The molluscan bio-fouling community on the Red Sea pearl oyster beds

(Mollusca: Pteriidae)

Torsten Wronski

Abstract. In the Red Sea, pearl oyster banks occur most extensively around the Dahlak and the Farasan Islands. Pearl oysters (*Pinctada*, Pteriidae) form extended beds by attaching themselves to hard substrates. Such beds attract a diverse bio-fouling fauna. Most dominant are the molluscs, but little is known about the associated biota of pearl oyster beds, their distributional abundance, and the structure of this community. In this study, the macro-molluscan fauna living on pearl oyster beds in the Red Sea around the Farasan Islands was studied using a quantitative survey of the by-catch left by pearl oyster divers. Bivalvia represented 99.6% of the malaco-fauna on pearl oyster beds around the Farasan Islands, while gastropods and chitons represented only 0.4%. In total, 33 mollusc species were identified (24 bivalves, 7 prosobranch gastropods, one basomatophore gastropod and one chiton), with *Brachidontes variabilis*, a species which is not found on Arabian Gulf pearl oyster beds, the most common bivalve (71% of all molluscs), and *Diodora ruppellii* the most common gastropod (0.12% of all molluscs). The results are discussed and compared with the pearl oyster beds from the Arabian Gulf.

Key words. *Pinctada radiata* community, bio-fouling, Red Sea, macro-molluscs, Saudi Arabia

Introduction

The countries of the Arabian Gulf are endowed with pearl oyster resources which have been exploited for natural pearls from time immemorial, and they have depended on these marine economic resources. Egyptian women had pearls in their jewellery as early as 1,500 B.C. and the early Arabian geographer Massoudi noted the existence of Gulf pearls in the 9th century (SHARABATI 1981). As early as the 3rd century B.C., Nearchus reported that, in the Red Sea, pearls occur most extensively around the Dahlak and the Farasan Islands in the southern part of the Red Sea (SHARABATI 1981). These pearls were usually marketed in India and Ceylon, while only a small number of Red Sea pearls were sold in Red Sea ports. No information is available on the quantity of pears harvested on Red Sea islands, but sources from Bahrain reported that 3,500 boats were employed in 1838, each harvesting between 1 to 50 tons of pearls per annum (SHARABATI 1981). Arab pearl divers are said to bring up 10 to 12 oysters per dive and to make 30 to 40 dives per day, each lasting between five and six minutes. Pearl oyster beds are located from a few hundred metres to 96 km offshore and occur at depths between 2 and 36 m (SHARABATI 1981, AL-KHAYAT & AL-ANSI 2008).

The pearl oysters belong to the genus *Pinctada* Röding, 1798 in the family Pteriidae and have a worldwide distribution, occurring in almost all the seas of the tropical belt as well as in some subtropical regions (OLIVER 1992, KAY 1979, FISHELSON 2000). *Pinctada* is a fouling species that lives attached by a byssus to hard substrates (under stones, in crevices of

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rocks). Ten species of the family Pteriidae belonging to three genera occur in the Red Sea (DEKKER & ORLIN 2000). *Pinctada radiata* (Leach, 1814) is found in the Arabian Gulf, Red Sea and the Indian Ocean and has contributed substantially to the pearl fisheries in Arabian waters (AL-KHAYAT & AL-ANSI 2008). In the Arabian Gulf, *Pinctada radiata* contributes up to 95% of the pearl oyster fishery, while *Pinctada margaritifera* (Linnaeus, 1758) and *Pteria aegyptiaca* (Dillwyn, 1817) contribute only 5% (AL-KHAYAT & AL-ANSI 2008). In the Red Sea and the Arabian Gulf, *P. radiata* is found predominantly in shallow water (OLIVER 1992), while *P. margaritifera,* having a similar lifestyle, is rather confined to the deeper waters (AL-KHAYAT & AL-ANSI 2008). Colonies of *P. radiata* are usually found on the ridges of rocks and corals where they are byssally attached among rocks and stones (OLIVER 1992).

Such colonies themselves function as hard substrates for a number of marine organisms such as echinoderms, crustaceans, corals, algae, polychaetes, sipuncula, actinaria and branchiopodes. The overall percentage distribution of the different biota collected from pearl oyster colonies in the Arabian Gulf indicates that the molluscs, especially gastropods and bivalves, were more abundant than other faunal elements (AL-KHAYAT & AL-ANSI 2008). The molluscan fauna contributed about 55% of the recorded fauna, with 104 species.

