

## SOME OBSERVATIONS ON THE BIOLOGY AND FISHERY OF IVORY SHELL (*BABYLONIA SPIRATA* (LINNAEUS, 1758))

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### ABSTRACT

*Babylonia spirata* (Linnaeus, 1758) which is a gastropod belonging to Order Neogastropoda: Family Babyloniidae is commercially harvested in Pakistan and many countries of the world. It is edible and exported mainly to Southeast Asian countries. It is mainly caught through aimed trap fisheries from coastal and offshore waters to a depth of about 40 m in Sindh and Balochistan. It is also caught as a bycatch of trawl fisheries in Pakistan. Although it is harvested throughout the year, its peak fishing season is September to April. Babylon fishery was started in Pakistan in 1992, however, now it is one of the common shell fishing activities along the coast of Pakistan. Its present annual production is estimated to be 4,418 m. tons which is mainly exported in frozen form, however, live *Babylonia spirata* shells are also exported. The paper provides details of the taxonomy, fisheries, and trade of ivory shells in Pakistan including details about its experimental farming.

**Keywords:** *Babylonia spirata*, ivory shell, babylon, aalo gulla, trap fishing, grading, processing, export, Babylonia farming.

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### INTRODUCTION

*Babylonia spirata* (Linnaeus, 1758) is a gastropod belonging to Order Neogastropoda: Family Babyloniidae which was created by Kuroda *et al.* (1971). It is a commercially important species that are marketed as ivory shell, “baigai”, babylon or spiral whelk. It is commonly known as “Aalo gulla” in Balochi and Sindhi in Pakistan. Kazmi *et al.* (2018; 2022) provided details of the occurrence of this species in Pakistan whereas Moazzam and Ahmed (1994) provided information about its fishing along the coast of Pakistan. Commercial fishing of ivory shells was started in 1992 when it was exported in frozen form to Taiwan. Since then its harvesting has been developed into a major fishing activity along the coast of Pakistan. Its aimed trap fisheries are now practiced throughout Pakistan coast and harvested shells are exported in frozen and live form to Southeast Asian and Persian Gulf countries. The present paper provides details of the taxonomy, fisheries, and trade of ivory shells in Pakistan including details about its experimental farming.

### MATERIAL AND METHODS

Information about the taxonomy of the *Babylonia spirata* (Linnaeus, 1758) was obtained through the review of the literature whereas information about the fisheries of this species was obtained from seafood processing plants, from fishermen, and from published scientific papers. In addition, fishing grounds and landing centres were visited along the Sindh and Balochistan coasts to collect information on its fishing methods, abundance, and distribution from major fishing grounds. Data about its landings was obtained from archives of the Marine Fisheries Department, Government of Pakistan. Results of some experiments on farming of this species are also presented in the paper.

### RESULTS AND DISCUSSION

#### TAXONOMY

Ivory shells belonging to the genus *Babylonia* Schlüter, 1838 are represented by six species in Pakistan; of which *Babylonia spirata* (Linnaeus, 1758) is reported to be the most common and recorded by many scientists. The taxonomy of the genus *Babylonia* is reviewed by Altena (1968), Altena and Gittenberger (1981), and Fraussen and Stratmann, (2013). There are anomalies regarding the identification of the species belonging to the genus *Babylonia* recorded from Pakistan. The present paper tries to resolve the issues pertaining to the taxonomy of the genus *Babylonia* occurring in Pakistan.

***Babylonia spirata*** Linnaeus, 1758

(Fig. 1)

This species was reported from Sindh coast it was reported from Bhit Island, Manora (East side) by Khan and Dastagir (1971), from Karachi by Melvill and Abercrombie (1893) and Melvill and Standen (1901) and from Karachi Fish Harbour by Tirmizi and Zehra (1984). It was reported from Bandri (Jiwani) by Ghani *et al.* (2018) and from the Balochistan coast by Moazzam and Ahmed (1995). It was also reported from the Pakistan coast without mentioning any specific location by Hussain (2003), Kazmi *et al.* (2018; 2022). Melvill and Standen (1901) reported this species as *Latrunculus spiratus* whereas Melvill and Abercrombie (1893) recorded it as *Eburna spirata*.

