

An Aquarist's Comprehensive Guide to Octopus Husbandry: For Small Scale Aquaristry

by

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Abstract

Octopuses are complex animals with whom humans have the privilege of interacting. They are unique organisms which are inspiringly intelligent. Escaping even the most well-secured tanks, solving puzzles, and using tools to find food are some of the specialties of octopuses. However, they are also delicate and sensitive creatures requiring the best care. Octopuses have idiosyncratic personalities, can identify their keepers, and bond with the people who care for them. They use mentally stimulating toys and puzzles. These exercise their mental capacity and keep them happy in their enclosure. When keeping an octopus, it's critical to follow proper aquarium guidelines for tank setup and maintenance. This includes feeding not only their bodies but their minds.

Introduction

To care for an octopus, whether for research, education, or personal enjoyment, it is best practice to learn as much as possible about the unique needs of this animal. Octopuses have complex anatomy and distinctive personalities. Knowing about the species, understanding their needs, and connecting with their personality will enable best care.

Octopuses are devilishly intelligent which makes them excellent escape artists (Asad et. al. 2021). Giant Pacific Octopuses (GPOs), for example, are commonly found in aquariums around the world. GPOs have the longest lifespan of any octopus species (3-5 years) and are the largest species, averaging 16 feet and 132 pounds. They are a spectacle in aquariums which makes them advantageous to display, but these octopuses are mischievous and can be hard to keep. Aquarium technicians all over the world tell versions of the same story when octopuses have escaped their tank at night, migrated to other populated tanks to feed, then returned to their tank by morning. This shows that the octopus can not only figure out how to escape its tank and get into others, but they can also determine when to travel and when to return, keeping their activity hidden from their keeper.

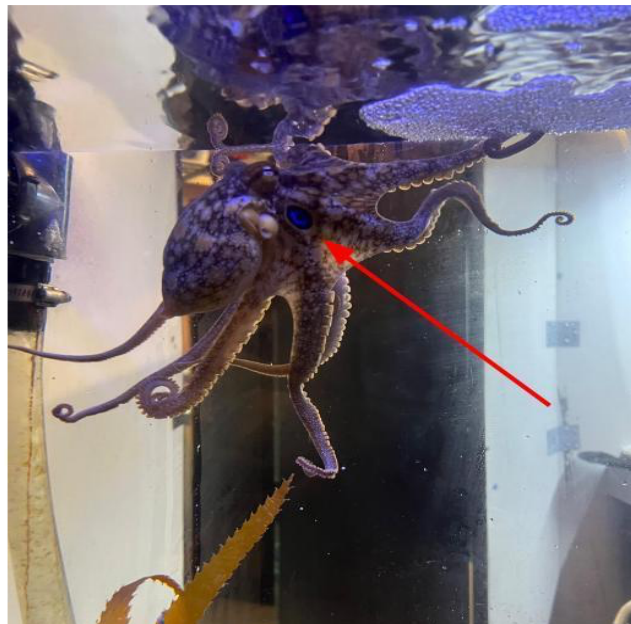
Octopus and vertebrate anatomy share few features. Octopuses are in the phylum Mollusca along with oysters, snails and chitons. However, these impressive animals share few traits with the other species in this phylum. Like most mollusks, octopuses have a mantle and a muscular foot, or in this case several muscular tentacles. Ancestors of octopuses even had a shell, but in modern species it was lost through the process of evolution (Amodio, 2019). Their eight muscular tentacles move independently due to the use of neural networks. Octopuses have a brain and eight neural networks that each control a tentacle. Each tentacle consists of a central nerve cord, branching to smaller nerve cords and ganglia in each sucker. These can send signals to and from the central nerve cord. With these anatomical features, octopuses can complete complex functions, such as opening sealed bottles and snatching prey that swims by. Male octopuses have a specialized hemocotyle tentacle without suckers at the tip, called a hectocotylus. This tentacle is used for the insemination of a female. It will place the spermatophore packets from their hemocotyle tentacle in the female during the mating season. Octopuses also have three hearts and blue blood. Two peripheral hearts work in tandem to pump blood through the gills, then the systematic heart pumps the oxygenated blood through the rest of the body. The octopuses' pale blue blood color is due to hemocyanin (Schweid, 2013). Hemocyanin is a protein that contains copper, unlike the blood of mammals which has hemoglobin containing iron.

This paper outlines the best practices and guidelines for taking care of octopuses, including a review of permits needed for collection, options for purchasing an octopus, how to cater to their specific personalities, and how to adjust care over their life span. These guidelines are directed toward the hobbyist or small scale aquarist. These practices may differ for larger aquariums and research facilities.