The associated biota of pearl oyster beds, their distributional abundance, topographical features and general ecology as well as their community structure and habitat conditions are either rarely considered or remain generally unknown. In this study, I therefore made an attempt to describe the molluscan community structure inhabiting *Pinctada radiata* pearl oyster beds in Red Sea waters surrounding the Farasan Islands. Since diving equipment could not be employed and pearl oyster diving has been stopped as a source of income on the Farasan Islands, I indirectly investigated the community structure by quantifying the shell remains and by-catch left by pearl oyster divers on the coral shores of Farasan Kebir Island.

Material and methods

Study area. The Farasan Islands are an assemblage of islands formed by raised fossil coral reefs at elevations between 0 to 30 m a.s.l. The archipelago is located in the Red Sea approximately 40 km off the Arabian coast (16°20' – 17°20'N, 41°30' – 42°30'E), opposite the town of Jizan in the extreme southwest of Saudi Arabia (FLAMAND et al. 1988, CHILD & GRAINGER 1990). The marine and coastal habitats of the region are generally in a healthy condition and the level of exploitation by people is low. There are, however, localized impacts arising from unsustainable fishing practices, tourism developments, oil pollution, and degraded water quality. In 1988 it was therefore decided to establish a marine protected area around the Farasan Islands (GLADSTONE 2000).

The main oceanographic feature of the Red Sea surrounding the Farasan Islands is its high salinity of up to 35-40‰ (BEMERT & ORMOND 1981). The high salinity is a consequence both of the hot climate and the absence of any river adding fresh water to the sea. The surface sea temperature ranges, according to the season, from approximately 25° to 31°C and falls with increasing depth to about 21.5°C at about 700 m, were it remains remarkably constant (BEMERT & ORMOND 1981). The normal tides are small, with peak tides of about 0.5 m. The shore in the study area is comprised predominantly of coral fringe reefs, lagoons and long sandy beaches (GLADSTONE 1994). Occasionally, the coastline comprises small bays with *Avicennia* spp. or *Rhizophora* spp. mangroves or macro-algal beds and reefs off the shore line (GLADSTONE 1994).

Data collection. At two places on Farasan Kebir, shell middens from recent pearl oyster diving activity were found, i.e. the eastern beaches of Seir in the north of the island, where pearl oyster collecting activities were stopped about 50 to 100 years ago, and at Ras Shida in the southwest of Farasan Kebir (Fig. 1), where such activities were stopped between 5 and 10 years ago. Here shells are distributed equally over an area of approximately 100 m^2, forming flat mats of shell material originating predominantly from molluscs, but also, to a far lesser degree, from polychaetes, sponges and barnacles (Fig. 2). The decay of shell material at Ras Shida was not as advanced as it was at the Seir site, and macro-molluscs could be determined to species level. Shell material of each species was quantified in sampling plots of 1 m^2. Sampling was carried out between 3 June and 2 July 2009 at a total of 17 plots. All shell layers down to the surface of the coral rock (max. 10 cm) were included in the count,. All gastropod, chiton and bivalve shells were counted. The number of bivalve shells was then divided by two to obtain the number of individuals. Sea slugs (Opisthobranchia) were not included in the study and molluscs smaller than 5 mm could not be detected since shell material was destroyed or invisible. Broken bivalve shells were only counted when the hinge was found, gastropods only when the aperture was found. The remains of sponges growing on the shells, barnacles and polychaetes forming calcareous tubes were not included. Bivalve species were determined using the following references: SHARABATI (1984), DELSAERDT (1986), OLIVER (1992), BOSCH et al. (1995), OLIVER & CHESNEY (1997), and RUSMORE-VILLAUME (2008). The systematics and nomenclature used here followed ROSENBERG et al. (2004).

To obtain an approximate value for the species diversity on pearl oyster banks around the Farasan Islands and to compare it with findings from the Arabian Gulf (AL-KHAYAT & AL-ANSI 2008), the Shannon-Wiener Diversity Index (H_s) was calculated, including all macro-molluscs found at Ras Shida, using the following equation: $H_s = -\sum P_i (\ln P_i)$, where P_i is the proportion of each species in the sample.

