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Baked blue mussels are sold on food carts in shopping malls across Turkey

Biology and Culture of Philippine MUSSELS

Ashley D. Salinas and Westly R. Rosario



National Integrated Fisheries technology Development Center

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Issues related to mussels

As mussels offer a number of benefits, like other shellfishes such they are confronted with some health and environmental issues which needs to be addressed.

Shellfish Poisoning

As filter feeders, mussels can accumulate toxic substances such as heavy metals, bacteria, viruses and excessive dinoflagellates (during red tide) present in the aquatic environment they inhabit. The expansion of aquaculture and shellfish consumption along coastal regions makes shellfish poisoning an increasing concern for public health management. The Bureau of Fisheries and Aquatic Resources, in coordination with national government agencies and local government units, conducts

Sites with harmful algal blooms in the Philippines

regular monitoring of red tide phenomenon in critical areas of the country and disseminates red tide updates and bulletins to ensure public safety and protection of seafood consumers.

Ecological invasion

Introduction and rapid reproduction of invasive species can cause serious ecosystem imbalances. These species can outcompete other economically important species for living space and food resources. However, their unwanted proliferation is also controlled by environmental fluctuations like changes in water salinity and temperature in an area (i.e. invasive Charru mussels die at 35 ppt in an experiment conducted in NIFTDC).

Some species tend to be fouling organisms attached different important industrial structures like piers, boat, docks, and ship hulls.

Mussel can be harvested after four months of culture period or until the desired size for market is attained. Marketable size mussels can be selected for market. Undersized mussels are placed in baskets and returned to the growing area until they reach the marketable size.



Market

Mussels are placed in sacks and brought fresh to the market. The market of this bivalve includes household consumers and food processors. Mussels are also a potential export product when dried.



They are usually sold by mussel farmers to middlemen who distribute them fresh to retailers or consumers. The market price can have seasonal fluctuations due to availability. Prices also vary between regions. Luzon which has a moderate mussel production, markets at a higher price. Whereas, in the Visayas where the production is highest, the price of mussels is comparatively low (Duncan & Andalecio, 2009)

The mussel industry when properly developed can support local coastal communities in terms of food supply and livelihood opportunities, therefore enhancing inclusive growth in the national economy.

NATIONAL SHELLFISH DEVELOPMENT PROGRAM MANUAL NO. 1
FEBRUARY 2016

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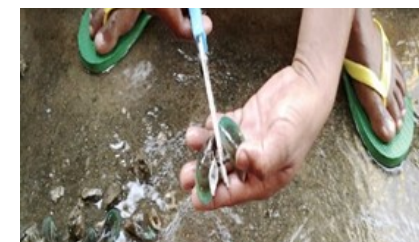
The Authors

C. Binding and deployment of mussel seedlings

Mussels can be transplanted in production areas by the following procedure:



Collecting of mussel seeds



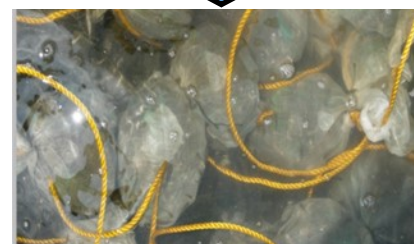
Cutting of byssal threads



Binding of mussel seeds using cotton



Mussel seeds ready for binding



Mussel seeds wrapped with cotton gauge



Transfer of mussel seeds to the grow-out area

B. Seed collection and culture

The materials commonly used by mussel farmers as seed collectors and attachment materials are lattice, tulos, rubber and plastic strips, old nets and oyster shells. However, rubber strips are not recommended due to issues on human health. Mussel spats are also found to attach to mussel shells. Any potential and readily available hard and rough materials where mussel seeds can attach on, can be used by farmers as seed collectors.

The collectors with seeded mussels are transferred to growing areas where culture is done in four to five months.



Oyster Shells



Bamboo Tulos



Bamboo Lattice



Rubber Strips



Plastic Strips



Old nets

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What are Mussels?

Mussels are one of among the many invertebrates belonging to Class Bivalvia under Phylum Mollusca. Their wide range of distribution across the globe makes them one of the most easily gathered seafood organisms making them a potential aquaculture commodity. This bivalve signifies a high quality food resource, either harvested from the wild or cultivated in farms and have been a subject of great interest in recent years due to their increasing commercial importance.