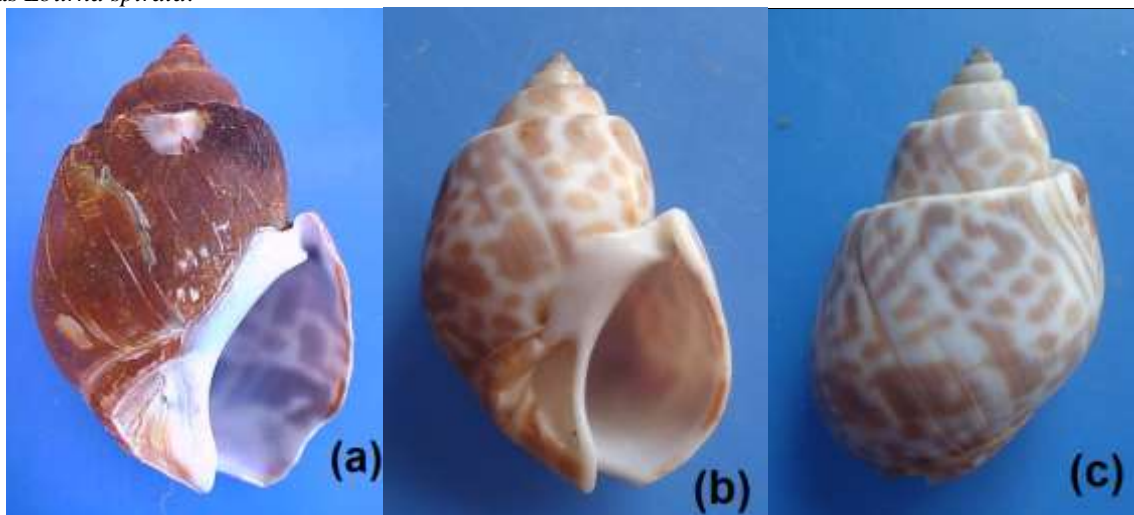


Fig. 1. *Babylonia spirata*. (a) apertural view; shell with periostracum. (b) apertural view. (c) abapertural view.

It was originally described as *Buccinum spiratum* by Linnaeus (1758) whereas *Ancilla pallida* Perry, 1811, *Babylonia hongkongensis* Lai and Guo, 2010, *Babylonia spirata balinensis* Cossignani, 2009, *Babylonia spirata f. chrysostoma* (Sowerby II, 1866), *Buccinum spiratum* Linnaeus, 1758, *Buccinum spiratum* var. *alborubra* Spalowsky, 1795, *Eburna Chrysostom* Sowerby II, 1866, *Eburna semipicta* Sowerby II, 1866, *Nassa canaliculata* Schumacher, 1817 and *Nassa molliana* Chemnitz, 1780 are considered to be synonym of this species.

Description (after Dance *et al.*, 1995). The shell is heavy, ovate, last whorl very inflated, protoconch pointed; sutures deeply channeled. Thick parietal callus. Deep narrow posterior canal. Outer lip sharp and smooth, strongly flexed at top. Fine growth striae crossed by fine spiral striae. Broad deep umbilicus usually obscured by parietal callus; umbilical area bordered by tick ridge. Greyish white with reddish brown or orange crescents, oblique streaks, and spots; early whorl bright purple. Operculum semilunar brown. The species can be characteristically identified from its congeners in having wide sutural canal and flattened whorls above the periphery.

***Babylonia valentiana*** (Swainson, 1822)

This species is reported from Karachi by Altena (1968), Altena and Gittenberger (1981), GBIF (2023), and Melvill and Standen (1901) and from Balochistan coast by Moazzam and Ahmed (1995), Melvill and Standen (1901), from Gwadar by Melvill (1898). It was also reported from the Pakistan coast without mentioning specific locations by Hussain (2003), Kazmi *et al.* (2018; 2022) and Khan and Dastagir (1971). Melvill and Standen (1901) reported this species as *Latrunculus valentianus* whereas Melvill (1898) reported it as *Eburna molliana*. It was reported from Pakistan as *Babylonia spirata valentiana* by OBIS (2006). Its synonymy includes *Eburna molliana* by Sowerby II (1859), *Eburna valentiana* (Swainson, 1822) and *Babylonia spirata valentiana*.