California Species

The most common octopus on the California coast is the two-spot octopus, *Octopus bimaculoides* (commonly referred to as “bimac”). They can be found along the Pacific Coast from Washington to Baja California, Mexico. Bimacs are often found in rocky reef tide pools during low tide. These octopuses are challenging to spot, blending into the rock and substrate around them. Bimacs are small and yellowish brown with two blue spots, or rings, on either side of their mantle. They are a small species of octopus, ranging from 1½ inches to 18 inches. Like most octopus species, the bimac can change its coloring from yellow to a medium brown, deep red, or greenish gray, using a specialized skin cell called a chromatophore. It can also raise its skin to form bumps and spikes, enabling it to appear larger and predatory. Bimac octopuses are a short-lived species usually living 1½ to 2 years, and maturing after 1 year. As a semelparous species, they only reproduce once, followed by the onset of senescence soon after reproduction and accelerating their death.

Fig 1. This image shows a healthy and full-grown *Octopus bimaculoides*.



It is easily identified by the round and smooth blue rings seen on either side of its mantle.

Another slightly less commonly found species on the Pacific Coast is *Octopus bimaculatus*, also known as the Verill's Two-spot Octopus. This species is similar to the two-spot octopus, except the ocelli (a "fake eye" for camouflaging as a larger species) has a more pointed pattern to the bimac's smooth circular patterns. Apart from the different ocelli, these species are similar and difficult to distinguish in live sightings.

Catching Octopus

Catching octopuses is not a simple task. They are speedy and hard to see because of their camouflaging ability. The most accessible way to collect octopuses is by tide pooling. Tide pooling is best done at low tide. In the summer, that is in the early morning, and during the winter, in the afternoon. Supplies include: containers for the captured octopus, flashlights, gloves (sometimes octopus bite), and clothes that can get wet. A common method is to wade into tide pools and flip over rocks. It is crucial to not disturb the habitat more than necessary and put everything back the way it was found. Check the bottom of the overturned rocks as sometimes octopuses cling to the rock when it is lifted. Look amongst seaweed and debris for camouflaged animals. Watch for remnants of a meal, cracked shells, and shells with small drilled holes made with their radula. Other methods of catching octopuses include snorkeling/scuba diving to search small caves and nooks, as well as putting bait in jars and tying them off piers. The former method can be very difficult as octopuses are agile and fast in the water. The latter method involves a lot of waiting around on the pier.

Securing the proper permits are essential before removing animals from the wild. For example, in California, it is only legal to remove invertebrates, including octopuses, from tide pools with a basic fishing permit, except within coastal zones with specific restrictions.¹ It is illegal to

¹ For specific laws in California, check wildlife.ca.gov, or the equivalent in your state or country.

remove invertebrates from marine reserves. Also, make sure to check the “bag limit” for the number of invertebrates you are allowed to remove during one trip. Regulations vary by state and region.

Buying From Breeders

Octopuses can be purchased from breeders and pet stores when looking for a specific non-local species or a particular age/size.² Octopuses are not a beginner-friendly aquatic pet. They have specific needs, can be temperamental, and sensitive. Research the species you plan to purchase. Some octopus species are well known for their color patterns and are sought by hobbyists, however, these species can be deadly. The blue-ring octopus is one of the most brilliantly patterned octopuses, with vibrant blue rings across its mantle and tentacles, but this species has a potent venom. Death can ensue quickly making this not a suitable pet (Asakawa et. al, 2019).



Fig. 2 The blue-ring octopus, *Hapalochlaena lunulata*, is one of the most venomous animals. Native to the Indo-Pacific, from Australia to Japan, spanning only 12 centimeters, it keeps to the shallow water no deeper than 20 meters deep.

² Before you buy from a pet store, or breeder, evaluate their methods and practices to ensure you are buying from an ethical and sustainable supplier, and to make sure the animals are healthy.

Handling

Octopuses are curious creatures. They can create long-lasting bonds with their handlers, but also remember traumatic events and therefore require careful handling. Octopuses have taste buds in their suckers, as they touch a person or object they are also tasting them and memorizing the individual (Walker et. al, 1970). Start by reaching out a finger so the octopus can touch you with their tentacle. They may then grab onto your hand or arm. Caution should be taken as octopuses can bite when frightened, but it is uncommon with large species although they may squirt jets of water. Unless you are a professional, it is best not to allow the animal to engulf your hand or arm. Once acquainted with the animal, be gentle and remember that as you are studying the animal it is studying you.

