Intertidal Ophiuroidea from the Saurashtra coastline, Gujarat, India

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Abstract: Present communication reports the diversity of intertidal Ophiuroidea (Phylum: Echinodermata) from the intertidal zones of the Saurashtra coastline, Gujarat state. Saurashtra coastlines were extensively surveyed from January 2019 to March 2022 for the Ophiuroidea diversity. A total of nine species of Ophiuroidea belonging to eight genera and six families were noted from the intertidal zones of the Saurashtra coastline. Amongst these, Macropiophirix variabilis, Ophiothrix savignyi and Ophiomaza cacoticus are newly observed species from the Gujarat coastline. The results of similarity indices show that each sampling site has a diverse variety of brittle star, making them spatially different from each other.

Keywords: Brittle star, echinoderms, intertidal, marine invertebrate, species diversity.
INTRODUCTION

The Ophiuroidea are known as brittle stars, basket stars (euryalids with branching arms) and snake stars (euryalids with non-branching arms). It is the largest group among extant living echinoderms, with 2,116 described species found in all oceans from the intertidal to the greatest depths (Stöhr et al. 2021). Among them, 160 species have been recorded from Indian waters (Samuel et al. 2017). Recently nine new brittle stars are reported from India (Parameswaran et al. 2021). 

Macrophothrix aspidota was the first Ophiuroid reported from Gujarat (James 1969). After that, Ophioplocus imbricatus was recorded from Pirotan Island (Clark & Rowe 1971). A total of 12 species were reported from Gujarat (Sastry 2004; Gohil & Kundu 2012; Poriya 2015). The literature indicates that not many studies were conducted, nor significant data were available for the species diversity of intertidal ophiuroids from the Saurashtra coastline, Gujarat.

The present study aims to better document the species diversity of ophiuroids from the Saurashtra coastline, Gujarat. An extensive sampling effort in the rocky intertidal coastal zone was undertaken at eight localities around the Saurashtra coastline. Below, we discuss each species encountered and compare species composition between selected localities.

MATERIALS AND METHODS

Total of eight locations were chosen for ophiuroids sampling (Figure 1, Table 1) during the low tide from January 2019 to March 2022. In situ photography of live specimens was carried out. Voucher specimens of some species were collected by direct hand-picking method from various habitats for further identification. Specimens were relaxed with magnesium chloride and fixed in 95% ethanol and 4% formalin. Encountered Ophiuroidea species preliminary identification was done with the monograph of Clark & Rowe (1971) and Cherbonnier & Guille (1978). Confirmed determinations up to species level was done using various research articles such as O’Hara et al. (2018) for family rank and above, Hoggett (1990) for Macrophiothrix, Thomas (1975) for Ophioplocus, and Clark (1953) for Ophionereis. Voucher specimens were deposited in the Museum of the Department of Biosciences, Saurashtra University. In the present study, the Jaccard similarity index (J) was measured using R to compare the similarity and diversity of the different sampling sites.

RESULTS

Diversity of Intertidal Ophiuroidea: In the present study, nine species of ophiuroids belonging to eight genera and six families were noted from the intertidal zones of the Saurashtra coastline (Table 2). Among these, only one species was reported from Simbor, three species each from Diu, Dhamlej, Mangrol, & Shivrajpur, five from Veraval, six from Dwarka, and seven species from Okha (Table 3). Systematic position, explanation, and habitation of noted ophiuroids are as follows:

Systematics section

Family Ophiocomidae Ljungman, 1867
Genus Ophiocomella A.H. Clark, 1939
Ophiocomella sexradia (Ducan, 1887)

Material: Diu (Gangeshwar coast, Jalandhar coast) - 8 specimens; Dhamlej - 3 specimens; Veraval - 6 specimens; Mangrol - 4 specimens; Dwarka - 5 specimens; Shivrajpur - 2 specimens; Okha - 6 specimens. Three specimens having Museum ID: ZEOOOO(5)19H, ZEOOOO(1)19H, ZEOOOO(8)19H, coll. Hitisha Baroliya, are deposited in the museum.

