

LIFE HISTORY AND MANAGED CARE OF THE COCONUT CRAB (*Birgus latro*) AT THE SAN DIEGO ZOO

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INTRODUCTION

Coconut crabs are the largest land crabs on earth. They are sometimes referred to as robber crabs, because of their reputation for stealing items, some of which are not edible, and dragging them back to their burrows where they store them indefinitely. Only a few zoos around the world house these impressive crustaceans because they are rarely imported, require large enclosures and have tropical temperature and humidity requirements. To date, the San Diego Zoo's coconut crab is the largest crustacean maintained in the Spineless Marvels Insect House. This paper outlines some of the husbandry methods our Entomology Department has used to raise this species in captivity. Although coconut crabs are not recommended for hands-on educational outreach programs, they have proven to be a valuable addition to our invertebrate collection.

NATURAL HISTORY

Coconut crabs belong to the Crustacean family *Coenobitidae*, which contains only two genera, *Birgus* and *Coenobita*- both of which are well adapted to terrestrial environments. *Coenobita* contains many species, such as the typical hermit crab, while *Birgus* consists of only one species, *B. latro*, in which the adult stage has a somewhat calcified abdomen and does not inhabit a hard outer shell (Burggren and McMahon, 1988). They have two body parts, two sets of antennae and ten pairs of legs, with the front pair of legs being large claws. The fourth pair of legs has small tweezer-like claws at the end to aid in eating and climbing. The hind pair of legs is usually held inside the carapace. These crabs naturally occur throughout islands in the western Pacific and Indian oceans. Caroline Island holds one of the largest populations, while they are now extinct on the island of Mauritius. Since these crabs have a planktonic larval stage, like their hermit crab relative, it is assumed that they colonized separate islands by way of the ocean (S. Lavery; D.R. Fielder, 1991). Coconut crabs live in shallow burrows, which they build themselves, or they find empty tree hollows to reside in during the day. Burrows not only protect them from predators, but they also provide shade during the hot days, which helps reduce desiccation. They will live close to the sea, but some individuals have been found up to four miles inland (Gibson-Hill, 1947 - Burggren and McMahon, 1988). Although they will live in close proximity to one another, adult crabs prefer to be solitary.

These crabs live up to 70 years, can weigh up to 5 kg (11 lbs), have a body length of 40 cm (16 in), and grow up to 91 cm (3 ft) in length from leg to leg. Males will grow to be larger than females. Mature female crabs have pleopods (swimming limbs) on the left side of the abdomen, while male crabs do not (Wegmann, A. 2015). Mating takes place on land and lasts for a short period of time. Once a female has been fertilized by a male, she will release up to 138,000 eggs at sea, usually during spring tide. They hatch on contact with saltwater and will float as planktonic larvae for twenty to twenty three days (Helfman, G.S. 1977). They inhabit a protective shell for a short period of time while in the ocean, but after their first molt on land, they abandon the shell entirely. Since coconut crabs have adapted to a terrestrial life, they will drown if placed in water as adults. Adult crabs breathe using a branchiostegal lung, which can be described as the stage between gills and lungs and is the most significant adaptations to this species and its habitat (V. Storch; U. Welsch, 1984).

HOUSING AND ENVIRONMENTAL CONDITIONS

When our crab first arrived in early 2014 (Image 1), he was originally cared for by the zoo's Reptile Department and was affectionately named "Kenny," after one of his keepers. He weighed 1.183 kg (2.643 lbs) and his carapace was 10.16 (4 in) cm wide and 5.08 (2 in) cm in length. He was housed in a retired amphibian enclosure measuring 106.6W (42 in) x 147.3H (58 in) x 91.4D(36 in) cm, which provided the appropriate height needed for climbing, but had inadequate floor space for him to roam or build a suitable-sized burrow (Image 2). Another problem was that the enclosure was not tightly sealed and within a few weeks, American cockroaches found their way into the exhibit during the evening and consumed the crab's food. This made it difficult for keepers to assess and record what the crab was eating daily and also introduced the risk of the animal coming into contact with dangerous pesticides. So, after only a couple of months, the decision was made to relocate him to a larger exhibit in the Insect House.



Image 1



Image 2

This new enclosure measured 132W (52 in) x 114.3H (45 in) x 93.9D (37 in) cm and had a steel frame base and a plexi-glass, bow-front window, with a screened, plastic lid (Image 3).

Designed for either terrestrial or aquatic animals, this exhibit's base was hollow to serve as an area for a sump or for general storage. It was also equipped with a plastic misting head inside attached to the lid, which was connected to the facilities' reverse osmosis water system. A rear-hinged door allowed for access and maintenance from the off-exhibit USDA containment area of the building (Image 4). In the end, this enclosure proved to be a more suitable environment for the crab, which has since become a permanent part of the Entomology collection.



