation of its morphological characters
152 clarifies its correct identity. The shell of *N. persicus* is similar to the western Indian
153 Ocean species *N. arcularia plicatus* (Röding, 1798) in having large shield like
154 columellar callous extending up to the penultimate whorl, creamy-yellow to pale grey
155 colour of shells, a narrow brown band or dark brown spots or a nebulous darker band
156 between sutural coronations of shells of both the species. But *N. persicus* can be
157 easily distinguished from *N. arcularia plicatus* in having a slender shell with high
158 spire, *N. arcularia plicatus* has a globous shell with moderate spire and spiral
159 sculpture. Misidentification of *N. persicus* as *N. olivaceus* could be only due to the
160 'olive green' colour of the shell in live condition, else not any morphological similarity
161 exists between these two species.
162
163 ***Nassarius tadjallii* Moolenbeek, 2007**
164 **(Figures: 1B; 2C-D, H-J & L)**

2007. *Nassarius tadjallii* Moolenbeek: 94, pl. 5, fig. 47.

165 **Vernacular name:** Tadjalli's Nassa.

166 **Type locality:** Ras al Batin, Abu Dhabi, United Arab Emirates.

167 **Examined material:** Holotype: ZMA.MOLL.139465, adult, 1.1997, Ras al Batin, Abu
168 Dhabi, United Arab Emirates, in breakwaters, 3 m, coll. P. Micali (images examined
169 from Moolenbeek, 2007: p. 58, figs. 1, 2) (specimen in Naturalis Biodiversity Center,
170 Leiden, Netherlands). NMR56145, 1 ex., adult, Al Bide, Kuwait, in sand at low tide,

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14.4.1982, coll. J.G.B. Nieuwenhuis (image examined from https://www.nmr-pics.nl/Nassariidae_new/album/slides/Nassarius%20marmoreus.html (specimen in the Natural History Museum, Rotterdam).

Other material: BNHS NASSA 323, 1 ex., adult, 15.i.2015, Narara, Devbhumi Dwarka, Gujarat, India, 22°28'09.6"N, 69°43'22.6"E, coll. Sayali Nerurkar, shell length 24.4 mm, shell width 12.2 mm. BNHS NASSA 324 (Figs. 2C-D), 1 ex., adult, 15.i.2015, Narara, Devbhumi Dwarka, Gujarat, India, 22°28'09.6"N, 69°43'22.6"E, coll. Sayali Nerurkar, shell length 24.0 mm, shell width 13.0 mm. BNHS NASSA 340 (Fig. 1B), 1 ex., adult, 17.i.2015, Shivrajpur, Devbhumi Dwarka, Gujarat, India, 22°20'42.7"N, 68°56'57.0"E, coll. Deepak Apte, shell height 26.4 mm, shell width 13.9 mm. BNHS NASSA 348, 1 ex., adult, 18.i.2015, Poshitra, Devbhumi Dwarka, Gujarat, India, 22°24'12.9"N, 69°12'05.8"E, coll. Deepak Apte, shell height 28.4 mm, shell width 14.2 mm. BNHS NASSA 324 was used for dissecting the radula and studying other morphological characters.

Diagnosis

Shell: Shell up to 28.4 mm in length (25.4 mm in holotype), elongate-ovate, conical with high spire and less convex whorls (Figs. 2C-D); periostracum was absent in all the collected specimens (thin, fibrous, brownish periostracum present in holotype). Protoconch of 2.5 white whorls approximately (Figs. 2H-I). Teleoconch of 6.25 to 6.50 whorls, of which first 3 axially ribbed and with 4-6 spiral grooves gradually disappearing; remaining whorls smooth with only one, rather strong sub-sutural groove. Suture prominently channeled. Between the suture and the sub-sutural groove, the area is slightly nodulose and consists of alternate creamy white and dark brown dots. Shell colour is white or cream in the background with light and dark brown patterned patches. These patches are arranged in two light and three dark

alternate bands, visible on the body whorl (shell colour in holotype is light brown, with darker brown patches). This banding pattern is not mentioned in the original description. The body whorl ends with three to four minor axial ridges followed by a strong varix. Varix is creamy white in colour and bears three distinct brown patches as extensions of the three dark patterned bands of the body whorl (Varix orange brown in holotype. This brownish hue caused by its intact periostracum). Aperture whitish, ovate, moderately wide, interior of outer lip with about nine lirate denticles. Columella plicate with two or three fine folds. Columellar callus thin, smooth, white, spreading slightly on body whorl and extending outwards at siphonal canal forming anterior ridge. Anterior or siphonal canal short, distinct, wide and marked with five spiral grooves or basal cords which ends as five denticles on outer lip. Posterior or anal canal distinct, moderately deep and marked by a strong posterior columellar ridge and a strong denticle on the top of the outer lip. Parietal denticle also prominent. Shell of BNHS NASSA 324 has three to four prominent repair scars on penultimate and body whorls.