Remarks: Commonly observed six arms O. sexradia at the Saurashtra coast, but we observed one specimen with seven arms. Specimens have small and imbricating scales and papillae, narrow and oval shaped radial shield, three to five elongate and blunt arm spines, one tentacle scale. Three to eight oral papillae on each side of jaw and one to six pair of dental papillae with one to seven square-tipped teeth.

Habitat: Rock crevices and under algal holdfast.

Distribution: Common across the Indo-West Pacific (Clark & Rowe 1971).

Previous records from Gujarat: Dwarka and Okha (Sastry 2004).

Present study: Veraval, Diu, Mangrol, Dwarka, and Okha.

Family Hemieuryalidae Verrill, 1899
Genus Ophioplocus Lyman, 1861
Ophioplocus imbricatus (Müller & Troschel, 1842)

Material: Dwarka - 3 specimens; Shivrajpur - 1 specimen; Okha - 4 specimens. Two specimens having Museum ID: ZEOAHO(1)19H, ZEOAHO(13)19B, coll. Bhavna Solanki and Hitisha Baroliya, are deposited in the museum.

Remarks: Disk Covered by small and imbricating
scales. Dorsal arm plate fragmented into number, three short and blunt arm spines, two tentacle scales. Four square shaped oral papillae on each side while as dental papillae absent, five square tipped teeth present in each jaw.

**Habitat:** Underneath of rock in shallow pool.

**Distribution:** West India, Pakistan, Sri Lanka, Bay of Bengal, East Indies, northern Australia, Philippine, China, southern Japan, South Pacific Islands and Hawaiian Islands (Clark & Rowe 1971); eastern Africa to Hawaii (Tortonese 1980); Australia (Rowe & Gates 1995).

**Previous reports from Gujarat:** Okha, Beyt Island, Hanuman Dandi, and Sikka (Sastry 2004).

**Present study:** Dwarka, Okha, and Shivrajpur

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**Table 1. Detailed information about sampling localities evaluated in the study.**

<table>
<thead>
<tr>
<th>Site name</th>
<th>GPS coordinates</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diu</td>
<td>20.70207 N, 70.91727 E</td>
<td>Island located on outer rim of Gulf of Kambhat. Sampling sites: Nagoa and Gangeshwar.</td>
</tr>
<tr>
<td>Simbor</td>
<td>20.76603 N, 71.15496 E</td>
<td>Small inlet located at the mouth of Sahil river at the Bay of Simbor. Sandy-rocky coast. Sampling site: rocky outcrop of ~350m length.</td>
</tr>
<tr>
<td>Dhamlej</td>
<td>20.77034 N, 70.61462 E</td>
<td>Near the Sustrapada, around 2 km long rocky substratum. Flat emergent rocky habitat covered by Zoanthus.</td>
</tr>
<tr>
<td>Veraval</td>
<td>20.91691 N, 70.34221 E</td>
<td>Largest fish landing site, 3 km long with fully rocky substratum with coral, zoanthid and Centithium assemblage.</td>
</tr>
<tr>
<td>Mangrol</td>
<td>21.0984 N, 70.11417 E</td>
<td>40 km west of Veraval. Coastal stretch 3 km long with fully rocky substratum.</td>
</tr>
<tr>
<td>Dwarka</td>
<td>22.23676 N, 68.9254 E</td>
<td>South-west part of Saurashtra coastline. Light house, 800 m long, sandy-rocky coastal area.</td>
</tr>
<tr>
<td>Shivrajpur</td>
<td>22.33049 N, 68.95123 E</td>
<td>‘Blue Flag beach’, located between Dwarka and Okha. 1 km in length.</td>
</tr>
<tr>
<td>Okha</td>
<td>22.47974 N, 69.08047 E</td>
<td>Located outer rim of the Gulf of Kutch, coastal length for this study was 3 km. Intertidal zone contains hard rocky substratum with sandy-rocky patches.</td>
</tr>
</tbody>
</table>

**Figure 1. The sampling stations of Saurashtra coast.**
lighthouse area.

Family Ophiurinereididae Ljungman, 1867
Genus Ophionereis Lütken, 1859

**Ophionereis dubia dubia** (Müller & Troschel, 1842)

**Material examined:** Veraval - 1 specimen; Okha - 3 specimens. One specimen having Museum ID: ZEOAOO(13)19H, coll. Hitisha Baroliya, are deposited in the Museum.