According to Melvill and Standen (1901), this species lives in mud in shallow waters and emerges from their whole to feed on medusa etc. which are casted ashore and return to their whole. They observed this species to be inhabiting soft spongy mud. This species is separated from its congeners in having a narrow sutural canal (wide in the case of *B. spirata*), whorls rather convex, and especially not flattened near the sutural canal (whorls flattened above the periphery in *B. spirata*). During the present investigation, thousands of samples of *Babylonia*

were examined but it seems that two species (*Babylonia spirata* and *B. valentiana*) cannot be separated and it seems that both the species are same. *Babylonia spirata* Linnaeus, 1758 has priority over *Babylonia valentiana* (Swainson, 1822), therefore, *valentiana* is considered as a synonym of *B. spirata*. Dance *et al.* (1995) also considered *Eburna valentiana* as a synonym of *B. spirata*.

#### *Babylonia formosae* (Sowerby, 1866)

Reported from Pakistan by Anonymous (1977) and Kazmi *et al.* (2018; 2022). This species is known from South China Sea (EOL, 2023) including Taiwan, Indonesia, Japan and China (GBIF, 2023). No specimen of this species from Pakistan is available for examination during the present study. Considering its restricted distribution in the South China Sea, its occurrence in Pakistan must be based on misidentification.

#### *Babylonia japonica* (Reeve, 1842)

Reported from Pakistan by Anonymous (1977) and Kazmi *et al.* (2018; 2022). This species is known from Korea, Japan and Taiwan (Altena and Gittenberger, 1981; EOI, 2023). The pattern is similar to that of *Babylonia zeylanica* and *B. spirata* but *B. japonica* has smaller and more numerous spots (GBIF, 2023). No specimen of this species from Pakistan is available for examination during the present study. Considering its restricted distribution in the South China Sea, its occurrence in Pakistan must be based on misidentification.

#### *Babylonia kirana* Habe, 1965

Reported from Pakistan by Anonymous (1977) and Kazmi *et al.* (2018; 2022). This species is known from the South China Sea, Japan, and the Ryukyu Islands to Taiwan and the Marianas or Ladrones Islands (Altena and Gittenberger, 1981; EOI, 2023). Considering its restricted distribution in the South China Sea, its occurrence in Pakistan must be based on misidentification. Anonymous (1977) reported this species as *Babylonia pallida* Perry, 1811 which is considered a synonym of *B. spirata*. No specimen of this species from Pakistan is available for examination during the present study.

A close examination of the reported species of genus *Babylonia* Schlüter (1838), it seems that it is represented by only one species i.e. *Babylonia spirata* Linnaeus (1758) from Pakistan whereas records of other species are erroneous and based on misidentification.

### DISTRIBUTION AND ABUNDANCE

Along the coast of Pakistan, *Babylonia spirata* is from the mid-littoral zone in the intertidal area with a soft bottom, (sandy-cum muddy or muddy) to outer limit of the continental shelf. It is being caught from shrimp/shrimp trawlers from a depth of 180 m, however, a dense population of this species is reported between a depth of 10 to 40 m in the coastal areas including in the creek system of the Indus Delta as well as on the continental shelf along Pakistan coast. According to Altena and Gittenberger (1981). *Babylonia spirata* is reported from 0.5 to 1.5 m depth on a mud-bottom in the Java Sea East of the canal to Pasar Ikan near Jakarta, from 1.8 m depth at Galle Harbour, Sri Lanka, and from 9 to 11 m depth on sand, grit and shells and Southwest of Suzeh in the Persian Gulf. In the Indian Ocean, this species is found to be up to a depth of 150 m (Mohan, 2007). This species is, however, not found on the rocky shore except on the rocky ledges that have mud and sand accumulations, like on Goth Mubbarak, Ormara (Demi Zur), Ras Juddi (Pasni), Sur, Gwadar (Demi Zur) and Jiwani, however, their population is very small on such shores. Altena and Gittenberger (1981) also reported that these species seem to avoid a rocky bottom.