Operculum (Fig. 2J): Operculum of BNHS NASSA 324 is corneous, yellowish brown in colour. Trapezoidal, elongate, simple, flattened with smooth inner margin, crenate outer margin and terminal nucleus. Information on operculum of holotype is not available.

Radula (Fig. 2L): Radula consists of 62-68 rows of teeth; rachidian teeth with concave crescentic base and cutting edge fringed with 9-11 sharp, pointed, conical denticles in symmetrical arrangement; corners of rachidian plate wide and smooth; accessory intermediate lateral plates present in between each rachidian tooth and left lateral and right lateral tooth, respectively. Lateral teeth with two arched, narrow, elongated and pointed hook-like cusps, the basal cusp being shorter than the upper cusp; the inner cutting edge of the lateral teeth (between the two cusps) is smooth.

The outer edge of the basal cusp (below the basal spur) is also smooth. Basal spur is prominent. Information on radula of holotype is not available.

Global distribution (Fig. 3): UNITED ARAB EMIRATES: Ras al Batin, Abu Dhabi; Al Imarat, Abu Dhabi; Dubai. KUWAIT: Al Bide; Bede Circle; Kuwait Towers; Kuwait Bay. IRAN: Chahbahar. OMAN: not any specific locality given (GBIF Occurrences https://www.gbif.org/species/6502821, Moolenbeek, 2007 and M. Al-Kandari, P.G. Oliver, W. Chen et al., 2020).

Localities within India: Previously none.

New localities within India (Fig. 3): All three localities namely, Narara, Poshitra from Gulf of Kachchh and Shivrajpur (Arabian Sea), falls under district Devbhumi Dwarka, Gujarat, on North-West coast of India.

Habitat: Intertidal, up to 1 m depth, within degraded reef-flat with coral sand and silt.

Remarks: *Nassarius tadjallii* Moolenbeek, 2007 is a new record for India which extends the distribution eastwards and is an addition to the marine fauna of Gujarat. This species shows morphological similarities and can be confused with *N. marmoreus* (A. Adams, 1852), *N. javanus* (Schepman, 1891) and *N. thachorum* Dekker, Kool & van Gemert, 2016. *N. marmoreus* from Oman is smaller and much darker in colour compared to *N. tadjallii*. *N. javanus*, which can be found in India (Tamil Nadu), is smaller and has a much more globose body whorl. *N. thachorum* from Vietnam differs from *N. tadjallii* in having a much weaker or lacking subsutural groove, the presence of a ridge consisting of small denticles on the columella, and has a darker colour of the shell (Dekker et al., 2016).

Discussion

Prior to this work, *Nassarius persicus* and *N. tadjalli* had not been reported from India (Nerurkar et al., 2020) and thus, the present records extend the known range of these species from the Arabian Peninsula to Gujarat, India.

Another surprising observation we have is that these two *Nassarius* species can only be found in Narara, Poshitra and Shivrajpur and cannot be found along the rest of the Indian coasts. Narara and Poshitra are in Gulf of Kachchh while Shivrajpur, Dwarka is in the Arabian Sea, hence, the ecological setting is very different at both these places from those in the Arabian Peninsula. The same observation was made by Williams et al. (2011) in the case of dispersal of *Lunella coronata* (Gmelin, 1791) morph B along the continental coastline, from Arabian Peninsula to Porbunder, Gujarat, India. Here, Porbunder is the range end point for *Lunella coronata* morph B. In the same way, the explanation for above phenomenon could be that an upwelling effect is present a bit down south from the Gulf of Kachchh up to the Dwarka shore, making them as the range end points for these two species. This might explain why these two species can be seen up to Dwarka but not beyond and south of it.

Likewise, Tripathy et al., 2013 list *Congetia chesneyi* (Oliver & Chesneyi, 1994) from Adatara beach near Okha, Gujarat, India, as it was previously known only from Kuwait area.