**Remarks:** Rare to moderately occurred at intertidal area of the Saurashtra coast. Radial shield trapezium shaped. Three arm spine, one ellipse shaped tentacle scale. Dorsal arm plate fan triangular shaped, ventral arm plate octagonal, concave by sides, four oral papillae, quadrate shaped one tooth on infradental plate.

**Habitat:** Under the rock crevices.

**Distribution:** Persian Gulf, west coast of India, Pakistan, Maldives, Sri Lanka, Bay of Bengal, East Indies, northern Australia, Philippine, China, and southern Japan (Clark & Rowe 1971); Australia (Rowe & Gates 1995).

**Previous reports from Gujarat:** Sikka and Pirotan Island (Sastry 2004).

**Present study:** Veraval and Okha.

Family Amphiuridae Ljungman, 1866
Genus Amphipholis Ljungman, 1866

**Amphipholis squamata** (Delle Chiaje, 1828)

**Material:** Diu (Gangeshwar, Jalandhar, and Nagoa) - 17 specimens; Dhamlej - 6 specimens; Veraval - 28 specimens; Mangrol - 8 specimens; Dwarka - 7 specimens; Shrivajpur - 4 specimens; Okha - 8 specimens. Five specimens having Museum ID: ZEOAAA (5)19H, ZEOAAA(8)19H, ZEOAAA(4)20H, ZEOAAA(13)19H, ZEOAAA(6)21H, coll. Hitisha Baroliya, are deposited in the Museum.

**Remarks:** Most common species of Saurashtra coast. Central primary plate is clearly visible, imbricating scales on disc. Radial shields separated proximally by a scale line, two tentacle scales, dorsal arm plate broader than long, three conical, erect, arm spines with serrated tip. Two oral papillae on each side, one distal long and opercular. A pair of infradental papillae with square tipped teeth.

**Habitat:** Rock crevices, underneath of rock and under the algal holdfast.

**Distribution:** Indo west pacific (Clark & Rowe 1971); Australia (Rowe & Gates 1995).

**Previous reports from Gujarat:** Dwarka, Beyt Island, Balapur bay, and Hanuman Dandi (Sastry 2004).

**Present study:** Dwarka and Okha.

Family Ophiactidae Matsumoto, 1915
Genus Ophiactis Lütken, 1859

**Ophiactis savignyi** (Müller & Troschel, 1842)

**Material:** Diu (Gangeshwar coast, Jalandhar, and Nagoa coast) - 13 specimens; Dhamlej - 5 specimens; Veraval - 23 specimens; Mangrol - 6 specimens; Dwarka - 7 specimens; Shrivajpur - 4 specimens; Okha - 8 specimens. Five specimens having Museum ID: ZEOAAA (5)19H, ZEOAAA(8)19H, ZEOAAA(4)20H, ZEOAAA(13)19H, ZEOAAA(6)21H, coll. Hitisha Baroliya, are deposited in the Museum.

**Remarks:** Rarely observed at Saurashtra coast. Five imbricating greyish black blotches clearly observed on the central part of the disc. Radial shield barrel shaped, flat, and longer, two radial shields distally separated by a single scale line and only united at proximal part. Five conical shaped arm spines.

**Habitat:** Underneath of rock.

**Distribution:** Indo west pacific (Clark & Rowe 1971); Australia (Rowe & Gates 1995).

**Previous reports from Gujarat:** Dwarka, Beyt Island, Balapur bay, and Hanuman Dandi (Sastry 2004).

**Present study:** Dwarka and Okha.

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### Table 2. Systematic position of species recorded in present study from Saurashtra coast.