Results

In total, 33 mollusc species were identified (Table 1), including 24 bivalves, 7 prosobranch gastropods, one basomatophore gastropod and one chiton (*Acanthopleura vaillantii* de Rochebrune, 1882). Bivalvia represented 99.6% of the malaco-fauna on pearl oyster beds around the Farasan Islands in the Red Sea, while gastropods and chitons represented only 0.4%. The most dominant species was the mussel *Brachidontes variabilis* (Krauss, 1848), representing 71.0% of all molluscs and 71.3% of the bivalves. The second most common bivalve species was the pearl oyster (*Pinctada radiata*), which contributed only 9.1% of all molluscs and 9.2% of the bivalves. The most common gastropod species found was *Diodora ruppellii* (Sowerby, 1834), which represented 0.12% of the total malaco-fauna and 31.3% of the gastropod fauna. Detailed percentage values for each mollusc species inhabiting the pearl oyster beds are summarised in Table 1. In the present investigation only one specimen of Scaphineura (*Dentalium* sp.) was encountered and it is not included in the above analyses. The mollusc diversity on pearl oyster banks around the Farasan Islands was expressed by a Shannon-Wiener Diversity Index (H_s) of 0.497.

Discussion

There is little known about the associated biota of pearl oyster beds, their distributional abundance, and the structure of this community. In this study, findings from the Arabian Gulf, i.e. from Qatar (AL-KHAYAT & AL-ANSI 2008), were compared with those found on

Table 1. Number of individuals of each species found in the by-catch of Red Sea pearl oyster beds on Farasan Kebir and the percentage proportion of the overall number of molluscs found.

SPECIES	INDIVID.	%
Bivalvia		
Barbatia (*Barbatia*) *foliata* (Forskål, 1775)	55	0.452
Arca (*Arca*) *avellana* Lamarck, 1819	51	0.423
Anadara (*Anadara*) *uropigimelana* (Bory de St. Vincent, 1824)	3	0.025
Septifer (*Septifer*) *forskali* Dunker, 1855	31	0.253
Gregariella ehrenbergi (Issel, 1869)	38	0.315
Brachidontes (*Brachidontes*) *variabilis* (Krauss, 1848)	8564	70.978
Modiolus (*Modiolus*) *auriculatus* (Krauss, 1848)	8	0.062
Lithophaga (*Leiosolenus*) *hanleyanus* (Reeve, 1857)	7	0.054
Pinna muricata Linnaeus, 1758	2	0.017
Atrina (*Servatrina*) *pectinata* (Linnaeus, 1767)	1	0.004
Pinctada radiata (Leach, 1814)	1101	9.121
Pteria macroptera (Lamarck, 1819)	25	0.203
Pteria producta (Reeve, 1857)	4	0.029
Isognomon (*Isognomon*) *legumen* (Gmelin, 1791)	1	0.004
Crenatula picta (Gmelin, 1791)	40	0.327
Malleus (*Malvufundus*) *regula* (Forskål, 1775)	151	1.247
Lima lima (Linnaeus, 1758)	1	0.004
Spondylus groschi Lamprell & Kilburn, 1995	7	0.054
Saccostrea cucullata (Born, 1778)	1	0.008
Dendostrea crenulifera (Sowerby, 1871)	969	8.027
Anomia achaeus Gray, 1850	11	0.091
Alectryonella plicatula (Gmelin, 1791)	62	0.514
Chama pacifica Broderip, 1834	490	4.057
Chama asperella Lamarck, 1819	402	3.332
Gastropoda		
Cellana eucosmia (Pilsbry, 1891)	1	0.033
Diodora ruppellii (Sowerby, 1834)	1	0.124
Trochus erithreus Brocchi, 1821	10	0.008
Bursa granularis (Röding, 1798)	4	0.033
Erosaria turdus (Lamarck, 1810)	4	0.008
Thais savignyi (Deshayes, 1844)	8	0.083
Ergalatax margariticola (Broderip, 1832)	15	0.066
Siphonaria crenata Blainville, 1827	2	0.017
Acanthopleura vaillantii de Rochebrune, 1882	3	0.025
TOTAL	**12,073**	

pearl oyster beds of the Farasan Islands in the Red Sea. AL-KHAYAT & AL-ANSI (2008) reported 104 mollusc species from Qatari waters in the Arabian Gulf. The most abundant groups were gastropods (41 species) and bivalves (60 species). The pearl oyster *Pinctada radiata* was the most dominant species. Other bivalves such as *Tucetona maskatensis* Melvill, 1879*, Malleus* (*Malleus*) *malleus* (Linnaeus, 1758), *Malleus* (*Malvufundus*) *regula* (Forsskål, 1775), *Chama asperella* Lamarck, 1819, and *Chama reflexa* Reeve, 1846 (=

Fig. 1. Landing site at Ras Shida (Farasan Kebir) where pearl oyster divers deposited their by-catch.