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Figures

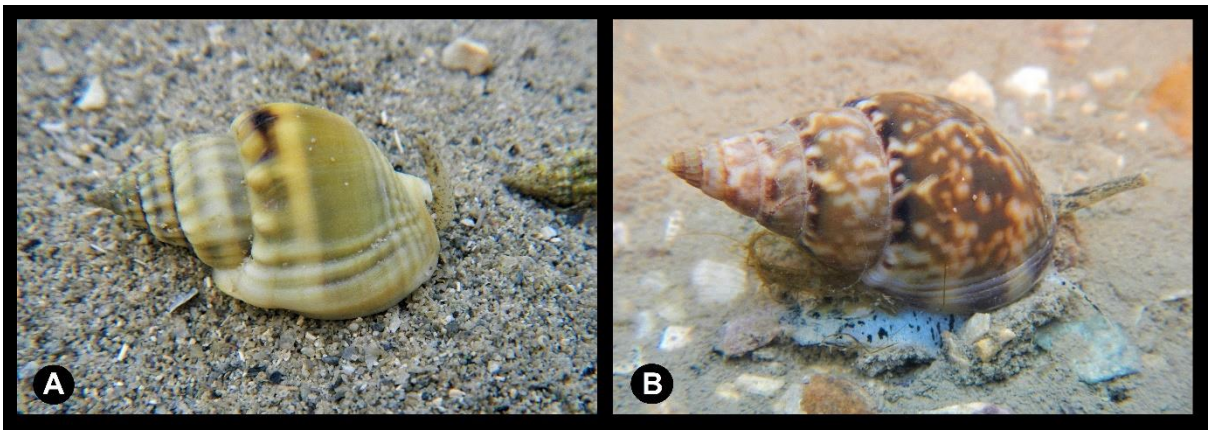

Figure 1: A, dorsal view of living animal of *Nassarius persicus* (Martens, 1874) from Poshitra, Gujarat, India, BNHS NASSA 304; B, dorsal view of living animal of *N. tadjallii* Moolenbeek, 2007 from Shivrajpur, Gujarat, India, BNHS NASSA 340.

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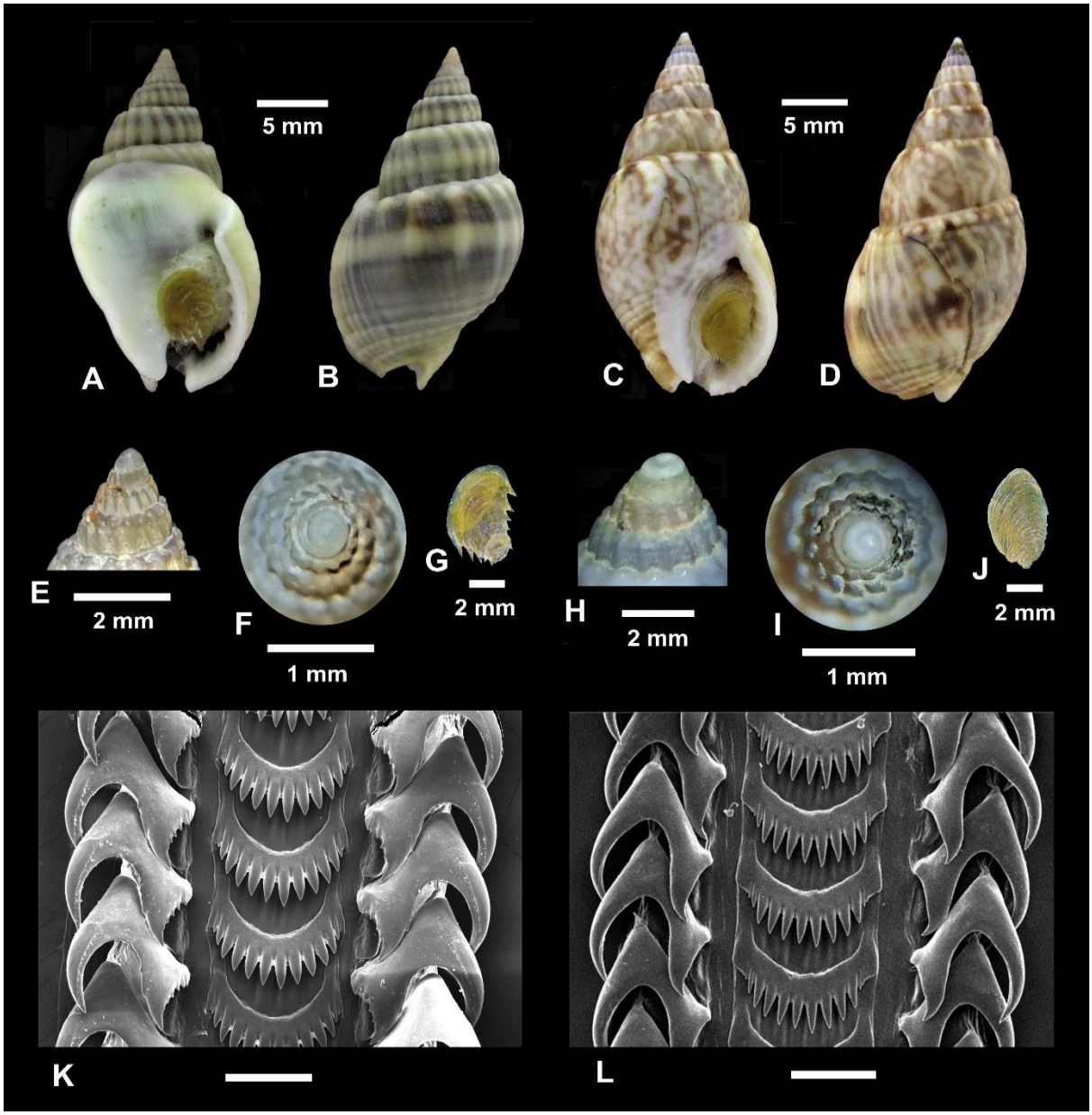