### FISHERIES OF *BABYLONIA SPIRATA*

Ivory shell (*Babylonia spirata*) is the most traded babylon mollusk globally (Mohan, 2007; Moazzam and Ahmed, 1994; Tan and Low, 2013). It is being caught, on a commercial scale, in almost entire areas of distribution, however, Pakistan and India are the leading fishing nations of *B. spirata* (Ayyakkannu, 1994). This species is traded by its common names including Babylon ivory shell, Babylon whelk or Baigai (Japanese name for genus *Babylonia*). In Pakistan, it is locally called “Kuchki”, or “Kuch” mainly in Balochistan, however, for the last 20 years, it is called “Aalo gulla” which is used mainly in the export industry. *Babylonia spirata* now supports a large coastal fishery in Pakistan which is estimated to involve about 3,000 small-scale fishing boats

generally categorized as “hora” in Sindh and “Rachin” in Balochistan. In addition, fiberglass boats obtained from shipbreaking industry which are locally known as “doonda” are also extensively engaged in this fishery.

#### EXPORT (HISTORY AND TRENDS)

The fishery for *Babylonia spirata* has a very long history, as its operculum which is locally known as “jinni nakhun” (translation n= nails of a genie) used to be collected from the intertidal area by womenfolk during low tides for centuries. These opercula used to be dried and exported through traditional channels to Oman where these are used for burning as incense. This trade is still continuing and opercula of *B. spirata* are exported to Oman which are still collected by women from the shores or obtained as a byproduct of boiled spiral babylon shells. From India, gastropod opercula including that of *B. spirata* are exported to Persian Gulf and other countries (Sundaram and Deshmukh, 2013).

Since *Babylonia* shells have striking coloration, therefore, these are used in the preparation of decoration pieces and other shell ornaments. Karachi especially Clifton Beach has been the hub of the ornamental shell industry for a long period. *Babylonia* shells for this trade used to be collected from Ibrahim Hayderi area about 30 years back, however, now *Babylonia* shells are obtained from seafood processing plants where these are important byproduct of the boiled shell meat industry.

*Babylonia* is considered an important seafood that is consumed mainly in Taiwan, Japan, China, Thailand, and Southeast Asian countries, where it is marketed as “Baigai” or “Ivory shell”. From Pakistan, the export of *Babylonia spirata* started in 1992 when one of the establishments (M/S Shah Sons. Pvt. Ltd.) started processing and exporting large-sized *Babylonia* in frozen form (whole and meat) to Taiwan. *Babylonia* used to be obtained as a bycatch of shrimp trawling or collected by hand-picking from intertidal areas for this trade. The average size of shells exported during the 1990s and 2000s ranged between 45.0 and 55.0 cm (under 10 pieces per kg to 22-48 pieces per kg). Smaller shells used to be discarded. The export of medium-sized ivory shells (60-80 pieces per kg) to Japan was started in 1995 for which depuration facilities were established at Korangi Fish Harbour.

A number of other seafood processing plants started the export of ivory shells after 1998 which also included the export of live shells to Hong Kong and Thailand. A major decrease in shell size was noticed which coincides with increased demand for medium-sized shells (30/50 pieces per kg). Bycatch of shrimp trawl fishing still used to be the main source of ivory shells for export. By 2000, demand for the export of *Babylonia* increased substantially, therefore, an aimed trap fishery was introduced in Pakistan. Presently about 15 different fisheries establishments are engaged in the export of live, frozen, and meat from *Babylonia* to UAE, Thailand, Malaysia, and China. Medium to small-sized ivory shells (30/50 pieces per kg to 80/120 pieces per kg) are the dominant sizes being exported.

#### HARVESTING OF IVORY SHELLS

Shrimp trawling was introduced in Pakistan in 1951 which ultimately led to the establishment of the seafood processing industry. These trawlers used to operate along the coastline up to a depth of 40 meters (van Zalinge, *et al.*, 1994). *Babylonia spirata* used to be an important bycatch species in these operations, but since there was no market for these shells, therefore, they used to be discarded. However, *Babylonia* shells used to be collected mainly from intertidal areas from the muddy beaches of Ibrahim Hayderi and adjacent creeks for the ornamental shell industry based in Clifton, Karachi.