<table>
<thead>
<tr>
<th>Class</th>
<th>Order</th>
<th>Family</th>
<th>Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ophiuroidea</td>
<td></td>
<td></td>
<td>Ophiacanthida</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Amphilepidida</td>
<td>Ophionereis dubia dubia</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ophiactidae</td>
<td>Amphipholis squamata</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ophiactis savignyi</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Macrophiothrix</td>
<td>virabilis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ophiomaza</td>
<td>cacaoeca</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Macrophiothrix</td>
<td>savignyi</td>
</tr>
</tbody>
</table>

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**Previous reports from Gujarat:** Diu, Veraval, Holiday camp, Narara beyt, Dwarka, and Okha (Sastry 2004).

**Present study:** Diu (Jalandhar, Nagoa, & Gangeshwar), Dhamlej, Veraval, Mangrol, Dwarka, Shrivajpur, and Okha.

Genus *Amphiura* Forbes, 1843

**Amphiura ambigua** (Koehler, 1905)

**Material:** Dwarka - 1 specimen; Okha - 2 specimens. One specimen having Museum ID: ZEOAAA(1)19H coll. Hitisha Baroliya, are deposited in the Museum.

**Remarks:** Rarely observed at Saurashtra coast. Five imbricating greyish black blotches clearly observed on the central part of the disc. Radial shield barrel shaped, flat, and longer, two radial shields distally separated by a single scale line and only united at proximal part. Five conical shaped arm spines.

**Habitat:** Underneath of rock.

**Distribution:** Indo west pacific (Clark & Rowe 1971); Australia (Rowe & Gates 1995).

**Previous reports from Gujarat:** Dwarka, Beyt Island, Balapur bay, and Hanuman Dandi (Sastry 2004).

**Present study:** Dwarka and Okha.
Table 3. Checklist of the recorded ophiuroid species at sampling sites. (Signs denote: ‘+’ presence, ‘-’ absence). SM—Simbor | DH—Dhamlej | VRL—Veraval | MGL—Mangrol | DWK—Dwarka | SRP—Shivrajpur | OK—Okha

<table>
<thead>
<tr>
<th>Species</th>
<th>Rocky intertidal zone</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DIU</td>
</tr>
<tr>
<td>1</td>
<td>Ophioplocus imbricatus</td>
</tr>
<tr>
<td>2</td>
<td>Ophionereis dubia dubia</td>
</tr>
<tr>
<td>3</td>
<td>Macrophiothrix virabilis</td>
</tr>
<tr>
<td>4</td>
<td>Amphipholis squamata</td>
</tr>
<tr>
<td>5</td>
<td>Amphiura ambigua</td>
</tr>
<tr>
<td>6</td>
<td>Ophiactis savignyi</td>
</tr>
<tr>
<td>7</td>
<td>Ophiomaza caecaotica</td>
</tr>
<tr>
<td>8</td>
<td>Ophiocomella sexradia</td>
</tr>
<tr>
<td>9</td>
<td>Ophiothrix savignyi</td>
</tr>
</tbody>
</table>
Ophiuroidea from Saurashtra Coast

Baroliya et al.

家庭: Ophiuroidea 群

物种: Ophiomaza Lyman, 1871
Ophiomaza cacaothica (Lyman, 1871)


注释: 标本有棕色或褐色的盘状和尖刺状的前臂。其盘状结构为壳状，中间有六到七个尖刺。

栖息地: 肉盘

分布: 波斯湾, 斯里兰卡, 孟加拉湾, 东印度, 北澳大利亚, 菲律宾, 中国, 南日本, 中南太平洋群岛 (Clark & Rowe 1971); 澳大利亚 (Rowe & Gates 1995).

现有研究: 这是首次发现于古吉拉特 (Simbor).

Ophiothrix Müller & Troschel, 1840
Ophiothrix savignyi (Müller & Troschel, 1842)

材料检查: Mangrol - 1 specimens. Museum ID: ZEOAOO(1)22N, coll. Niyati Gajera, are deposited in the museum.

注释: 这个物种与早前报道的 O. foveolata 差异较大。O. foveolata 有明显的尖刺，而此物种有刺/刺状，三叉形。

栖息地: 位于岩石下。

分布: 南东阿拉伯, 波斯湾, 西印度和巴基斯坦 (Clark & Rowe, 1971).