Transportation

Transporting an octopus can be challenging depending on the length of the journey. Steps should be taken to ensure safe travel before collection. For short trips, under an hour, they can be kept in small collection containers and put in a cooler. Make sure everything is properly sealed and add a few inches of sea water to the cooler in case the animal escapes the first container. Long distance travel poses challenges. The water can quickly become anoxic if it is not being refreshed and too much waste accumulates in the water. Octopuses are also sensitive to temperature changes (Prescott JH and Brosseau C, 1963). For longer distances, it is recommended to have the animals in tanks with both temperature and aeration controls. A study on long-distance octopus transportation showed positive results and low-stress responses to octopuses kept at 10°C after decreasing temperature from their ambient temperature by 1 degree Celsius an hour. However, this study

showed that this method increased the ammonia level in the tank, but with the addition of an airstone for aeration it stayed at a safe level. (Araújo et. al. 2020).³

Aquarium Set Up

Proper aquarium set up is important for the animal's quality of life. The tank should have an aeration system. Usually, this is a pump that rests in the tank, filtering water and infusing oxygen. Research facilities may be able to use seawater hoses instead, but it is always good procedure to add an airstone for circulation and aeration. The substrate should not have sharp edges as octopuses have delicate skin. Some culturists opt out of a substrate because it is harder to clean and maintain. A mixture of sand and larger smooth rocks will mimic a California habitat and allow for enrichment and provide a hiding space.

Octopuses are crazy escape artists, but there are a few things that can be done to keep them contained. Completely cover the top of the tank with a plastic cover that leaves no gaps and overlaps the edges of the tank, if possible. Either latch this cover down or place a heavy object like a brick on the cover. Octopuses can squeeze through any crack they can get their beak through because that is the only hard structure in their body. This means even a seemingly small crack can lead to an escape. Octopuses strongly dislike astroturf (Wood and Anderson, 2004). Using this to rim the top few inches of the tank will stop the octopus from feeling around the top of the tank for a crack. If feeding salt water tubes into your tanks from a salt water piping system, cover the remaining gaps with mesh to prevent escape.

³ There is research done on anesthetizing octopus before transport, but I will not go into the controversies and challenges concerning that method.



Fig 3. This figure shows 2 different methods of covering tanks to make them “escape-proof”. The first method shows one plastic cover over most of the tank with a 2-inch gap for adding food, which is then covered by a glass panel. Two corners of the tank are held down with bricks and a mesh covering is used where the saltwater hose enters the system. The second method shows one plastic covering with a small hole for the saltwater hose, covered by two smaller plastic coverings held down by a brick. Both methods are suitable but an additional inch of astroturf along the inside of the tank would make it much harder for an octopus to escape.

Physiological Needs

In the wild, octopuses hunt mollusks and crustaceans including crabs, shrimp, clams, scallops, and snails (Ambrose, 1984). The larger species will occasionally catch fish. In captivity, they can be fed frozen shrimp or pieces of fish (that have been thawed), which are easy to source and adequately nutritious. However, I recommend that shelled organisms are supplemented. These provide exercise and enrichment for the octopus. If feeding live crabs, ensure they are small compared to the octopus and remove the pincer claws so that the octopus is not injured. Buy human quality seafood to lessen the likelihood of toxicity in the diet. Octopuses especially enjoy mussels, collected from docks and underwater structures. Either freeze the mussels or keep them in a separate aquarium. Having a diversity of food options for the octopus will help keep them enriched and will provide them with the nutrients needed to stay strong and healthy.



Fig 4. This image shows a Two-spot Octopus attacking a clam. It will engulf it with its tentacles then use its radula to drill a small hole in the shell where it will suck out the meat of the animal.

It is helpful to have an automatic/timed light for your tank. Studies done with the Northern Octopus, *Eledone cirrhosa*, have shown that octopuses have similar circadian rhythms to humans. A 12hr light-dark cycle allows them to have a “nocturnal pattern of activity under a light-dark cycle” (Cobb et. al, 1995). In that study octopuses were “inactive” during light hours with brief periods of being “alert.” They emerged to hunt and play during the dark hours. This mimics the natural habitat of octopuses but can be difficult for aquarists who may want more alertness during daylight hours.

Keeping the water quality stable is necessary for maintaining a healthy habitat for the animal. Water quality levels should be tested biweekly and recorded so that trends can be analyzed and adjusted as needed. Easy to use and effective testing kits are available online. Record and test for: salinity, ammonia, nitrate, nitrite, pH, and temperature. Good numbers for water quality levels are: pH 7.4, Salinity 36 ppt, Ammonia $< 0.1 \text{ mg.l}^{-1}$, Nitrate 50 mg.l^{-1} , Nitrite $< 0.1 \text{ mg.l}^{-1}$, Temperature 14-15°C (Boyle, P.R, 1981). These levels will differ for octopus species from warmer areas.⁴ Water quality may change based on the amount of waste in the tank. Ammonia levels can build quickly if the tank

⁴ The octopus used in this study is native to British waters and therefore likes a colder temperature than tropical or California species.

has not been cleaned and is not properly circulating. This can be deadly for the animal. Any ammonia reading above 0.25 ppm should be remediated immediately.