Because of the increased demand for ivory shells for export purposes in the 1990s, shrimp trawlers started landing their catch of *Babylonia* shells which used to be auctioned at Karachi Fish Harbour and Ibrahim Hayderi Landing Jetty. At that time, only large shells (under 10 and 10/20 per kg) used to be marketed, processed, and exported. The export of live *Babylonia* and its meat was started in the late 1990s. At the same time utilization of medium-sized shells (22-40 pieces per kg to 60-80 pieces/kg) also started for export. Demand for ivory shells increased substantially during the early 2000s which led to the establishment of aimed trap fishing for *Babylonia*. The traps that were previously used for catching swimming crabs in shallow coastal waters were used for catching *Babylonia* in shallow coastal waters. Trash fish and offal of fish and poultry industries were used as bait in the traps used for catching ivory shells. Since these traps were not ideally designed, therefore, some *Babylonia* used to escape from them, therefore, an improved design (Fig. 2) was introduced in the late 2000s which is now widely used in Pakistan.

In the newly designed traps, stale, partially stale, dried, and rarely fresh fish are used as bait. Usually, Indian mackerel, small ribbonfish, sardinella, shad, and mullet are considered preferred bait. A boat usually carries about 200 or 300 such traps. However, smaller boats may carry fewer traps whereas larger boats may carry up to 400 traps. Smaller boats carry 2 to 3 crew (Fig. 3) whereas larger boats may carry 7 to 8 fishermen.

The traps are laid in a long line with a lazy line at the start of the long line with a marking flag whereas the end of the line is attached to the boat. The traps are attached to the mainline at a distance of 5 to 10 m. In most cases, the one-day operation is undertaken, however, multiday is commonly practiced in some areas including the Jiwani and Indus Delta areas. In most cases, the traps are laid down in the evening (between 5 and 7 o'clock) and retrieved early in the morning (between 4 and 7 o'clock). After retrieval, traps are checked for the presence of ivory shells which are taken out and placed in gunny bags, wicker baskets, or plastic crates. On rare occasions, especially when *Babylonia* catch was good, traps may again be placed a second time in a day.



Fig. 2. Trap being used for harvesting *Babylonia spirata* from coastal waters of Pakistan. (a) Trap; (b) Boats loaded with traps ready to depart for fishing in Jiwani.



Fig. 3. Baited traps being deployed along the Karachi coast for catching ivory shells.

In most cases, fishing operation for catching ivory shells is managed by individuals or operators/owner of the fishing boats, like other fishing operations. They are required to land their catch and market it through a money lender through whom an operation loan was taken. This form of operation is being undertaken in almost all major types of fishing operations in Pakistan. In some areas especially along the Balochistan coast including Malan, Sapat, and Jiwani, fishermen engaged in ivory shell fisheries do not take operational loans from money lenders and dispose of their catch directly to buyers from the processing plants. In some places like Kund Malir and Karachi, fishermen take loans from the processing plants and are bound to sell their catch to the representative of the respective processing plant.

In the Indus Delta, a specialized operation is carried out for the harvesting of *Babylonia* which is called “Tapal” which is a joint operation of about 10 to 15 boats (including fiberglass boats obtained from shipbreaking industry which are locally known as “doonda”) that are managed in a “Tapal”. These fishing boats are provided with the supplies of ration, fuel, bait, and water in the fishing ground by the “Tapal” operator.

About 1,000 or 2,000 baited traps are deployed from these boats. Each boat manned by 7 to 8 crew stays in the fishing ground for about 8 to 10 days, especially during the spring tide period. They deploy their traps once or twice a day depending on the catch rates. The fishing grounds are located near the mouth of Khajar, Wari, Khuddi, Wari, and other creeks of the Indus Delta. A collection boat owned by “Tapal” owner will collect ivory shells from each fishing boat on a daily basis and provide supplies including bait to them. The catch from these boats is then landed at Ibrahim Hayderi or taken directly to the processing plants. The operation is closed during neap tides or limited only to the mouth of deeper creeks only with a limited number of boats.

*Babylonia spirata* is also caught, on a commercial scale, in Iran using same traps and technique being used in Pakistan. Their major ivory shell fishery is located between Kanarak, Pozem, Bris, and Pasbandar adjacent to the Pakistan coast (Erfanifar, *et al.*, 2023). A major part of their catch is transported by boats to Jiwani, Pakistan through traditional channels including barter trade. The imported *Babylonia* from Iran is processed in Pakistan and exported. The quantity of imported *Babylonia* from Iran is not known, however, it is estimated that during peak fishing season (October to March) about 15 to 25 m. tons of *Babylonia* is imported from Iran on a daily basis processed in Pakistan and exported to Southeast Asian countries.