Chama pacifica Broderip, 1834) were commonly found on pearl oysters in the Arabian Gulf. This study is very much in line with the findings reported by AL-KHAYAT & AL-ANSI (2008), except that *Brachidontes variabilis* was by far the most dominant species. It is surprising that *B. variabilis* occurred in this study in considerable numbers while it was not mentioned by AL-KHAYAT & AL-ANSI (2008) for the Arabian Gulf. Epifaunal growth and survivorship of *B. variabilis* depend to a large extend on water temperature and cover. Experiments in the Gulf of Suez revealed that epifaunal growth and survivorship are increased in winter and that limited growth and survivorship in summer are compensated if the mussel grows amongst other organisms (infaunal growth; MOHAMMED 1997). The dominance of *B. variabilis* on pearl oyster beds around the Farasan Islands may therefore be attributed to the lower water temperatures in the southern Red Sea. Winter minimum temperatures in Farasan waters vary between 25-27°C, and summer maximum temperature between 31-33°C (BEMERT & ORMOND 1981, GLADSTONE 1994). Contrasting with that, the water temperature in Qatari waters varied between 33 and 35.3°C in August-September and between 28 and 30°C in November (AL-KHAYAT & AL-ANSI 2008). Other bivalves, as mentioned above, also occurred commonly on pearl oyster beds of the Farasan Islands. *Tucetona maskatensis* is replaced by *Tucetona audouini* Matsukuma, 1984 in the Red Sea and was found only once on a shell midden in Seir (northern Farasan Kebir, not included in Table 1).

Fouling organisms and predators affect the growth of natural pearl oyster beds in the Red Sea to a considerable degree (REED 1962, MOHAMMAD 1976, GERVIS & SIMS 1992). The fouling organisms of most importance are barnacles, bryozoans, tunicates and molluscs. Barnacles, oysters and jewel boxes (Chamidae) can physically prevent the pearl oyster from opening along the hinge line or cement the valves together (ALARGASWAMI & CHELLAM 1976, 1977). Competition and reduced plankton availability caused by decreased water flow

Fig. 2. Shell grit at Ras Shida landing site (Farasan Kebir) from which mollusc abundance was determined.

also hamper the growth of pearl oysters but benefit the mussels. Boring polychaetes, sponges and isopods also cause considerable damage to pearl oysters (GERVIS & SIMS 1992). Amongst the boring molluscs, *Lithophaga* (*Leiosolenus*) *hanleyanus* (Reeve, 1857) was the most common borer found in this study (0.05% of all molluscs). Carnivorous gastropods, such as Muricids, also pose a major threat to the pearl oysters. Two species, *Thais savignyi* (Deshayes, 1844) and *Ergalatax margariticola* (Broderip, 1832), were found preying on the community, but both in low abundance (0.08 and 0.06% respectively).

The lowest species diversity index reported by AL-KHAYAT & AL-ANSI (2008) for the Arabian Gulf was $H_s = 0.949$. This included not only molluscs but also a number of other fouling organisms as mentioned above. The Shannon-Wiener Index found in this study was $H_s = 0.497$ and included only macro-molluscs. A lower species diversity and lower number of individuals are indicative of a macro-benthos fauna and habitat response to stressful environmental conditions (GERVIS & SIMS 1992). Considering that only macro-molluscs were sampled in this study, the diversity is relatively high, indicating moderate to good environmental conditions in Farasan waters.

References

ALARGASWAMI, K. & A. CHELLAM (1976): On fouling and boring organisms and mortality of pearl oysters in the farm at Veppalodai, Gulf of Mannar. – Indian Journal of Fisheries 23: 10-22.