Image 3



Image 4

In preparing the enclosure for the crab, keepers partially filled the bottom with a mixture of play sand, two 40 lb bags of *Loamex* organic soil amendment mixed with coco peat (shredded coconut husk, formed into bricks that expand in water). Large logs were placed diagonally into the corners to serve as climbing structures. Various tropical plants and flowers, collected on zoo grounds, were provided to add to the aesthetics of the exhibit as well as additional enrichment for the crab.

Temperature in this exhibit ranged from 25° to 33° Celsius, depending on the time of the year. Humidity ranged from 45% to 80%. Acceptable ranges are 23° to 32° Celsius and 63% to 90% humidity. Misting a minimum of twice daily is required for this species. The amount of water used will depend on the size of the enclosure. Approximately one gallon of water a day was used for the 132W (52 in) x 114.3H (45 in) x 93.9D (37 in) cm exhibit.

The most important aspect of the exhibit is the burrow. Coconut crabs must have a burrow in order to feel secure in their environment. It not only serves as a hiding place when they require privacy, but it is also crucial for molting. Without a burrow, the crab may suffer from extreme stress and anxiety, which can result in death. A dome shape is preferable (similar to the shape of an empty tortoise shell), so the crab can dig out the substrate inside to create a comfortable resting area. Burrows can be made from plastic, wood or rock, just as long as it is can be sturdily set in place in an enclosure. Patience with this species is of the utmost importance, as they tend to remain in the burrow for weeks at a time. This may be a result of the molting process or simply because they instinctively seek shelter during the day.

Burrows can be covered or partially hidden in soil. The crab will move the substrate around and form the burrow to their particular specifications (Images 5 & 6). If the burrow entrance is sealed with soil, the crab is most likely molting (Image 7). A swollen abdomen, created by the accumulation of fluid and nutrients, is a sign that the crab is preparing to molt (W.J. Fletcher, I.W. Brown, D.R. Fielder, A. Obed 1989). Intake of salt water will also rise beforehand. During a molt, they require darkness and privacy, so they will seal themselves away in the burrow. Temperature and humidity levels in the burrow may increase during molting, since that area is temporarily sealed. Molting may take up to three months, but food and water can still be offered on a daily basis, in case the crab should exit during this time.

Burrow size: 76.2 (30 in) x 76.2 (30 in) cm with a 25.4 (10 in) cm opening, made from fake rock.



Image 5 (Photo: Susy Zanese)



Image 6 (Photo: Susy Zanese)



Image 7 (Photo: Susy Zanese)

Below is detailed documentation on our crab's first molt. Information was gained by puncturing the dirt of the burrow entrance with a portable drain inspection camera.

30 April 2014:	Sealed himself inside the burrow
8 June 2014:	Observed he was in the process of molting
12 June 2014:	Completely out of his old exoskeleton - had begun eating it
13 June 2014:	Molted exoskeleton was entirely eaten
20 June 2014:	Crab almost back to normal exoskeleton coloration
6 July 2014:	A mouse was placed in the burrow, but was not eaten
19 July 2014:	Overnight, crab removed the soil entrance to the burrow - exited and salt water was consumed
23 July 2014:	One mouse was partially eaten
26 July 2014:	Exited burrow - in public view for an entire day

Our crab molted twice in this exhibit, but soon exhibited behaviors that we interpreted as frustration. His activity was high on a daily basis. He constantly flipped over the water bowls, sometimes immediately after we filled them. He also began destroying the inside of the exhibit; digging up plants and pulling off plastic pieces of the exhibit that were permanently attached

(Images 8 & 9). During this time period, a small glass mammal exhibit became available in the main zoo near tigers, and Kenny found yet another home.



Image 8



Image 9

The crab was moved to this enclosure in August 2015 and still resides there. It is free standing and measures 3.65H (12 ft) x 1.98L (6.5 ft) x 2.59W(8.5 ft) m (Images 10-12). Filled with even larger logs and plants, this exhibit also provides a lower area for a sand and dirt beach, a small pond, and a ledge measuring 91.4H (36 in) cm, where the burrow resides (Images 13 & 14). The climbing structures are nailed together and into the ground for strength, while also providing perfect hanging spots for tropical plants. These wooden perching structures were cut down at the top to reduce the crab's access to the ceiling of the exhibit (Image 15). Electric fluorescent lighting is available, even though the exhibit has three sides of glass and a sky-light, which provides natural lighting during the day. The exhibit also features a built-in heating system controlled by a thermostat, and during colder months, a 1500-watt portable space heater can be placed outside of the caged keeper door, in the vestibule area, to provide additional heat. All lights and heating units are on timers, so keepers are not required to service the area before the zoo opens to the public. Temperature ranges from 25° to 32° Celsius and humidity ranges from 75% to 96%.