#### FISHING SEASON

Fishing for *Babylonia spirata* is carried out throughout the year, especially in the Indus Delta and some bays and lagoons along the Balochistan coast. Main harvesting is done during the spring tide period, however, in some cases, the fishing is continued even during the neap tide period. Peak fishing season for harvesting *Babylonia* is from mid-September to mid-April, especially along the Balochistan coast. A part of the fishing fleet consisting of small and medium-sized boats is dedicatedly engaged in this fishing operation in shallow coastal waters. Major fishing grounds along the Balochistan coast are located in Phor to Kund Malir, Malan to Ormara, Pasni Bay, Gwadar (West Bay), and Gwater Bay (Jiwani). No trap fishing was undertaken during monsoon months along the major part of the Balochistan coast during to southwest monsoon (May to September) because of rough sea conditions. When traps are not in use during the off-seasons, these are stored in collapsed form so that the net around the trap is not damaged (Fig. 4).



Fig. 4. Storage of traps during off-seasons in collapsed form.

#### PROCESSING OF *BABYLONIA*

*Babylonia spirata* are transported from fishing grounds to seafood processing plants located along the Balochistan and Karachi coasts in gunny bags, wicker baskets, or plastic crates (Fig. 5). In most cases, these shells are routed through fish landing centers but in other cases, these are directly transported from fishing grounds to processing facilities. During their transportation from fishing grounds to processing either directly or indirectly through landing centers, these are kept moist by spraying seawater so that they may not die. Dead shells are discarded at the processing facilities, as a first step. In the second step, shells are washed to remove extraneous material including sediments.

*Babylonia spirata* shells are graded according to size either manually or through a specially designed grading machine (Fig. 6). Depending on the quantity of shells to be processed, they may be kept in seawater for depuration for the removal of sand from the bodies of live animals and to separate dead shells.



Fig. 5. *Babylonia spirata* shells are brought to processing plants in fish crates or gunny bags.



Fig. 6. (a) Locally designed machine which is used for grading of *Babylonia spirata*. (b) The largest preferred size is (50 to 80 pieces per kg) is accumulated in the last tray.

In the 1990s, most specimens that used to be exported were of the large size category. The dominating size in the 1990s used to be under 10 pieces/kg (U/10), 10/20, and 20/30 pieces per kg and exported to Taiwan in the frozen form. Category U/10 was observed to have a size range between (45 and 50 mm). In addition, boiled-frozen meat of these categories was also exported. Meat recovery from the shell was estimated to be about 8 to 10 % of the live weight of the *Babylonia* shell. Export of live *Babylonia* was started in early 2000s and 60/80 pieces per kg used to be the most preferred size and exported mainly to Japan.

A major reduction in size categories was reported by 2010 and large-sized specimens (u/10 to 120/30 pieces/kg) almost disappeared from the commercial landings. Presently, the most common size categories are 30/50, 50/80, 80/120, 120/200, and 200/300 pieces per kg; of which 50/80 pieces per kg is the most dominating size category which has a size range of 20 to 25 mm (Fig. 7). At present, frozen *Babylonia* (Fig. 8) is exported to Thailand, Malaysia, and Indonesia whereas live ivory shells are exported to Persian Gulf countries (mainly UAE). Ironically very small specimens locally known as “Bajri Dana” consist of specimens having a size range of 300 to 500 pieces per kg or even smaller sizes (sizes less than 10 mm) are harvested and exported (Fig. 9).



Fig. 7. Grading of *Babylonia spirata* according to number of pieces per kg. Most common exportable sizes (a) 30-50 pieces per kg; (b) 50/80 pieces per kg.

## LANDINGS AND EXPORT

Harvesting and export of ivory shells (*Babylonia spirata*) was started in 1990's, however, because of small quantities being harvested, these were not reported in Government statistical data of fish landings till 2000 (Anonymous, 2011). The landing data of ivory shells from Pakistan indicates that it increased linearly between 2000 and 2022 (Fig. 10). The landing data for two Maritime Provinces (Sindh and Balochistan) was also recorded (Fig. 11). Although harvesting of *Babylonia spirata* was started a bit late in Gwadar, Balochistan in 1997, however, because of small quantities it was not reflected in the landings data till 2002. In the initial years, harvesting of *Babylonia spirata* was restricted to bays in Gwadar and Pasni.