ALARGASWAMI, K. & A. CHELLAM (1977): Change of form and dimensional relationship in the pearl oyster *Pinctada fucata* from Gulf of Mannar. – Indian Journal of Fisheries 24: 1-14.

AL-KHAYAT, J. A. & M. A. AL-ANSI (2008): Ecological features of oyster beds distribution in Qatari waters, Arabian Gulf. – Asian Journal of Scientific Research 1: 544-561.

BEMERT, G. & R. ORMOND (1981): Red Sea coral reefs. – London & Boston, 192 pp.

BOSCH, D. T., S. P. DANCE, R. G. MOOLENBEEK & P. G. OLIVER (1995): Seashells of eastern Arabia. – Dubai, Abu Dhabi & London, 296 pp.

CHILD, G. & J. GRAINGER (1990): A system plan for protected areas for wildlife conservation and sustainable rural development in Saudi Arabia – Appendix II. National Commission for Wildlife Conservation and Development, Riyadh, Saudi Arabia, 335 pp.

DEKKER, H. & Z. ORLIN (2000): Check-list of Red Sea mollusca. – Spirula 47 (supplement): 1-46.

DELSAERDT, A. (1986) Red Sea malacology. Revision of the Chamidae of the Red Sea. – Gloria Maris 25(3): 73-125.

FISHELSON, L. (2000): Marine animal assemblages along the littoral of the Israeli Mediterranean seashore: The Red-Mediterranean Seas communities of species. – Italian Journal of Zoology 67: 393-415.

FLAMAND, J. R. B., C. R. THOULESS, H. TATWANY & J. F. ASMODÉ (1988): Status of the gazelles of the Farasan Islands, Saudi Arabia. – Mammalia 52: 608-610.

GERVIS, M. H. & N. A. SIMS (1992): The biology and culture of pearl oysters (Bivalvia: Pteriidae). – ICLARM Studies & Reviews 21, Manila, Philippines, 49 pp.

GLADSTONE, W. (1994): The Farasan Marine Protected Area. Vol. 1: Biological resources, conservation values, human uses and impacts. – NCWCD, Riyadh, 134 pp.

GLADSTONE, W. (2000): Farasan Islands Protected Area master management plan. – NCWCD, Riyadh, 48 pp.

KAY, E. A. (1979): Hawaiian marine shells. – Honolulu (Hawaii), 653 pp.

MOHAMMAD, M. B. M. (1976): Relationship between biofouling and growth of the pearl oyster *Pinctada fucata* (Gould) in Kuwait, Arabian Gulf. – Hydrobiologia 51: 129-138.

MOHAMMED, S. Z. (1997): Growth, survival and settlement of the mussel *Brachidontes variabilis* (Bivalvia: Mytilidae) in epifaunal and infaunal substrates in the Suez Canal. – Indian Journal of Marine Science 26: 350-355.

OLIVER, P. G. (1992): Bivalved seashells of the Red Sea. – National Museum of Wales, UK, 330 pp.

OLIVER, P. G. & H. C. G. CHESNEY (1997): Taxonomy and descriptions of bivalves (Lucinoidea, Galleommatoidea, Carditoidea, Cardioidea, Tellinoidea & Myoidea) from the Arabian Sea. – Journal of Conchology 36: 51-76.

REED, W. (1962): Report to the government of Sudan on the Sudanese shell industry and Red Sea fishery based on the work of W. Reed. – FAO Reports 1489: 1-47.

ROSENBERG, G., W. F. PONDER, P. U. MIDDELFART, T. M. GOSLINER, P. BOUCHET & P. J. MORRIS (2004): OBIS Indo-Pacific Molluscan Database. – URL <http://data.acnatsci.org/obis>.

RUSMORE-VILLAUME, M. L. (2008): Seashells of the Egyptian Red Sea. – American University in Kairo Press, Cairo & New York, 307 pp.

SHARABATI, D. (1981): Saudi Arabian sea shells. – London, 119 pp.

SHARABATI, D. (1984): Red Sea shells. – London, 128 pp.

Author's address: Torsten Wronski, King Khalid Wildlife Research Centre, Saudi Wildlife Commission, Thumamah, P.O. Box 61681, Riyadh 11575, Kingdom of Saudi Arabia, and Zoological Society of London (ZSL), Conservation Programs, Regents Park, London NW1 4RY, United Kingdom. – Email: t_wronski@gmx.de.