Figure 2. *Nassarius persicus* (Martens, 1874), BNHS NASSA 304: A-B, Shell, height 21.6 mm, width 13.5 mm; E-F, apex; G, operculum; K, radula (scale bar = 100 µm). *Nassarius tadjallii* Moolenbeek, 2007, BNHS NASSA 324: C-D, Shell, height 24.0 mm, width 13.0 mm; H-I - apex; J, operculum; L, radula (scale bar = 100 µm).

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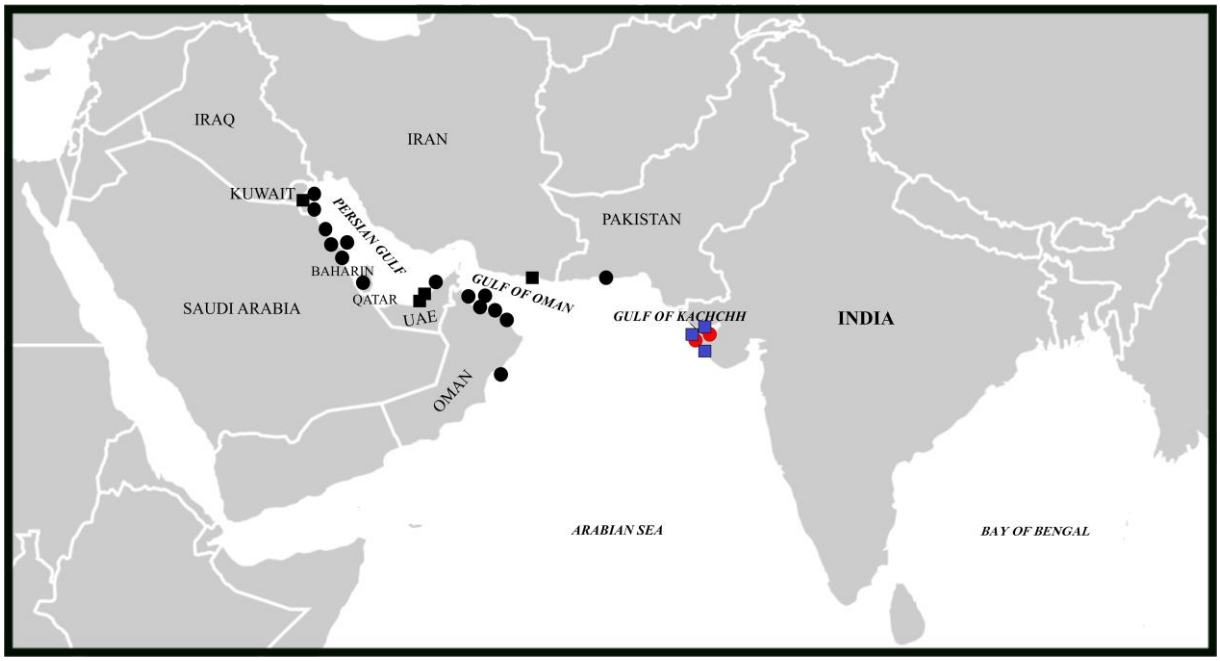
316 

317 Figure 3. Geographical distribution of *Nassarius persicus* and *Nassarius tadjallii*.
318 Symbols indicate following: Black dots (●), known localities of *Nassarius persicus*;
319 Red dot (●), its new localities from India. Black squares (■), known localities of
320 *Nassarius tadjallii;* blue squares (■), its new localities from India.