现有研究: 这是首次发现于古吉拉特 (Mangrol).

讨论

现有栖息在古吉拉特海岸的棘皮动物的多样性描述。主要的岩石海岸线的古吉拉特海岸被调查。

Dwarka - 8 specimens; Shivrajpur - 6 specimens; Okha - 10 specimens. Four specimens having Museum ID: ZEOAOO(8)19H, ZEOAOO(4)19H, ZEOAOO(5)19H, ZEOAOO(1)19H, coll. Hitisha Baroliya, are deposited in the Museum.

注释: 在古吉拉特海岸线上的物种。径向骨板大，卵形，间断地靠近边缘。两旬口状骨板每条侧边，一对内口状骨板有方形形态的上部牙齿。

栖息地: 岩石皱纹，底栖带的海藻基质和裂缝。

分布: 印度西太平洋，阿拉伯海到东印度 (Clark & Rowe 1971).

现有报告的古吉拉特: Veraval, Dwarka, Okha, Pirotan Island, and Mandvi (Sastry 2004).

现有研究: Diu (Jalandhar, Nagoa, & Gangeshwar), Dhamlej, Veraval, Mangrol, Dwarka, Shivrajpur, and Okha.

Ophiomaza Lyman, 1871
Ophiomaza cacaothica (Lyman, 1871)


注释: 标本有棕色或褐色的盘状和尖刺状的前臂。其盘状结构为壳状，中间有六到七个尖刺。

栖息地: 肉盘

分布: 波斯湾, 斯里兰卡, 孟加拉湾, 东印度, 北澳大利亚, 菲律宾, 中国, 南日本, 中南太平洋群岛 (Clark & Rowe 1971); 澳大利亚 (Rowe & Gates 1995).

现有研究: 这是首次发现于古吉拉特 (Simbor).

Ophiothrix Müller & Troschel, 1840
Ophiothrix savignyi (Müller & Troschel, 1842)

材料检查: Mangrol - 1 specimens. Museum ID: ZEOAOO(1)22N, coll. Niyati Gajera, are deposited in the museum.

注释: 这个物种与早前报道的 O. foveolata 差异较大。O. foveolata 有明显的尖刺，而此物种有刺/刺状，三叉形。

栖息地: 位于岩石下。

分布: 南东阿拉伯, 波斯湾, 西印度和巴基斯坦 (Clark & Rowe, 1971).

现有研究: 这是首次发现于古吉拉特 (Mangrol).

讨论

现有的多样性棘皮动物的栖息区从古吉拉特海岸线被描述。主要的岩石海岸线的古吉拉特海岸线被调查。
the diversity estimation. Earlier 12 ophiuroids were reported from the Gujarat coast (Sastry 2004). A recent evaluation of ophiuroids diversity fascinated with nine species, *Microphiothrix variabilis*, *Ophiothrix savignyi*, and *Ophiomaza cacaotica* are three new records for the Gujarat coast. This study revealed several unreported species from the intertidal areas of various station. *Ophiocomella sexradia*, *Ophionereis dubia dubia*, & *Microphiothrix variabilis* first time reported from Veraval, *Ophiothrix savignyi* from Mangrol, *Ophiactics savignyi* & *O. sexradia* from Diu, *Amphiura ambigua*, *M. viriabilis*, & *O. dubia dubia* from Okha, and *Ophioplocus imbricatus* from Dwarka. Rest of the sites are first time evaluated in the present study with no previous records (Table 3). The similarity index result value varied from 0 to 1 (Image 2). Sampling site wise similarity index shows that all the seven sites were similar upto some extent in terms of species composition. Highest similarity was observed between Diu & Dhamlej, Diu & Mangrol, and Mangrol & Dhamlej because of the ophiuroid shared by this station are similar and their substratum and habitat structure are similar. While, Simbor has lowest similarity. Except two cosmopolitan species *A. squamata* and *O. savignyi*, all the species of Ophiuroidea were found to be very much confined to selected station. The results of similarity indices show that each sampling sites has diverse variety of the Brittle Star, which makes them spatially altered from each other. Some of the species were associated with other marine creatures.

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