The data indicates a steady increase between 2000 and 2012 when a major increase in landings was noticed in ivory shells landing in Balochistan. A major increase in landings of *Babylonia spirata* was observed since 2014 when seasonal and aimed fisheries for *Babylonia spirata* started in Sapat, Malan and Jiwani area. Almost the entire fleet of Malan and Sapat between October and March is engaged in trap fisheries for ivory shells whereas in Jiwani a major part of small boats are engaged in the harvesting of *Babylonia spirata*.



Fig. 8. Graded *Babylonia spirata* is backed in polyethylene bags before freezing and packaging.

Another major increase in the landings of *Babylonia spirata* was noticed in 2019 (Fig. 10-11) when landings in both Sindh and Balochistan increased substantially which is attributed to increased demand for ivory shells in the international markets. To meet this demand, fishing efforts in terms of the number of boats engaged in trap fishing were increased. Import of *Babylonia spirata* through traditional channels from Iran was started in Balochistan in 2020 which is evident from landings data for the years 2020 to 2022 (Fig. 11). It may be added that there is no local consumption of *Babylonia spirata* in Pakistan and all harvested ivory shells are exported in frozen and live forms. Export data for *Babylonia spirata* is not separately recorded and merged with other mollusk species including hard clams, blood clams, star shells (*Indothais lycera*) and razor clams.



Fig. 9. (a) Small sized *Babylonia spirata* (200/300 pieces per kg); (b) Small sized packaged.

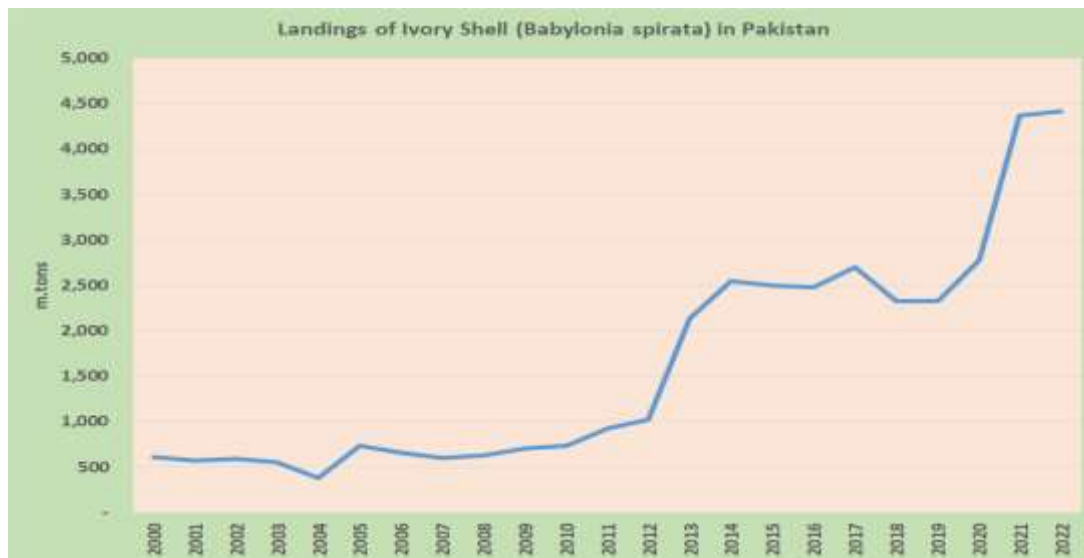


Fig. 10. Landings of the ivory shells (*Babylonia spirata*) from Pakistan coast.



Fig. 11. Landings of the ivory shells (*Babylonia spirata*) from Sindh and Balochistan coast.

### TRIAL FARMING OF IVORY SHELLS

Ivory shells (*Babylonia spirata*) are successfully being farmed in many South and Southeast Asian countries including India, Thailand, Indonesia Chaitanawisuti and Krisanapuntu (1997a, 1997b, and 1998), Chelladurai 2017). Chelladurai and Mohanraj (2014). Edwards *et al.* (2006), Fatoni, *et al.* (2020), Patterson *et al.* (1995a, 1995b), Rachmawati *et al.* (2012), Raghunathan *et al.* (1994), (Rejek and Susilowati 2011), Shanmugaraj *et al.* (1994) and Sreejaya *et al.* (2004). Some of these studies such as Sreejaya *et al.* (2004) have provided information about larval development of *Babylonia spirata* which can provide seed for farming of this important export commodity.