The longest history of mussel culture was dated far back in 1235 in France (bardach et. Al., 1972) while Spain is the known top producer of farmed mussels. Meanwhile, mussels were initially considered as a fouling organisms in oyster farming in the Philippines. Mussels farming has been widespread in the different regions of the country. In the Western Visayas, it started as early as in 1950s (Samonte, 1992) while Binakayan, Cavite was recorded to have started in 1962, (Aypa, 1980). Some of the other highest mussel producing areas of the country recorded by BAS are Pangasinan, Bulacan, Negros Occidental, Iloilo, Capiz and Aklan.

There are three native mytilids known in the Philippines namely *Perna viridis* (green-lipped mussel), *Modiolus philippinarum* and *Modiolus moduloides* (both known as brown mussels). Until recently, as Western Hemisphere blue mussels, *Mytella charruana* (Charu mussel) was discovered to have been unintentionally introduced and populate some areas of the Northern Philippines (bowman, Rawson, Rice, & Rosario, 2015).



The following are done to determine the suitability of the area for mussel culture and the ideal spat collection period for mussel farmers:



Measure water salinity using refractometer (left) and the temperature using thermometer (right).



Measure plankton density using plankton net



Plankton identification using microscope (left); and larvae count using profile projector (right)

Abundance of plankton and larvae are assessed from the water samples to determine its availability and quantity in the culture site.

Steps in mussel farming

Steps in mussel farming include spatfall monitoring and forecasting, seed collection, binding and deployment for grow-out up to marketable size.

A. Spatfall monitoring and forecasting

Spatfall monitoring is done to determine spatial and seasonal abundance of mussel seeds. Such information can be used to forecast the abundance of spats and the proper time for collection.



Retrieval of monitoring string from the site (left); and counting of spats in the laboratory using a stereomicroscope (right).

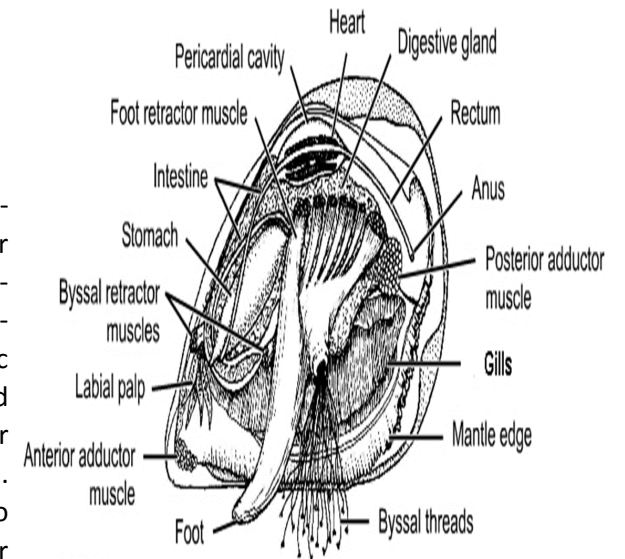
Clean and dried oyster or scallop shells are used as monitoring string collectors deployed in the target culture sites. They are retrieved every three days to identify and count the attached spats. The procedure helps in identifying the right time of deploying grow-out collectors to avoid attachment of fouling organisms. When ten mussel spats are attached on each shell of the monitoring string, the quantity of spats may be suitable for good growth.

Biology of Mussels

Mussels are bivalve mollusks with an elongated and asymmetrical shell outline. They are known to exist in bays, coves and inlets where they grow best in brackish to salty waters, with salinity ranging from 27-35 ppt (varies between species). In an experiment conducted by A. Salinas (unpublished), it showed that Charru mussels can survive from 2 to 30 ppt but are already unable to develop byssus and dies when subjected at 35 ppt. They reach their sexual maturity during the first year and they spawn year-round having a peak period which ranges from May-June and September-October (Aypa, 1990). However, having an opportunistic type of gonadal cycle, this can vary depending on the fluctuations in the environment (e.g. temperature, food availability) which can trigger the spawning of bivalves.

Basic anatomy

The anatomy of mussel is relatively similar to other bivalves. One of their distinguishing feature is the presence of strong and elastic thread-like structure called byssus which they use for attachment in hard substrates. They have a distinct ability to detach their byssus from their initial substrate and transfer to a more preferable and convenient environment. External morphology of mussels vary from species and to their respective habitats.