Behavior

Octopuses have distinctive personalities once comfortable and relaxed. They can be shy at first, but after a period of adjustment, they become curious and creative with differing temperaments. Octopuses can make strong bonds with their caregivers. Aquarium workers have commented that an octopus can distinguish between different caregivers and remember which caregivers they can play rough with and which ones are not as strong or steady and prefer gentle playing.⁵ Octopuses have been known to jet water at caregivers who they don't like, or with whom they are playing. Smaller octopus species tend to be more hesitant than larger species. Smaller species can be feisty and guarded whereas larger species tend to be more immediately trusting, however, this does not stand for all species and is a general observation.

It was previously thought that octopuses were solitary species that fought for territory with other individuals, but new research and deep-sea footage shows octopuses congregating in large groups. Very little research has been published regarding socializing octopuses. However, one paper shows that both female and male bimac octopuses will choose to spend time in a tank with a female octopus of the same species over a male octopus and over an empty tank with a random object (Gutnick T. and Kuba M.J, 2018). This research does not mean you should plan on keeping more than one octopus in a tank, that could cause too much stress to the animals. The octopuses may fight with one another if kept in the same tank. In this instance, it is an example of how octopus behavior is more complex than previously believed.

⁵ While visiting the Oregon Coast Aquarium, an Aquarist on staff told me octopus play differently with each keeper based on the keeper's strength and personality.

Enrichment

Providing an octopus with enrichment activities will boost their engagement and make them happier and healthier. Some recommendations include plastic boats, houses, boxes, puzzles, increased water flow, and live food (Cooke et al., 2019). Octopuses given enriched environments with toys have been recorded as being more exploratory and curious than were octopuses without enrichment (Yasumuro H and Ikeda Y, 2011).

Aquarist Mark Rehling at the Cleveland Metroparks Zoo experimented with different enrichment toys with an *Octopus dofleini*. He found that leaving food/prey in a sealed clear glass jar was very effective. The octopus could see the food and was able to twist open the jar after several attempts with increased difficulty, starting with no lid and advancing to a lightly closed lid, then a tightly closed lid. Other toys, including a hamster ball, a tube with several compartments, a rotating compartment cylinder, and a hamster-style maze, were very effective and well-received. Rehling explained that the octopus became eager for toys and challenges, and became harder to stump.

Senescence

When an octopus reaches the end of its life and goes into senescence, drastic changes in its appearance and behavior will start to appear. Senescence is an indication that the octopus is nearing the end of its life, having just a few weeks to a few months to live. This life phase can often cause rapid death, normally occurring after or during brooding for females and after the release of all spermatophores in males. Senescence sets in at full sexual maturity but does not show symptoms until after mating. It begins with secretions from the optic gland, leading to maturation of the reproductive organs (Cooke et. al., 2019). These fluids cause inactivation of digestive glands and can interfere with the immune system, causing the animal to become more susceptible to illness and

parasites (Anderson et al., 2002). Senescence is characterized by a malabsorption syndrome (the reduced capacity to absorb nutrients), loss of appetite, retraction of the skin around the eye, undirected or uncoordinated activity, and chronic white lesions on the skin. It is common for octopuses in senescence to die from predation due to their increased uncoordinated activity which makes them easy for predators to locate and capture. Octopuses will also reduce or completely stop feeding. They start to metabolize their own body for fuel, causing them to dramatically shrink in size, becoming a gray color. When symptoms of senescence first appear, it is best to reduce activity and monitor them closely. Octopuses that are being exhibited should be removed from the public, or from active studies that do not include evaluation of senescence. The octopus will be quiescent and melancholy during this period, experiencing a few bursts of uncoordinated movement, such that they may bump into things. This is the end for the octopus, be gentle with them. Reduce feeding at the previous frequency and be slow and steady when cleaning or handling them. Watch for lesions that may appear and remove hazards from the tank. Take note of the symptoms as they arrive to better evaluate time to death.

Discussion

Octopuses are an amazing animal to keep as an exhibit or as a pet. They have specific needs including proper feeding, tank maintenance, enrichment, and senescent care. Given proper research and husbandry practices, they can thrive in captivity. These animals are astonishingly intelligent and can make lifelong bonds with their caregivers. Many aquarists comment on the relationships they have made with larger octopus species like the Giant Pacific Octopus, including octopuses showing gratitude, dislike, love, and humility. Unfortunately, they live decidedly short lives for a species as perceptive as they are. The guidelines laid out here will enhance a caretaker's ability to maintain

octopuses. Owning and caring for an octopus will change a person's view of invertebrates.

Appreciating their intelligence can expand a greater appreciation for the complexities of animal life.

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