Considering the success of farming of *Babylonia spirata* in other countries preliminary experiments of farming this species were trialed in Pakistan. Live shells that were harvested from off the Indus Delta having a size range of 5 g were selected from “Bajri Dana” category (200-300 pieces per kg) and kept in depuration tanks having a size to 2.5 x 2.5 m with a constant flow of about 5 liter per minute of filtered seawater. A total of 300 shells were kept alive in this tank for 24 days. *Babylonia* shells were fed with 2 kg of meat of clam (*Marcia recens*) twice a day (10:00 AM and 05:00 PM). After keeping food for one hour, the remaining food was removed from the tank. After a period of 24 days shells have achieved an average weight of 15 g (range 14-20 g).

The trial aquaculture of ivory shells (*Babylonia spirata*) has shown promising results and it is planned that further experiments on ponds that were previously used for crab fattening will be used for farming of *Babylonia* shells. Additionally it is planned to undertake the pen culture of *Babylonia* for pen culture, as well. Patterson *et al.* (1995a) have provided detailed information about pen culture of *Babylonia spirata* which can be practiced on a commercial scale in Pakistan and other countries. Rejek and Susilowati (2011) have used abandoned brackish water farms for the culture of ivory shells.

## CONCLUSION

Although a number of species of ivory shells belonging to the genus *Babylonia* were recorded from Pakistan, however, there is overwhelming evidence that all records belong to *B. spirata* Linnaeus 1785 and have wrongly been attributed to other species. *Babylonia spirata*, is sold mainly in frozen as seafood worldwide; mainly in India, Sri Lanka, Thailand, Malaysia, China, Taiwan, and Japan (Fraussen and Stratmann, 2013; Tan and Low, 2013). Harvesting of ivory shells is now an important part of small-scale fisheries of Pakistan which is mainly practiced in and along the Indus Delta and major muddy cum sandy habitats along Karachi, Sonmiani Bay, Pasni, Gwadar, and Gwater Bay (Jiwani). It is estimated that about 40,000 fishermen are engaged in the trap fishery for this shell. It has been observed that due to an uncontrolled increase in fishing efforts, the stocks of this species are overexploited which is evident from major changes in sizes of the harvested shells. Large-sized shells (U/10 and 20/30 pieces per kg) have almost disappeared from commercial harvesting whereas very small-sized shells ("Bajri Dana" consist of specimens having a size range of 300 to 500 pieces per kg) or even smaller sizes also form an important part of commercial landings. The need for development and implementation of a management regime for this fishery is immediately and essentially required.

There is no information available about the oceanographic conditions associated with the distribution and abundance of *Babylonia spirata* along the Pakistan coast. Erfanifar, *et al.* (2023) observed that along the Iranian coast, nutrients play an important role in the density of ivory shells. They noted that with the increase of nutrients, the density of *Babylonia spirata* increases with a sharp peak and reaches the maximum in October and November, and after that, with the decrease of food, the density decreases. They also noted that multiple linear regression analysis indicates that the nitrite was highly related to the catch per unit effort of the *Babylonia spirata* in Iranian waters. No similar studies were carried out along the Pakistan coast. There is a need to study the fisheries potential, stock assessment, and catch per unit effort (CPUE) of *Babylonia* and other mollusks in Pakistan and its relationship with oceanographic and related biological factors.

A preliminary study on maintaining *Babylonia* shells in tanks in Pakistan indicates their immense potential of farming in Pakistan. Attempts may be made to develop its seed production locally to meet the anticipated demands of cultivable juveniles. Seed production techniques for farming of *Babylonia spirata* have already been developed (Shanmugaraj *et al.*, 1994; Sreejaya, *et al.*, 2004). In addition, the fattening of small-sized ivory shells locally known as "Bajri Dana" category (200-300 and 300-500 pieces per kg) can also be started in pond and pen farms including in the abandoned shrimp and crab fattening ponds along Sindh coast.

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