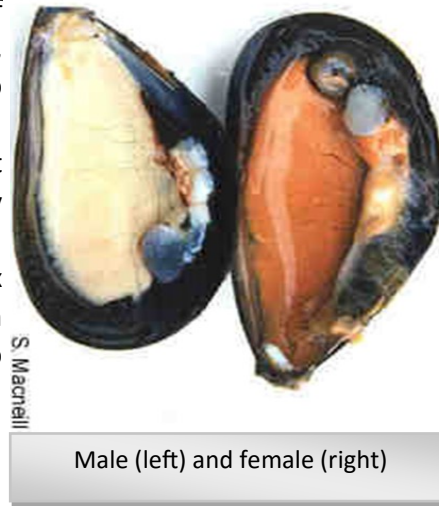
Source: © BIODIDAC

General anatomy of mussels

Sexual dimorphism

Mussels are dioecious organisms having separate sexes although hermaphroditism can occur. The meat and gonad tissue of a sexually mature fe-

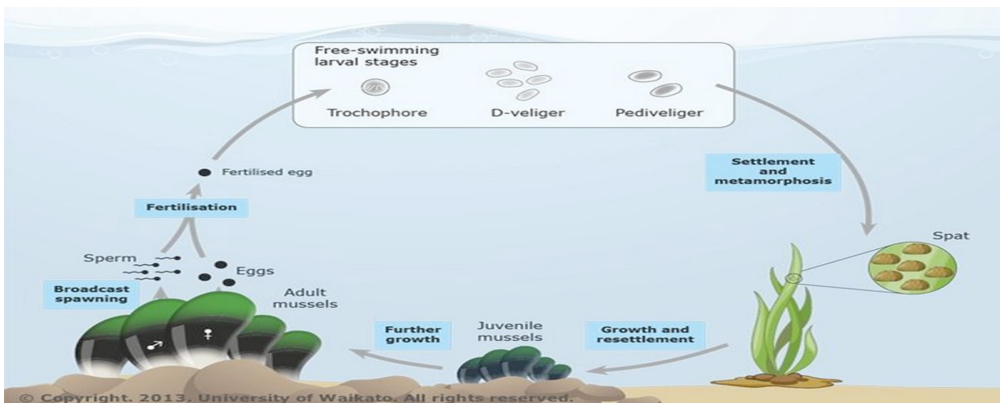
male appears reddish-apricot while that of the female appears creamy white. However, sexually immature individuals can be hard to be distinguished from each other. In Charru mussels, it was determined in a study that the minimum size (shell length) of sexually reproductive mussels is 1.25 cm (Stenyakina, Walters, Hoffman, & Calestani, 2010). Sex reversal from female to male may happen when the mussel population is exposed to starvation.



Male (left) and female (right)

Life Cycle

Generally, mussels have two distinct phases in their life cycles: free swimming planktonic larvae & sessile adult. External fertilization takes place and the fertilized eggs develop into a free swimming larvae. After 2-5 weeks from fertilization, the larvae (about 0.5mm) starts to form byssus in preparation to settlement to hard substrates as a spat where their final metamorphosis takes place. They can resettle by detaching their byssus and by mucus drifting. Further growth occurs until they reach their maximum size as adult mussels. The shell color deepens overtime as they grow old and reach sexual maturity from about one year when they start spawning to start the cycle again.



Culture and grow-out

Mussel farming does not require highly sophisticated techniques. However, its success greatly depends on the culture site, food availability and other pre-requisites.

Site selection

- ◆ Well-protected areas
- ◆ Presence of mussel spats
- ◆ Absent or minimum predators
- ◆ Accessible
- ◆ Salinity: 27-35 ppt (green-lipped mussels); 2-30 ppt (Charru blue mussels)
- ◆ Temperature: 27-30 degrees Celcius
- ◆ Bottom: mixture of sand & mud (and non-shifting)

Different culture methods

Traditional methods

1. Tulos
2. Plot-hanging



Modern Methods

1. Raft
2. Long line
3. Basket



Yellow banded Horse Mussel (*Modiolus metcalfei*)

Description: Roughly triangular and elongated to ovate shell outline with only fine concentric growth marks with unbranched periostracum hairs; dull olive-brown periostracum with a median yellowish radial band and a pearly, pale grayish blue shell interior.

Geographical Distribution: Indo-West Pacific Region: from East Africa to Philippines and north to Japan and south to Indonesia

Climate Range: Tropical

Habitat: Usually attached to pebbles or mangrove roots or in muddy bottoms of sheltered bays; littoral and sub littoral to a depth of 25 m

Size: Can reach up to 80 mm; common size: 60 mm

Economic Importance: Gathered for human consumption



Charru Mussel/ Western Hemisphere Blue Mussel (*Mytella charruana*)

Description: Dark brown to bluish black external shell with semicircular rings with a wavy dark (brown, purple, dark green) pattern; and an iridescent purple interior shell

Geographical Distribution: Pacific/ Atlantic Central and South America; from Guaymas, Mexico to Ecuador and lately in the Philippines (Pangasinan)

Climate Range: Tropical and Sub-tropical

Habitat: Usually found in natural hard submerged and intertidal surfaces and prefers shallow lagoons and mudflats in bays; can thrive in a wide range of salinity; Test conducted by the author in Dagupan City, Philippines, showed that the species can survive salinity shock from 5 ppt to 30 ppt.