Image 10 [back]



Image 11 [front] (Photo: Ken Bohn)



Image 12 [front]



Image 13



Image 14



Image 15

It is important to think about the entire area of the enclosure when setting it up for a coconut crab. Because these crabs are curious, they will inspect as many areas as they can access. Also limiting higher areas will eliminate possible injury, should the crab climb too high and fall. Coconut crabs are excellent climbers, so they will attempt to go as high as an exhibit allows.

BEHAVIOR

Coconut crabs have the ability to walk forward and backwards quickly in order to escape danger. When threatened, adult crabs will lift one of their forelegs in what is called an ambulatory leg raise. They will hold the leg in the air for several seconds, or quickly bring it down, striking the ground (Helfman, G.S., 1977). This behavior will be seen before they attempt to pinch and they will do it quickly as a way to frighten away potential predators. Handling these crabs should be minimal in order to reduce stress. If any hands-on contact is needed, give the animal something to grab on to, so they are preoccupied. Handle them by gripping under the abdomen, away from the claws. A large tub or bucket with a lid is recommended if the animal needs to be transported or relocated (Image 16).



Image 16 (Photo: Ken Bohn)

DIET

Since these crabs are scavengers, and 40% of their brain is used for smell, we offered ours a variety of foods. Suggestions from colleagues from the originating institution, field observations and scientific studies were also used. Different fruits, vegetables, and cuttlebone are offered daily. Both fresh and salt water are available 24 hours a day. We detoxify the tap water with Kordon AmQuel and the salt water is prepared with a mixture of Instant Ocean® (salinity should be 1.022 to 1.024). The left claw of a coconut crab is larger than the right. This large claw is used for holding and/or tearing at food items, while the small right one is used for eating.

Food preferences:

Favorite foods	Popcorn, dead mice, raw corn, bone marrow, shrimp, cuttlebone, raw beef, oyster and clam, cooked sweet potato, young coconut, cooked oatmeal with fruit or coconut flakes mixed in, very ripe mango, cooked chicken.
Secondary favorite	Coconut (in the husk), apple, papaya, African cycad fruit, orange and lettuce.
Moderate acceptance	Crickets, tuna-fish, smelt, raw oats, beetle jelly, watermelon, mango, grape, yam, cucumber, avocado, green beans and strawberries.
Usually ignored	Dried coconut shavings, banana, zucchini, spinach, arugula, bean sprouts, carrot, sunflower seeds, peanuts, almonds and walnuts.

(Fruits and vegetables are organic to avoid pesticides.)

ENRICHMENT

A coconut crab will approach anything that catches its eye, as long as it does not pose an immediate threat. Enrichment items placed in their exhibit can improve many aspects of their well-being. These enrichment items may vary from different types of food to inedible items that simply pique their curiosity. Exhibit space also plays an important role in enrichment. Sturdy climbing structures, vines, rocks, plants, large logs and burrows provide adequate novelty and support for a crab's home. One observation we made was our crab appeared to shy away from plastic items, even if we presented them with food. We eventually refrained from using plastic enrichment items of any kind.

Enrichment preferences:

Favorite items	Mirrors (Image 17), bone marrow (left inside the bone), bread, Cheerios™, hallowed out coconut filled with popcorn, hanging from high branch (Image 18), straw basket intertwined with popcorn and one dead adult mouse placed inside a small metal cage (Images 19 & 20).
Moderate acceptance	Raw oats, cooked chicken, honey, maple syrup and various spray scents: Lobster, popcorn, earthworm, coconut, cinnamon and sandalwood.
Always ignored	Piñata filled with popcorn, plastic disk topped with dried orange pieces (Image 21), camel hair, plastic PVC pipe filled with popcorn, zucchini, grape & apple (Image 22).



Image 17 (Photo Susy Zanese)



Image 18



Image 19



Image 20



Image 21



Image 22

CONCLUSION

We have learned a lot about keeping our coconut crab alive and well in several different enclosures over the past two years. The most important aspects of his survival have been adequate space to roam and explore as well as providing him with a burrow for privacy. Availability of salt water along with fresh water has proven to be an important part of his diet. Working with our enrichment coordinator, we are now investigating the possibility of crate training him, so we can continue to refrain from directly handling him, should there be a need to relocate him from his exhibit. As of July 2016, he is sealed in his burrow, going through his third molt.

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