Size: Can reach up to 60 mm; common size: 20 mm

Economic Importance: Gathered for human consumption in some areas in the Philippines and are potential invasive species.



Feeding behavior

Mussels are filter feeders like other bivalves. They can take up various organic and inorganic particles from the water serving like tiny water filtration systems in an aquatic ecosystem. Their main food are phytoplankton, specifically diatoms such as *Chaetoceros* and *Isochrysis galbana*. These plankton as well as oxygen are trapped and extracted through pumping of water over mussels' gills and are transported to their mouth for feeding. It has been studied that a mussel can filter between two to five liters of water per hour, i.e. 90,000 liters per day for one rope full of mussels. A

raft of mussels can filter 70,000 m³ per day (Nunes and Parsons, 1998).

Nutritional Benefits (Mussel Facts & Health Benefits, 2016)

Being nutritious and versatile in many kitchen recipes, mussels have been considered as one of the nutrient-dense seafood choice worldwide. Some of its nutritional benefits are the following:

1. Low calorie content
2. Excellent source of Omega 3 Fatty Acids for lowering bad cholesterol
3. Selenium (anti-oxidant compound)
4. Iodine (for natural production of thyroid hormones)
5. Carbohydrates
6. High quality protein
7. Vitamin B12 (for red blood cell production)
8. Manganese (part of enzymatic functions, bone formation and metabolizing energy from food)
9. Vitamin C (for better absorption of iron)
10. Iron (essential part of hemoglobin and supports immune system)

Baked Mussels

Economic Use

Mussels have long been one of aquatic organisms to provide copious benefits to human, animals and the environment.

Food Consumption

Mussels, like other bivalves are excellent sources of various vitamins, minerals and other substances beneficial to human health. They have been consumed for millennia and are one of potential aquaculture commodities around the world. Mussels can be baked, smoked, roasted, boiled, steam, barbecued or fried in butter or vegetable oils and added to almost any recipe for protein source.

Moules au Safran/ Steamed New Zealand mussels in Vikings, Pasay City, Philippines

Handicrafts making

As pearl production becomes an important industry in many countries, mussel shells are used to produce beads that are implanted into marine pearl oysters. Their shells can also be used as ornamental objects in homes.

'Mussel Shell Flowers'

Animal Feeds

Mussels can be utilized as animal feeds or additives. The mussel meal for poultry includes the chopped whole mussel (meat and shell) portion mixed with azolla or rice bran. The chopped mussels are rich in protein and other minerals and can be a replacement for fish meal. The shells are good source of calcium needed in the production of poultry eggs. Mussels can also serve as supplemental feeds for crustaceans such as crabs, freshwater and Brackishwater shrimps.

Chopped blue mussels mixed with azolla fed to ducks

Philippine mussel species

There are four mytilids known in the Philippines. The considered indigenous species are *Perna viridis*, *Modiolus philippinarum* and *Modiolus metcalfei*. Recently, an exotic mussel unintentionally introduced and populate the Philippine waters, was identified (Rice, et al., 2015, unpublished abstract).

Green-lipped/Asian Green Mussel **(*Perna viridis*)**

Description: Smooth and elongated shell (ends in a downward-pointing beak) with vivid green to dark brownish-green periostracum and pearly white to iridescent blue internal shell valves.

Geographical Distribution: Indo-Pacific region across the Indian and southern Asian coastal regions extending from Japan to New Guinea and from Persian Gulf to South Pacific Islands.

Climate Range: Tropical

Habitat: Coastal regions at depths less than 10 m and are commonly found in intertidal, subtidal and estuarine habitats with salinity ranging from 18-33 ppt and a temperature from 10-35 deg. C

Size: Can reach up to 165 mm

Economic Importance: Farmed and harvested as a food source.



Philippine Horse Mussel **(*Modiolus philippinarum*)**

Description: Elongated to ovate thin shell with smooth yellowish brown periostracum and numerous concentric growth marks

Geographical Distribution: Indo-Pacific region from eastern Africa to eastern Indonesia, north to Japan and south to Australia

Climate Range: Tropical

Habitat: Thrives in benthic region along muddy substrates or mudflats; littoral and sub littoral to a depth of 40 m.

Size: Can reach up to 130 mm; common size is about 80 mm

Economic Importance: Simply gathered for human consumption

